CLIMATE CHANGE
09/2012

Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2012

National Inventory Report for the German Greenhouse Gas Inventory 1990 - 2010

Umwelt Bundesamt

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Federal Environment Agency, Germany

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Chapter 4.2.3	Robert Kludt (UBA I 2.6)
Chapter 4.2.4	Birgit Brahner (UBA III 2.3-K)
Chapter 4.2.5	Robert Kludt (UBA I 2.6)
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Chapter 4.3.3	Johannes Drotleff (UBA III 2.3-K
Chapter 4.3.4	Birgit Brahner (UBA III 2.3-K)
Chapter 4.3.5	Birgit Brahner (UBA III 2.3-K), Johannes Drotleff (UBA III 2.3-K), Edda Hoffmann (UBA III 2.3-K)
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Chapter 4.4.5	Cornelia Elsner (UBA III 1.4), David Kuntze (UBA I 2.6)
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Chapter 4.5.2	Ulrich Gromke (UBA III 2.3-K)
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Chapter 5.3	Folke Dettling (UBA III 1.4), David Kuntze (UBA I 2.6)
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Content

List of Figures

List of tables

List of abbreviations

AbfAblV	Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (Abfallablagerungsverordnung)
ABL	Old German Länder
AGEB	Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)
AK	Working group (Arbeitskreis)
ALH	All other deciduous/broadleaf trees with high life expectancies (BWI tree-species group)
ALN	All other deciduous/broadleaf trees with low life expectancies (BWI tree-species group)
ANCAT	Abatement of Nuisances from Civil Air Transport
AR	Activity data (=AD)
ARD	Afforestation, reforestation, deforestation
ATKIS	Official topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem)
AWMS	Animal Waste Management System
BAFA	Federal Office of Economics and Export Control
BAT	Best Available Technique
BDZ	Federal Association of the German Cement Industry (Bundesverband der Deutschen Zementindustrie)
BEF	Biomass-expansion factor
BEU	Balance of emissions sources for stationary and mobile combustion processes (Bilanz der Emissionsursachen für stationäre und mobile Verbrennungsprozesse)
BGR	Federal Institute for Geosciences and Raw Materials (Bundesanstalt für Geowissenschaften und Rohstoffe)
BGS	Fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) publicly connected to such operations
BGW	Federal Association of the German Gas and Water Industry (Bundesverband der deutschen Gas- und Wasserwirtschaft)
BHD	Diameter at breast height (= DBH; tree-trunk diameter at a height of 1.30 m above the ground)
BHKW	Combined heat and power (CHP) unit (Blockheizkraftwerk)
BKG	Federal Agency for Cartography and Geodesy (Bundesamt für Kartographie und Geodäsie)
BImSchV	Statutory Ordinance under the Federal Immission Control Act
BML	cf. BMELV
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMELV	Federal Ministry of Food, Agriculture and Consumer Protection
BMVEL	cf. BMELV
BMVG	Federal Ministry of Defence

BMWA	cf. BMWi
BMWi	Federal Ministry of Economics and Technology
BoHE	Main survey on soil use (Bodennutzungshaupterhebung)
BREF	BAT (Best Available Technique) Reference Documents
BSB	Biological oxygen demand (= BOD; Biologischer Sauerstoffbedarf)
BSB_5	Biological oxygen demand within 5 days (BOD_5)
BV Kalk	German Lime Association (Bundesverband der Deutschen Kalkindustrie)
BÜK	Soil-overview map (Bodenübersichtskarte)
BWI	National Forest Inventory (Bundeswaldinventur)
BZE	Forest Soil Inventory (Bodenzustandserhebung im Wald)
C_2F_6	Hexafluorethane
CAPIEL	Coordinating Committee for the Associations of Manufacturers of Industrial Electrical Switchgear and Controlgear in the European Union
CFC	Chlorofluorocarbons (= Fluorchlorkohlenwasserstoffe (FCKW))
CFI	Continuous Forest Inventory
CH_4	Methane
C_{org}	Organic carbon stored in the soil
CO	Carbon monoxide
CO_2	Carbon dioxide
CORINAIR	Coordination of Information on the Environment, sub-project: Air
CORINE	Coordinated Information on the Environment
CRF	Common Reporting Format
CSB	Chemical oxygen demand (COD)
D	Germany (Deutschland)
D7	Tree-trunk diameter at a height of 7 m above the ground
DEHSt	German Emissions Trading Authority (Deutsche Emissionshandelsstelle)
DESTATIS	Federal Statistical Office (Statistisches Bundesamt Deutschland)
DFIU	Franco-German Institute for Environmental Research, at the University of Karlsruhe (Deutsch-Französisches Institut für Umweltforschung an der Universität Karlsruhe)
DG	Landfill gas (Deponiegas)
DGMK	German Association of Oil, Natural Gas and Coal Science (Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle eV.)
DIN	DIN standard (Deutsche Industrienorm)
DIW	German Institute for Economic Research (Deutsches Institut für Wirtschaftsforschung)
DLR	German Aerospace Center (Deutsches Zentrum für Luft- and Raumfahrt)
DMKW	Diesel-engine power stations (Dieselmotorkraftwerke)
D_N	Nitrogen in wastewater
DOC	Degradable organic carbon
DOC_F	Fraction of DOC dissimilated (converted into landfill gas)
DSWF	"Forest Fund Database" for the former GDR (Datenspeicher Waldfonds)
DTKW	Steam-turbine power stations (Dampfturbinenkraftwerke)
DVGW	German Association of the Gas and Water Industry (Deutsche Vereinigung des Gas- und Wasserfachs eV.)
EBZ	Energy Balance line in the BEU (Energiebilanzzeile)
EEA	European Environment Agency

EECA	European Electronic Component Manufacturers Association
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz); promulgated in Federal Law Gazette Part I No. 40 of 31 July 2004, p. 1918 ff.)
EF	Emission factor
EI	Emission index = emission factor
E_{KA}	Inhabitant connected to wastewater-treatment system (Einwohner mit Kläranlagenanschluss)
EL	Fuel oil EL (EL = easily liquid)
EM	Emission
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
EMEV	Emissions-relevant energy consumption (Emissionsrelevanter Energieverbrauch)
ERT	Expert Review Team
ESIA	European Semiconductor Industry Association
ETS	EU Emissions Trading Scheme
EU	European Union
EU-EH	ETS (Europäischer Emissionshandel)
EUROCONTROL	European Organisation for the Safety of Air Navigation
EUROSTAT	Statistical Office of the European Communities
EW	Population (Einwohnerzahl)
FA	Combustion systems (Feuerungsanlagen)
FAP	Specialised contact person in the NaSe (Fachlicher Ansprechpartner)
FAL	Federal Agricultural Research Centre
FAO	United Nations Food and Agriculture Organisation of the United Nations
FCKW	CFC (Fluorchlorkohlenwasserstoffe)
F gases	Hydrofluorocarbons
FHW	District heating stations (Fernheizwerke)
FKW	Perfluorocarbons (PFC)
FKZ	Research project number (Forschungskennzahl)
FV	Responsible expert (Fachverantwortlicher) in the NaSE
FWL	Thermal output from combustion (Feuerungswärmeleistung)
GAS-EM	GASeous EMissions (a calculation programme for emissions in the agriculture sector)
GEREF	GERman Emission Factor Database
GFA	Large combustion systems (Großfeuerungsanlagen)
GG	Total weight (Gesamtgewicht)
GIS	Gas-insulated switching systems
GMBL	Joint Ministerial Gazette (Gemeinsames Ministerialblatt)
GMES	Global Monitoring for Environment and Security
GMKW	Gas-engine power stations (Gasmotorkraftwerke)
GPG	Good Practice Guidance
GSE FM-INT	GMES Services Elements Forest Monitoring: Inputs for national greenhouse-gas reporting
GT	Gas turbines
GTKW	Gas-turbine power stations (Gasturbinenkraftwerke)

GuD	Gas and steam turbine power stations (Gas- und Dampfturbinenkraftwerke)
GWP	Global Warming Potential Global Warming Potential)
HFC	Hydrofluorocarbons (= HFKW)
HFCKW	Hydrochlorofluorocarbons (HCFCs; Wasserstoffhaltige Fluorchlorkohlenwasserstoffe)
HFKW	Hydrofluorocarbons (HFC)
HK	Key category (Hauptkategorie): Used synomously with the term "key source" in the NIR, the term refers to both emissions sources and sinks.
HS-GIS	High-voltage gas-insulated switching systems
IAI	International Aluminium Institute
IE	Included Elsewhere
IEA	International Energy Agency
IEF	Implied emission factor
IfE	Institute for Energy and Environment (Institut für Energetik und Umwelt)
IFEU	Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung)
IKW	Industrial power stations (Industriekraftwerke)
IMA	Interministerial Working Group (Interministerielle Arbeitsgruppe)
IPCC	Intergovernmental Panel On Climate Change
IS08	Inventory Study 2008 (Inventurstudie 2008)
K	Fuel input for power generation (direct drive)
k.A.	No entry (keine Angabe)
KP	Kyoto Protocol
KS	Sewage sludge (Klärschlamm)
l	Level (= Level assessment pursuant to IPCC Good Practice Guidance)
LF	Agriculturally used land (landwirtschaftlich genutzte Flächen)
LKW	Truck (Lastkraftwagen)
LTO	Landing/take-off cycle
LUCF	Land Use Change and Forestry
LULUCF	Land Use, Land Use Change and Forestry
MBA	Mechanical-biological waste treatment (MBT; Mechanisch-Biologische Abfallbehandlung)
MCF	Methane Conversion Factor
MS	Medium voltage (Mittelspannung)
MSW	Municipal solid waste
MVA	Waste incineration plant (Müllverbrennungsanlage)
MW	Megawatt
N	Nitrogen
N_2O	Nitrous oxide (laughing gas)
NA	Not Applicable
NASA	National Aeronautics and Space Administration
NaSE	German National System of Emissions Inventories (Nationales System Emissionsinventare)
NBL	New German Länder (neue Bundesländer)
NE	Not Estimated
NEAT	Non-energy Emission Accounting Tables

NEC	Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain air pollutants National Emission Ceilings).
NEV	Non-energy-related consumption (nichtenergetischer Verbrauch)
NFR	New Format on Reporting, Nomenclature for Reporting to the UN ECE
NFZ	Utility vehicles (Nutzfahrzeuge)
NH_3	Ammonia
NIR	National Inventory Report
NMVOC	Non-Methane Volatile Organic Compounds
NO	Not Occurring
NO	Nitrogen monoxide
NSCR	Non-selective catalytic reduction
OCF	One-Component Foam (installation foam)
OX	Oxidation factor
PAH	Polycyclic aromatic hydrocarbons (= PAK)
PAK	Polycyclic aromatic hydrocarbons (Polycyclische aromatische Kohlenwasserstoffe; = PAH)
PARTEMIS	Measurement and prediction of emissions of aerosols and gaseous precursors from gas turbine engines
PCDD/F	Polychlorinated dibenzo-dioxins/- furans
PF	Process combustion (Prozessfeuerungen)
PFC	Perfluorocarbons
PKW	Automobile (Personenkraftwagen)
PU	Polyurethane
QK	Quality control (QC; Qualitätskontrolle)
QS	Quality assurance (QA; Qualitätssicherung)
QSE	Quality System for Emissions Inventories
REA	Flue-gas desulphurising plant (Rauchgasentschwefelungsanlage)
ROE	Oil equivalent (OE; Rohöleinheit)
RSt	Raw steel
RWI	Rheinisch-Westfälisches Institut für Wirtschaftsforschung
S	Fuel input for power generation
S	Heating oil, heavy (high viscosity; "Heizöl S")
S&A Report	Synthesis and Assessment Report
SA	Heating oil, heavy (high viscosity; low sulphur content; "Heizöl SA")
SE	Sampling error
SF_6	Sulphur hexafluoride
SKE	Hard-coal units (Steinkohleneinheiten)
SNAP	Selected Nomenclature for Air Pollution
SO_2	Sulphur dioxide
STEAG	STEAG Aktiengesellschaft (a large power producer in Germany)
T	Trend (= trend assessment pursuant to IPCC Good Practice Guidance, in the source-category overview tables)
TA Luft	Technical directive on air quality control; First General Administrative Provision on the Federal Immission Control Act (Clean Air Directive; Technische Anleitung zur Reinhaltung der Luft)
TAN	Total Ammoniacal Nitrogen

THG	Greenhouse gases (GG; Treibhausgase)
TM	Dry matter (Trockenmasse)
TOC	Total Organic Carbon
TREMOD	Traffic Emission Estimation Model
TS	Siccative (Trockenstoff)
TÜV	Technischer Überwachungsverein (Certifying body for technical and product safety)
TVF	Tonne of utilisable production (Tonne verwertbare Förderung)
UBA	Federal Environment Agency (Umweltbundesamt)
UN ECE	United Nations Economic Commission for Europe
UN FCCC	United Nations Framework Convention on Climate Change
UN	United Nations
UStatG	Environmental Statistics Act (Umweltstatistikgesetz)
VDEh	German Iron and Steel Institute (Verein Deutscher Eisenhüttenleute; in 2003, renamed "Stahlinstitut VDEh")
VDEW	Electricity Industry Association (Verband der Elektrizitätswirtschaft)
VDI	Association of German Engineers (Verein Deutscher Ingenieure e.V.)
VDN	Association of German network operators (Verband der Netzbetreiber e.V.)
VDZ	German Cement Works Association (Verein Deutscher Zementwerke e.V.)
VGB	Technical association of operators of large power stations (Technische Vereinigung der Großkraftwerksbetreiber e.V.)
VIK	Association of the Energy and Power Industry (Verband der Industriellen Energie- and Kraftwirtschaft e.V.)
VOC	Volatile Organic Compounds
VS	Volatile Solids
vTI	Johann Heinrich von Thünen Institute
vTI-AK	Johann Heinrich von Thünen Institute, Institute of Agricultural Climate Research (Institut für agrarrelevante Klimaforschung)
vTI-WOI	Johann Heinrich von Thünen Institute, Institute of Forest Ecology and Forest Inventory (Institut für Waldökologie und Waldinventuren)
W	Fuel input for heat generation
WS	Portion of a specific wastewater treatment system (e.g. aerobic, anaerobic)
WZ	Economic activity listed in the National Classification of Economic Activities (NACE; Wirtschaftszweig)
XPS	Extruded polystyrene
ZSE	Central System of Emissions (CSE)

Units and sizes

Multiplication factors, abbreviations, prefixes and symbols

		Prefix/symbol	
Multiplication factor	Abbreviation	Name	Symbol
1,000,000,000,000,000	10^{15}	peta	P
1,000,000,000,000	10^{12}	tera	T
1,000,000,000	10^{9}	giga	G
1,000,000	10^{6}	mega	M
1,000	10^{3}	kilo	k
100	10^{2}	hecto	h
0.1	10^{-1}	deci	d
0.01	10^{-2}	centi	c
0.001	10^{-3}	milli	m
0,000.001	10^{-6}	micro	µ

Units and abbreviations

Abbreviation	Units
°C	degrees Celsius
a	year
an	animal
cal	calorie
g	gram
h	hour
ha	hectare
J	joule
m^3	cubic metre
pl	(animal) place
ppm	parts per million
t	tonne
W	watt

Standard conversions

Units	is equivalent to
1 tonne (t)	1 megagram (Mg)
1 kilotonne / thousand tonnes (kt)	1 gigagram (Gg)
1 megatonne / million tonnes (Mt)	1 teragramm (Tg)

Reading the introductory information tables

The introductory information tables appear at the beginning of each source category chapter. Each such table provides an overview of the relevant source category's importance and of the methods used in connection with it.

CRF 1.x.x.x (example)	Gas	Key category (source)		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	CO_2	L	T/T2	339,017.9	(27.76 %)	305,235.0	(32.56 %)	-10.0 %
All fuels	N_2O	L	T	3,610.0	(0.30 %)	3,371.1	(0.36 %)	-6.6 %
All fuels	CH_4	-	T	185.8	(0.02 %)	1,567.8	(0.17 %)	744.0 %

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2			CS

Key category

The upper section of the table shows the key-category-analysis lines that are relevant for the source category in question; the emissions, as an absolute figure (Gg CO_2 equivalent) and as a percentage of total emissions in 1990 and in the last reported year; and the pertinent emissions trend between the base year and the last reported year. In the NIR, the term "key category" is used synonymously with the term "key source".

L = Key category in terms of emissions level
T = Key category in terms of emissions trend
T2 = Key category pursuant to Tier-2 analysis

Gas

The lower section of the table provides information about the methods used, the source for the activity data and the emission factors (EF) used.

Method used

D = IPCC default
RA = Reference Approach
T1 = IPCC tier 1
T1a/ T1b/ T1c = IPCC tier 1a/ 1b/ 1c
T2 = IPCC tier 2
T3 = IPCC tier 3
C = CORINAIR
CS = Country-specific
M = Model

Source for the activity data

M = Model
Q = Questionnaires, surveys
PS = Plant-specific data
AS = Associations, business organizations
RS = Regional statistics
NS = National statistics
IS = International statistics

Emission factor (EF)

D = IPCC default
C = CORINAIR
CS = Country-specific
PS = Plant-specific
M = Model

0 SUMMARY (ES)

As a Party to the United Nations Framework on Climate Change (UNFCCC), since 1994 Germany has been obliged to prepare, publish and regularly update national emission inventories of greenhouse gases. In February 2005, the Kyoto Protocol entered into force. As a result, for the first time ever the international community of nations is required to implement binding action objectives and instruments for global climate protection. This leads to extensive obligations vis-à-vis the preparation, reporting and review of emissions inventories. As a result of Europe's own implementation of the Kyoto Protocol, via the adoption of EU Decision 280/2004[1], these requirements became legally binding for Germany in spring 2004.

Pursuant to Decision 3/CP.5, all Parties listed in ANNEX I of the UNFCCC are required to prepare and submit annual National Inventory Reports (NIRs) containing detailed and complete information on the entire process of preparation of such greenhouse-gas inventories. The purpose of such reports is to ensure the transparency, consistency and comparability of inventories and support the independent review process. The Secretariat of the Framework Convention on Climate Change has made submission of the inventory report a pre-requisite for performance of the agreed inventory reviews.

Pursuant to to decision 15/CMP.1, as of 2010 all of the countries listed in ANNEX I of the UN Framework Convention on Climate Change that are also parties to the Kyoto Protocol must submit annual inventories in order to be able to make use of flexible mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.

Together with the inventory tables, Germany submits a National Inventory Report (NIR), which refers to the period covered by the inventory tables and describes the methods and data sources on which the pertinent calculations are based. The report and the report tables in the Common Reporting Format (CRF) have been prepared in accordance with the UNFCCC guideline on annual inventories (FCCC/SBSTA/2006/9) and in accordance with the *IPCC Good Practice Guidance* (IPCC-GPG, 2000) and the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC-GPG LULUCF, 2003). The NIR contains a Part II, along with additional sub-chapters, that fulfill the expanded requirements under the Kyoto Protocol and the relevant obligations at the European level.

Part I of the NIR presents, in Chapters 1 to 10, all the information relevant to the annual greenhouse-gas inventory.

Chapter 1 provides background information about climate change and about greenhouse-gas inventories, as well as further information relative to the Kyoto Protocol. This section describes the National System pursuant to Article 5.1 of the Kyoto Protocol, which system is designed to aid and assure compliance with all reporting obligations with respect to atmospheric emissions and removals in sinks. In addition, this chapter describes the basic principles and methods with which the emissions and sinks of the IPCC categories are calculated, presents a short summary of key-category assessment and describes the Quality System for Emissions Inventories (QSE). The chapter concludes with sections on uncertainties analysis and completeness analysis.

[1] Decision No. 280/2004/EC of the European Parliament and the Council of 11 February 2004 on a system for monitoring greenhouse-gas emissions in the Community and for implementing the Kyoto Protocol (OJ EU L 49 p. 1).

Chapter 2 provides a general overview of development of emissions of direct and indirect greenhouse gases and of removals of carbon dioxide in sinks.

Chapters 3 to 9 present information about the individual source and sink groups. Along with general descriptions and information relative to the methods used, the sub-chapters also include information about pertinent uncertainties, quality assurance and quality control, recalculations carried out and planned improvements for relevant source and sink categories.

The inventories, the National System and the Quality System for Emissions Inventories have all been further improved in keeping with the results of the reviews that have taken place in recent years. More-detailed information about recalculations, and information relative to the improvements and changes made with regard to the last greenhouse-gas inventory, is presented in **Chapter 10**.

Part II of the NIR, in **Chapters 11 to 16**, presents the so-called "Kyoto-NIR", in fulfillment of the expanded requirements for Kyoto reporting, and in keeping with the required organisation (annotated NIR).

Chapter 11 contains all information relative to Kyoto reporting in the areas of land use, land-use changes and forestry (LULUCF), especially the definition of "forest" chosen, details on the land-classification technique used and all information relative to selected activities pursuant to Arts. 3.3 and 3.4 of the Kyoto Protocol.

Chapter 12 is devoted completely to accounting for Kyoto units, a process for which, in Germany, the German Emissions Trading Authority (DEHSt) is responsible.

Chapters 13 and 14 provide an overview of changes made in the National System, and at the German Emissions Trading Authority, with the aim of ruling out the possibility of any undue influences on Kyoto reporting.

Chapter 15 lists all the measures that Germany is taking to minimise negative impacts pursuant to Article 3 (14).

Chapter 16 presents any required further information relative to Kyoto reporting.

Annexes 1 through 7, in **Chapters 17-23**, contain more-detailed descriptions of key categories, of individual source categories, of the CO_2-reference procedure, of completeness issues, of the National System and the Quality System, of the CSE emissions database and of uncertainties.

More-detailed information about specific relevant issues is presented in the literature listed in **Chapter 24**.

The Federal Environment Agency makes all calculations for the greenhouse-gas inventory and carries out all relevant compilation. Data on emissions and sinks in the land use, land-use changes and forestry sector have been provided by the Johann Heinrich von Thünen Institute (vTI).

0.1 Background information on greenhouse-gas inventories and climate change (ES.1)

0.1.1 Background information about climate change (ES1.1)

Ever since the start of industrialisation, significant trans-regional and global changes in the substance balance of the atmosphere have been observed as a consequence of human activities. Worldwide, concentrations of carbon dioxide (CO_2) have risen by approximately 35 % compared to their levels in pre-industrial times, whilst those of methane (CH_4) have increased by 145 % and those of nitrous oxide (N_2O) have risen by 18 %. Furthermore, a number of brand-new substances such as chlorofluorocarbons (CFCs), halons, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6) have entered the atmosphere which almost never occur in nature and are generated almost exclusively by humans. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[2] shows that human impacts on climate are scientific fact.

0.1.2 Background information about greenhouse-gas inventories (ES1.2)

In February 2005, the Kyoto Protocol entered into force. As a result, the international community of nations is required to implement binding action objectives and instruments for global climate protection. In the framework of the Kyoto Protocol, the European Union (with 15 Member States at that time) has committed to reducing its greenhouse-gas emissions by 8% by the 2008–2012 period, in comparison to their base-year levels (1990 and 1995[3]). This commitment has been divided within the EU in the framework of a burden-sharing agreement between the participating Member States[4]. Under this agreement, Germany has agreed to reduce its emissions by 21 % in comparison to the base year and thus has agreed to make a substantial contribution to fulfillment of the EU's commitment. Consequently, Germany's relevant measures, and its calculations relative to emissions reductions, are being followed with considerable interest.

0.1.3 Background information relative to supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol (ES.1.3)

The present report, in keeping with decision 15/CMP.1, presents, for the first time, supplementary information pursuant to Article 7 (1) of the Kyoto Protocol, for support of the review process under the Kyoto Protocol. This information includes:

- General information on inventory preparation in connection with reporting pursuant to Article 3 (3) Kyoto Protocol and for the selected additional activities pursuant to Article 3 (4) Kyoto Protocol; (cf. Chapter 10)
- Information regarding the certificates under the Kyoto Protocol in connection with decisions 13/CMP.1 and 5/CMP.1; (cf. Chapter 12)

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2 IPCC Fourth Assessment Report: Climate Change 2007, available in the Internet at: http://www.ipcc.ch/ipccreports/assessments-reports.htm

3 For HFC, PFC and SF_6

4 Burden-sharing agreement, adopted with Council Decision 2002/358/EC of 25 April 2002 concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfilment of commitments thereunder [OJ L 130 of 15 May 2002]

- Information regarding changes in the National System of emissions reporting pursuant to Article 5 (1) of the Kyoto Protocol; (cf. Chapter 13)
- Information regarding changes in the National Registry; (cf. Chapter 14)
- Information regarding minimisation of negative impacts pursuant to Article 3 (14) of the Kyoto Protocol; (cf. Chapter 15)

0.2 Combined greenhouse-gas emissions, their removals in sinks, and emissions and removals from KP-LULUCF activities (ES.2)

0.2.1 Greenhouse-gas inventory (ES.2.1)

By 2010, Germany had fulfilled its obligations within the framework of the aforementioned European burden-sharing, by achieving a reduction of 24.0 % with regard to the base-year emissions determined in 2007[5], 1,232,429.543 Gg (CO_2 equivalent). As a result of economic recovery, overall emissions in 2010 increased by 2.7% with respect to the previous year. From 2008 to 2009, they had decreased by 6.6 % as a result of the global economic crisis. (cf. Chapter 2.1).

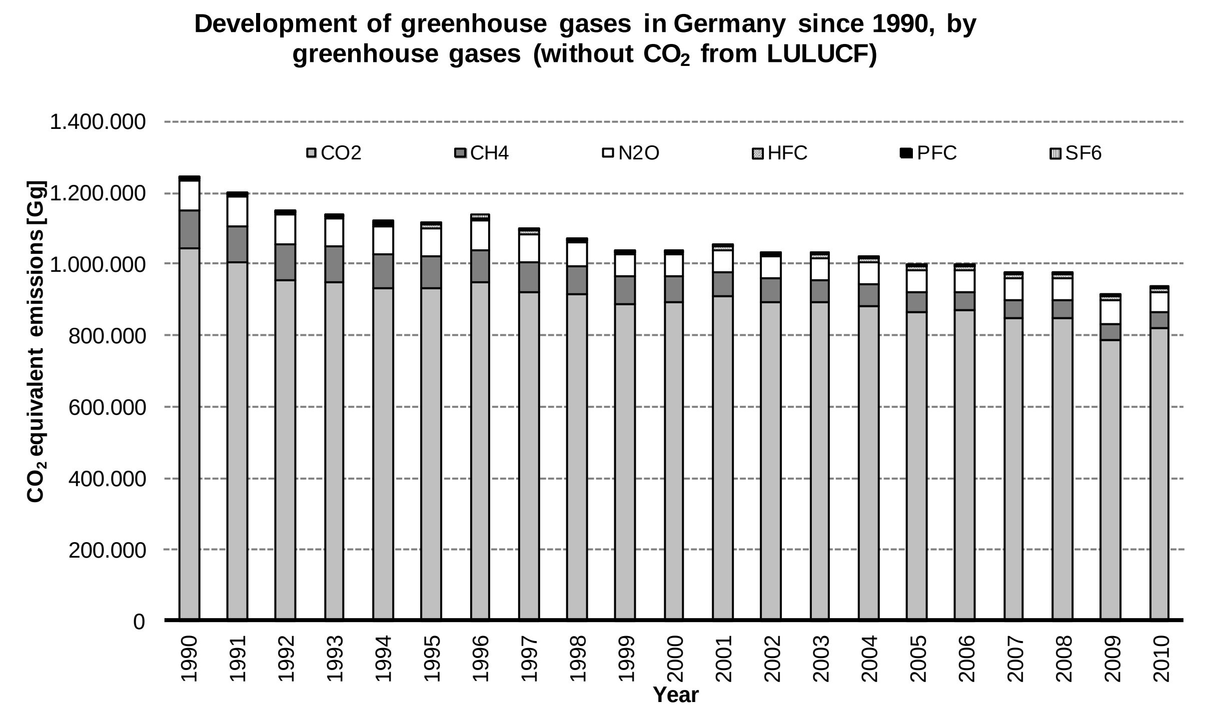

Figure 1: Development of greenhouse gases in Germany since 1990, by greenhouse gases [6,]

The individual greenhouse gases contributed to this development to varying degrees (cf. Table 1). This is hardly surprising given that, in any given year the various greenhouse gases account for varying proportions of total emissions (cf. Table 2). Detailed tables are provided in Annex Chapter 22.3.

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[5] The reference figures for determining achievement of reduction obligations under the Kyoto Protocol have been defined in keeping with results of the review, carried out in 2007, of the initial report and of reporting for 2006 pursuant to Article 8 of the Kyoto Protocol. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to 21 %.

[6] CO_2 emissions from, and removals in, soils are reported under land-use changes and forestry.

In 2010, carbon-dioxide releases were the most significant greenhouse-gas emissions, accounting for 87.4 % of all such emissions. Most of the carbon dioxide is released via stationary and mobile combustion of fossil fuels. As a result of a disproportionately large reduction of other greenhouse-gas emissions, CO_2 emissions' share of total emissions has increased by over 4 percentage points since the base year. Methane (CH_4) emissions, caused predominantly by animal husbandry, fuel distribution and landfills, accounted for a 5.1 % share in 2010. Emissions of nitrous oxide (N_2O), caused primarily by agriculture, industrial processes and burning of fossil fuels, contributed 5.9 % of greenhouse-gas releases. Fluorocarbons (so-called "F gases") accounted for about 1.6 % of total emissions. The distribution of greenhouse-gas emissions in Germany is typical for a highly developed and industrialised country.

Table 1: Emissions trends in Germany, by greenhouse gas and source category

GG emissions / sinks, in CO_2 equivalents (Gg)	**1990**	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Net CO_2 emissions / removals	1,014,192	903,574	864,834	881,490	886,282	864,814	862,545	801,257	835,991
CO_2 emissions (not including LULUCF)	1,042,161	931,040	891,624	865,959	871,041	849,040	846,526	784,297	818,962
CH_4	107,109	91,223	73,444	55,587	52,572	50,485	50,646	48,553	47,699
N_2O	85,276	79,971	62,105	61,563	60,789	62,521	63,769	63,667	54,982
HFC	4,592	6,912	7,040	10,252	10,794	11,369	11,657	12,128	11,597
PFC	2,627	1,773	781	709	571	510	521	359	309
SF_6	4,642	6,779	4,269	3,475	3,396	3,332	3,114	3,059	3,250
Total emissions / removals, including LULUCF	1,218,439	1,090,232	1,012,473	1,013,075	1,014,405	993,031	992,252	929,024	953,827
Total emissions, not including CO_2 from LULUCF	1,246,407	1,117,698	1,039,264	997,544	999,164	977,257	976,233	912,064	936,798

GG emissions / sinks, by source and sink categories, in CO_2 equivalents (Gg)	**1990**	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1. Energy	1,020,759	903,824	857,935	827,035	830,553	808,417	807,421	753,379	782,313
2. Industrial processes	94,580	97,094	77,213	80,735	81,998	84,683	82,077	75,114	72,631
3. Solvent and other product use	4,477	3,553	2,909	2,052	2,074	1,949	1,812	1,626	1,882
4. Agriculture	83,211	73,143	73,861	69,853	68,506	67,612	70,467	68,659	67,479
5. Land use, land-use changes & forestry	-27,699	-27,203	-26,526	15,798	15,510	16,039	16,285	17,221	17,283
CO_2	*-27,968*	*-27,466*	*-26,791*	*15,531*	*15,242*	*15,774*	*16,019*	*16,959*	*17,028*
N_2O & CH_4	*269*	*263*	*265*	*267*	*268*	*265*	*266*	*262*	*255*
6. Waste	43,111	39,820	27,081	17,602	15,764	14,331	14,190	13,024	12,239

Table 2: Contributions to emissions trends in Germany, by greenhouse gas and source category

GG emissions / sinks; shares for various GG, not including CO_2 from LULUCF (%)	1990	1995	2000	2005	2006	2007	2008	2009	2010
CO_2 emissions (not including LULUCF)	83.6	83.3	85.8	86.8	87.2	86.9	86.7	86.0	87.4
CH_4	8.6	8.2	7.1	5.6	5.3	5.2	5.2	5.3	5.1
N_2O	6.8	7.2	6.0	6.2	6.1	6.4	6.5	7.0	5.9
HFC	0.4	0.6	0.7	1.0	1.1	1.2	1.2	1.3	1.2
PFC	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0
SF_6	0.4	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

GG emissions / sinks; shares for emission & sink categories, not including CO_2 from LULUCF (%)	1990	1995	2000	2005	2006	2007	2008	2009	2010
1. Energy	81.9	80.9	82.6	82.9	83.1	82.7	82.7	82.6	83.5
2. Industrial processes	7.6	8.7	7.4	8.1	8.2	8.7	8.4	8.2	7.8
3. Solvent and other product use	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
4. Agriculture	6.7	6.5	7.1	7.0	6.9	6.9	7.2	7.5	7.2
5. Land use, land-use changes & forestry (N_2O)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6. Waste	3.5	3.6	2.6	1.8	1.6	1.5	1.5	1.4	1.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Information about the relevant trends is provided in Chapter 2, while all detailed tables relative to discussion of trends are provided in Annex Chapter 22.3.

0.2.2 KP-LULUCF activities (ES.2.2)

Removals of CO_2 pursuant to Article 3.3 have decreased by 0.6 % with respect to 2009. N_2O emissions have decreased by 8.5 %.

CO_2 removals pursuant to Article 3.4, via Forest Management activities, have remained nearly constant throughout the report period. Emissions of CH_4 (forest fires) decreased by 30.8 % with respect to the previous year, while emissions of N_2O remained constant.

0.3 Combined emissions estimates, and trends for source and sink groups, including KP-LULUCF activities (ES.3)

0.3.1 Greenhouse-gas inventory (ES.3.1)

Figure 2 shows the contributions of individual source and sink categories to total greenhouse-gas emissions. It highlights the relative constancy of the relative shares of the various source and sink categories and the absolute predominance of energy-related emissions. On the other hand, absolute energy-related emissions have continuously decreased over time. The fluctuations that are superimposed over this trend are largely temperature-related. Because winter temperatures affect heating patterns, they also affect energy consumption for heating, and thus they have major impacts on annual trends in energy-related CO_2 emissions.

All in all, emissions of greenhouse gases have decreased considerably with respect to the base year for the 2006 report[7], whose emissions were determined to be 1,232,429,543 Gg CO_2 equivalent (24.0 % decrease of CO_2-equivalent emissions). Considerations of the various components involved confirm this trend, to varying degrees. With respect to the base-year emissions, the relevant emissions changes for the most important greenhouse gases in terms of quantity were as follows: - 21.4 % for carbon dioxide (CO_2), - 55.5 % for methane (CH_4) and - 35.5 % for nitrous oxide (N_2O). The corresponding trends for the so-called "F" gases, which contribute about 1.6 % of greenhouse-gas emissions overall, have not been as clearly similar to each other, however. In keeping with the introduction of new technologies, and with use of these substances as substitutes, since base year 1995 SF_6 emissions decreased by 52.1 % and PFC emissions dropped by 82.6 %, while HFC emissions increased by 67.8 %.

With respect to the previous year, 2009, total emissions increased by 2.7 %, following a 6.6 % decrease between 2008 and 2009. In 2009 and 2010, the impacts of the global economic crisis outweighed all other factors affecting emissions.

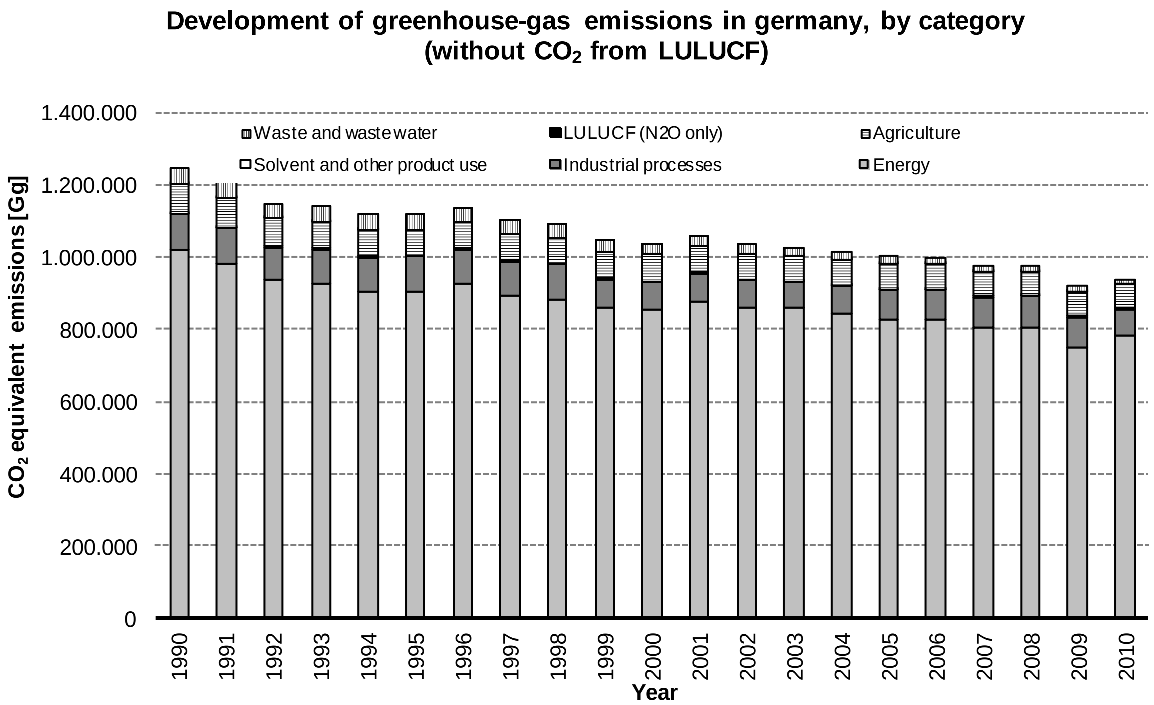


Figure 2: Emissions trends in Germany since 1990, by source categories[8,]

Figure 3 shows the relative developments of emissions from polluter categories since 1990. The most significant reduction occurred in the area of waste emissions. Increased recycling of recyclable materials (Packaging Ordinance), and reuse of materials as compost (Biowaste Ordinance), have led to a reduction in the quantity of waste that is landfilled and hence to a reduction in landfill emissions. Emissions-reducing measures carried out in 1997 and 2009 in

[7] The reference figures for determining achievement of reduction obligations under the Kyoto Protocol have been defined in keeping with results of review of the initial report and of reporting for 2006 pursuant to Article 8 of the Kyoto Protocol. Such definition does not take account of any further possible improvements in the basic data. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to 21 %.

[8] CO_2 emissions from, and removals in, soils are reported under land-use changes and forestry.

the sector of adipic-acid production had major impacts on emissions from industrial processes. Emissions from solvent and other product use decreased markedly, as a result of decreased narcotic use of N_2O. The development of emissions from agriculture essentially follows the development of livestock data. A detailed discussion of emissions trends is presented in Chapter 2, Trends in Greenhouse Gas Emissions.

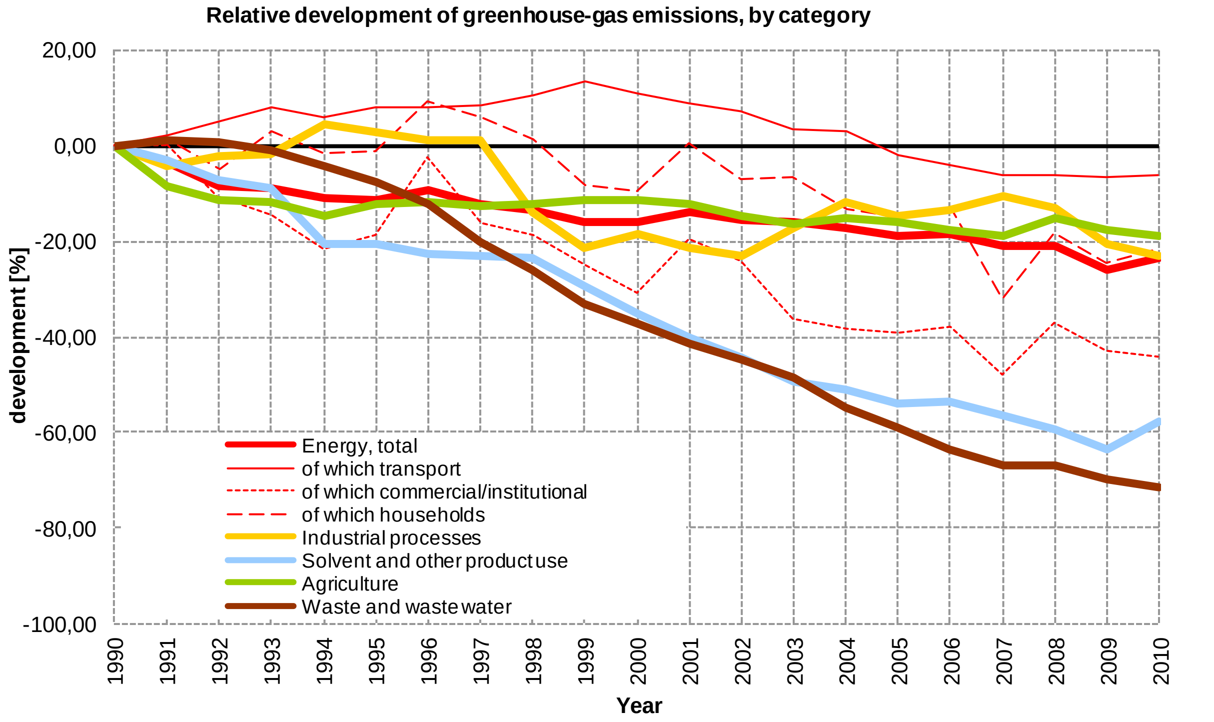


Figure 3: Relative development of greenhouse-gas emissions since 1990, by source categories[9,10]

0.3.2 *KP-LULUCF activities (ES.3.2)*

Germany reports under KP-LULUCF Article 3 (3), and it reports in the area of forest management with regard to the selected additional activities pursuant to Article 3 (4) Kyoto Protocol. It reports emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide.

Under Article 3.3, it reports removals of -5,824.26 Gg CO_2 equivalent. The emissions are composed of CO_2 removals via afforestation and reafforestation, amounting to -5,944.55 Gg CO_2 equivalent, and emissions from deforestation, amounting to 120.29 Gg CO_2 equivalent. In the deforestation category, emissions of 118.51 Gg CO_2, and of 1.78 Gg CO_2 equivalent of N_2O, are reported.

Under Article 3.4, it reports removals of -19,410.3 Gg CO_2 equivalent. The removals are composed of CO_2 removals via afforestation and reafforestation, amounting to -20,092.11 Gg CO_2 equivalent, and emissions of 681.8 Gg CO_2 equivalent. Under Article 3.4, it reports CO_2 removals of -19,479.24 Gg CO_2, N_2O emissions of 65.74 Gg CO_2 equivalent and CH_4 emissions of 3.2 Gg CO_2 equivalent.

[9] CO_2 emissions from, and removals in, soils are reported under land-use changes and forestry.
[10] The reference value consists of the emissions in 1990 (=100%), and not of base-year emissions.

On afforestation areas, a removals increase of -47.34 Gg CO_2 equivalent was determined for the period from 2009 to 2010. In the deforestation category, a slight emissions increase of 14.43 Gg CO_2 equivalent was seen. On the other hand, removals in connection with forest management increased slightly from 2009 to 2010. The increase amounted to -2.47 Gg CO_2 equivalent (cf. also Table 15 in Chapter 2.5).

1 INTRODUCTION

1.1 Background information regarding greenhouse-gas inventories and climate change, and supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

1.1.1 Background information about climate change

Climate change consists of changes in average weather conditions, and in extreme events, over an extended period of time; it can occur in a particular area or be global.

Climate change may be attributable to the following causes:

- Changes in so-called "geo-astrophysical parameters" such as the solar constant, elements of the earth's orbit, etc.
- Changes in the earth's surface
- Changes in the energy balance in the "earth's surface and atmosphere" system
- Changes in the substance balance in the atmosphere (such as changes in the concentration of greenhouse gases).

Greenhouse gases, among which are carbon dioxide, nitrous oxide (laughing gas), methane, ozone and water vapour (the most important natural greenhouse gas), have a particular property. They allow the energy-rich radiation falling onto the earth from the sun (primarily in the visible, short-wave range) to pass almost unhindered, yet partially absorb the long-wave radiation emitted by the heated earth. This places them in an energetically excited state for a brief time, after which they return to their original basic state whilst emitting infrared radiation. Heat radiation occurs equally in all spatial directions – in other words, a substantial portion of this is returned to the earth's surface ("*thermal back radiation*"). So that this additional quantity of energy may nevertheless be irradiated (this must occur due to the dynamic, energetic equilibrium, at whose centre are the earth and the atmosphere), the earth must have a correspondingly higher temperature. This is a simplified description of the greenhouse effect.

Without the greenhouse gases occurring naturally, life on our planet would not be possible. Instead of having an average global temperature of approximately 15°C, the earth would have an average temperature of approximately –18°C. In other words, the natural greenhouse effect protects our life on earth.

Since the beginning of the industrial era, mankind has brought about marked changes in the atmosphere's substance cycles. These changes have been caused by humans' energy-intensive lifestyles and related emissions of greenhouse gases. Since 1750, the worldwide concentration of carbon dioxide (CO_2) has increased by about 35 %, while that of methane (CH_4) has more than doubled and that of nitrous oxide (N_2O) has increased by about 18 %. Furthermore, a number of brand-new substances such as chlorofluorocarbons (CFCs), halons, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6)

have entered the atmosphere which almost never occur in nature and are generated almost exclusively by humans. In spite of being "trace gases", greenhouse gases have considerable impacts. Their increasing concentrations have led to the anthropogenic (human-caused) greenhouse effect, which supplements the natural greenhouse effect.

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (2007) is very clear on the following point: Observations and measurements unambiguously indicate that the climate system is warming, with respect to its pre-industrial state, and that humans are primarily responsible for this trend. The global warming is clearly apparent in the increase of the average global near-ground air temperature, amounting to 0.76°C in the period 2001 to 2005 with respect to to pre-industrial levels (1859 to 1899); in the increase of the average temperature of the world's oceans (for layer 0 to 700 m, by 0.10°C for the period 1961 to 2003); in extensive melting of ice and snow; and in the increase of average global sea level. Pursuant to the IPCC (2007), these trends have intensified, and the rate of warming seen over the past 50 years (1996 to 2005) is twice as high as that of the past 100 years (IPCC 2007: S. 237, WG I). The climate change will have extensive impacts on ecological and societal systems, with potentially serious consequences.

If dangerous impacts of climate change are to be prevented, global warming must be constrained to no more than 2 °C in comparison to pre-industrial levels. Of that increase, 0.7°C have already taken place. In addition, so the IPCC (2007), greenhouse-gas emissions have to peak, and a trend reversal has to take place, within the next 10 years. Furthermore, so the IPCC (2007), by 2050 global emissions have to be reduced by at least 50 %, with respect to 2000, if the temperature increase is to be limited to 2 and 2.4 °C.

1.1.2 Background information about greenhouse-gas inventories

The world's nations were quick to recognize that the expected temperature changes would pose threats to ecosystems and to human civilisation, because the changes would take place relatively quickly, and existing systems would not be able to adapt to the new climate conditions without suffering damage.

The Framework Convention on Climate Change was adopted in 1992, in Rio de Janeiro, by nearly all nations of the world. Since 1994, the countries listed in Annex I of the Framework Convention on Climate are required to submit annual inventories of greenhouse gases, as of 15 April of each year, to the Secretariat of the Framework Convention. Such inventories must include data on emissions and sinks for the base year (1990 for CO_2, N_2O, CH_4; 1995 for HFCs, PFCs, SF_6) and for all years until two years prior to the year of the relevant report.

At the third Conference of the Parties, held in Kyoto, legally binding obligations on emissions limitations and reductions were defined, for the first time, for industrialised countries. Pursuant to the Kyoto Protocol, industrialised nations must reduce their emissions of the six greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) by an average of 5.2 percent by 2012. In the framework of the Kyoto Protocol, the European Union (then with 15 Member States) has committed to reducing its greenhouse-gas emissions by 8% by the 2008–2012 period, in comparison to their base-year levels. This commitment has been divided up between the participating Member States via a burden-sharing arrangement[11] whereby Germany is called on to make a substantial contribution of a 21 % emissions reduction in comparison to the base year. Consequently, Germany's relevant measures, and its calculations relative to emissions reductions, are being followed with considerable interest.

The effectiveness and success of the Kyoto Protocol vis-à-vis reduction of global greenhouse gas emissions will depend on two key factors: Whether its Parties abide by the rules of the Protocol and meet their obligations, and whether the emissions data used for controlling compliance are reliable. As such, national reporting and the subsequent international review of emissions inventories play a key role.

1.1.3 Background information relative to supplementary information, as required pursuant to Article 7 (1) of the Kyoto Protocol (KP NIR 1.1.3.)

Pursuant to decision 15/CMP.1 of the 1st COP of the Kyoto Protocol, as of 2010 all of the countries listed in ANNEX I of the UN Framework Convention on Climate Change that are also parties to the Kyoto Protocol must submit annual inventories in order to be able to make use of flexible mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.

In 2008 (with the NIR 2008), Germany began early, on a voluntary basis, to fulfill these reporting obligations. In the process, over the past two years it has begun preparing intensively for the binding reporting required pursuant to Art. 7 of the Kyoto Protocol.

The first binding report, that for 2010 (NIR 2010), was reviewed in detail in September 2010 in the framework of an In-Country Review. That review led to recalculations for some source categories of the 2010 report, as well as to a resubmission of the data in November 2010. Other changes requested via the 2010 In-Country Review have been implemented in the present 2012 report.

In submitting its tenth National Inventory Report (NIR 2012), Germany also submits its fifth inventory report, pursuant to the Kyoto Protocol, that includes all of the information called for in Art. 7.

Information relative to Arts. 3.3 and 3.4 of the Kyoto Protocol (KP-LULUCF) are provided in Chapter 10. Information on bookkeeeping relative to Kyoto units is presented in Chapter 12. The relevant changes in the National System are described in Chapter 13, and the changes in the National Registers are described in Chapter 14. Information on minimisation of negative influences pursuant to Art. 3 (14) of the Kyoto Protocol is presented in Chapter 15.

1.2 Description of institutionalisation of inventory preparation, including the legal and procedural definitions relative to the planning, preparation and management of the inventory

Article 5.1 of the *Kyoto Protocol* mandates the establishment of National Systems for preparation of greenhouse-gas emissions inventories. The National System for Germany fulfils the requirements of the *Guidelines for National Systems* (UNFCCC Decision 19/CMP.1), requirements which are binding under the *Kyoto Protocol* and *Decision 280/2004/EC*.

11 Burden-sharing agreement; adopted via Council decision 2002/358/EC

The National System provides for the preparation of inventories conforming to the principles of transparency, consistency, comparability, completeness and accuracy. Such conformance is achieved through use of the methodological regulations from the *IPCC Guidelines* and the *IPCC Good Practice Guidance*, through ongoing quality management and through continuous inventory improvement.

The National System in Germany was established via an agreement of state secretaries representing the ministries involved in emissions reporting, an agreement set forth in the paper, on basic emissions-reporting principles, entitled "National System" and dating from 5 June 2007.

In recent years, decisive progress has been made in institutionalising the National System. Initially, such progress came via the establishment of the national co-ordinating committee (Single National Entity), issuance of an in-house directive for the Federal Environment Agency and development of a procedure for using monitoring data from European emissions trading. Further institutionalisation is now taking place primarily via signing of relevant agreements with other federal institutions, with industrial associations and with individual business enterprises.

1.2.1 Overview of the institutional, legal and procedural definitions relative to preparation of greenhouse-gas inventories and of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

In Germany, the National System has been established, in the main, at three levels: at the level of the Federal Environment Agency (UBA), at the ministerial level and at a level outside of the federal administrative sector.

At the ministerial level, the National System has been established under the leadership of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), via an agreement 5 June 2007 signed by state secretaries of the participating ministries. The System now incorporates other German ministries, including the Federal Ministry of the Interior (BMI), the Federal Ministry of Defence (BMVg); the Federal Ministry of Finance (BMF), the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry of Transport, Building and Urban Development (BMVBS) and the Federal Ministry for Food, Agriculture and Consumer Protection (BMELV). As a result, the process of emissions-inventory preparation now includes all of the key institutions that are in a position to make high-quality specialised contributions to it. The "Nationales System" ("National System") principles paper of 5 June 2007 on emissions reporting defines the relevant responsibilities of the various participating federal ministries, and it mandates that the National System is to be built on the basis of existing data streams. Where the data streams in incomplete, the pertinent gaps are to be closed by the responsible ministries, via suitable activities. In support of the reporting process, the participating ministries established a co-ordinating committee (cf. Chapter 1.2.1.1).

The "National System" principles paper also assigns the Federal Environment Agency the task of serving as the Single National Entity for Germany (cf. Chapter 1.2.1.2). Working at the level of the Federal Environment Agency, the Single National Entity links other specialised units in the establishment of the National System. For co-ordination of pertinent work within the Federal Environment Agency, a working group on emissions inventories was established (cf. Chapter 1.2.1.3). For implementation of the IPCC Good Practice Guidance relative to quality control and assurance, a Quality System of Emissions was established within the Federal Environment Agency in 2005, via an in-house directive (cf. Chapter 1.2.1.5).

In addition, numerous external institutions and organiations outside of the federal administrative sector are integrated within the National System (cf. Chapter 1.2.1.4).

The following Figure 4 provides an overview of the structure of the National System in Germany.

The paper "National System" of 5 June 2007, on basic principles of emissions reporting, is provided in Annex Chapter 22.1.1.

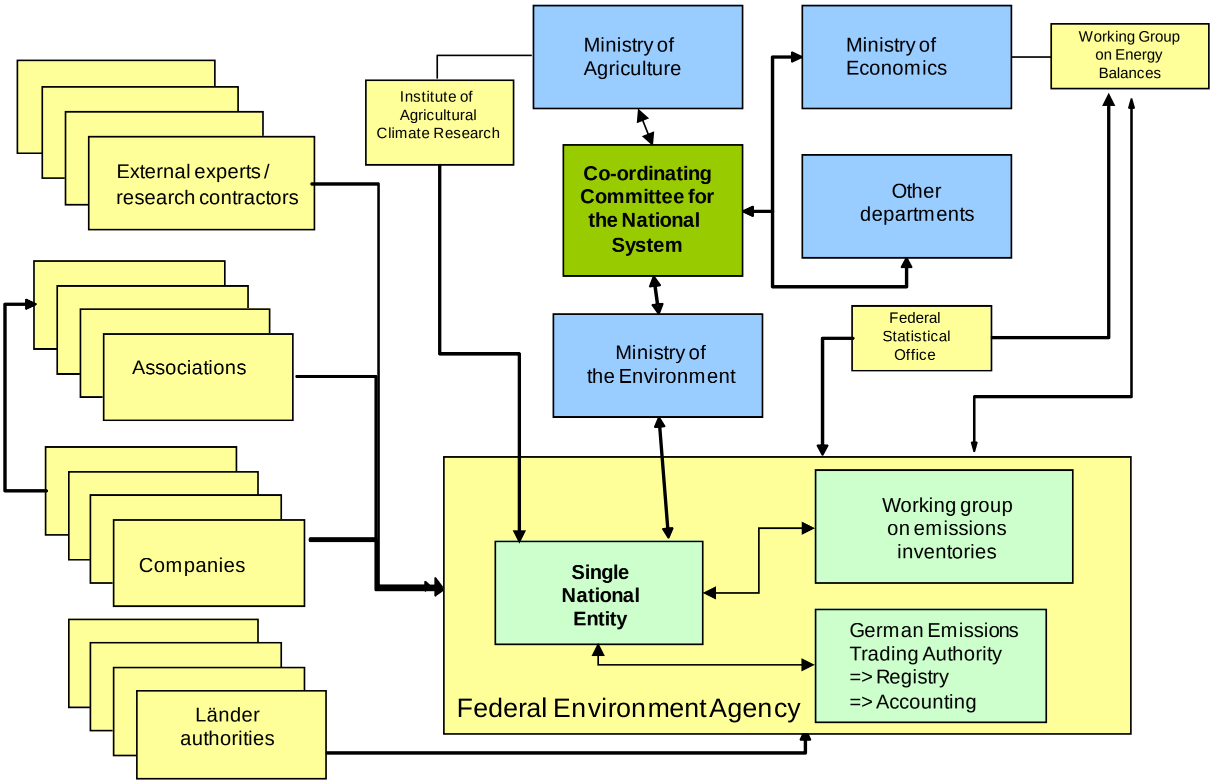


Figure 4: Structure of the National System of Emissions (NaSE)

1.2.1.1 The National Co-ordinating Committee

In its Sec. 2, the state secretaries' resolution of 5 June 2007 provides for the establishment of a National Co-ordinating Committee that is to be headed by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and to include representatives of all federal ministries that participate in emissions reporting.

The National Co-ordinating Committee has the tasks of supporting the emissions-reporting process and clarifying open issues pertaining to the National System. In particular, the Committee carries out consultations with regard to gaps in data streams and settles issues pertaining to assigned responsibilities.

In addition, the National Co-ordinating Committee is responsible for approving inventories and the reports required pursuant to Arts. 5, 7 and 8 of the Kyoto Protocol.

The National Co-ordinating Committee met for the first time on 21 December 2007. It meets at least once per year, at the invitation of the BMU. Between meetings, the participating federal ministries carry out co-ordination via electronic communication.

The National Co-ordinating Committee has become a basic component of the National System. The body's establishment has implemented the recommendation expressed in the Initial Review 2007, Paragraph 11, and it has contributed to the institutionalisation of the National System of Emissions Reporting.

1.2.1.2 Co-ordination agency (SNE) for the National System

The state secretaries' policy paper appointed the Federal Environment Agency to carry out tasks of the **national co-ordination agency** for emissions reporting (Single National Entity). The Federal Environment Agency's in-house directive (Hausanordnung) 11/2005 gave section "Emissions Situation" (FG I 2.6) responsibility for carrying out that function.

The Single National Entity's tasks include planning, preparing and archiving of inventories, describing inventories in the inventory reports and carrying out quality control and assurance for all important process steps. The *Single National Entity* serves as a central point of contact, and it co-ordinates and informs all participants in the *National System*. During the period 2003 to 2007, the Single National Entity has given priority to developing new data sources. Since 2008, its focus has been especially on improving existing data sources, and safeguarding their availability for the long term, by improving the **institutionalisation of the National System**. Furthermore, institutions that need to be integrated within the **National System** have been identified and are now being successively integrated (cf. Chapter 1.2.1.4). Other important work has had to do with implementing the Quality System for Emissions Inventories (cf. Chapter 1.2.2).

The Single National Entity has developed two key **instruments** for carrying out those tasks:

The Federal Environment Agency's *Central System on Emissions* (CSE) database is the national, central database for emissions calculation and reporting. It is used for central storage of all information required for emissions calculation (methods, activity data, emission factors). The CSE is the main instrument for documentation and quality assurance at the data level.

Both within and outside of the Federal Environment Agency, the Quality System for Emissions Inventories (QSE) provides the necessary framework for good inventory practice and for routine quality assurance. Established within the Federal Environment Agency in 2005 via in-house directive 11/2005, it comprises the processes necessary for continually improving the quality of greenhouse-gas-emissions inventories. The framework it provides includes defined responsibilities and quality objectives relative to methods selection, data collection, calculation of emissions and relevant uncertainties and recording of completed quality checks and their results (confirmation that objectives were reached, or, where objectives were not reached, listing of the measures planned for future improvement). Ongoing quality improvement in the framework of the QSE is supported by a database that serves as the repository for all tabular documents emerging from the national QC/QA process (QC/QA plan, checklists, lists of responsibilities, etc.).

The quality control procedures have been developed with the help of external experts, taking special account of the Federal Environment Agency's work structures, general guidelines for quality assurance and the *IPCC Good Practice Guidance*.

Since 2008, the QSE has been expanded to cover the entire National System. This has occurred via integration of additional authorities, institutions and inventory experts in the quality-management process – via specification of minimum requirements for data documentation, QC/QA and archiving. In addition, the procedure is designed to enable other organisations to build their own internal quality assurance systems on the basis of their existing structures. It thus addresses the comments provided in Paragraph 18 of the 2007 Initial Review. The QSE is described in detail in Chapter 1.2.2.

The manner in which these instruments interact in the framework of inventory preparation is shown in Figure 5.

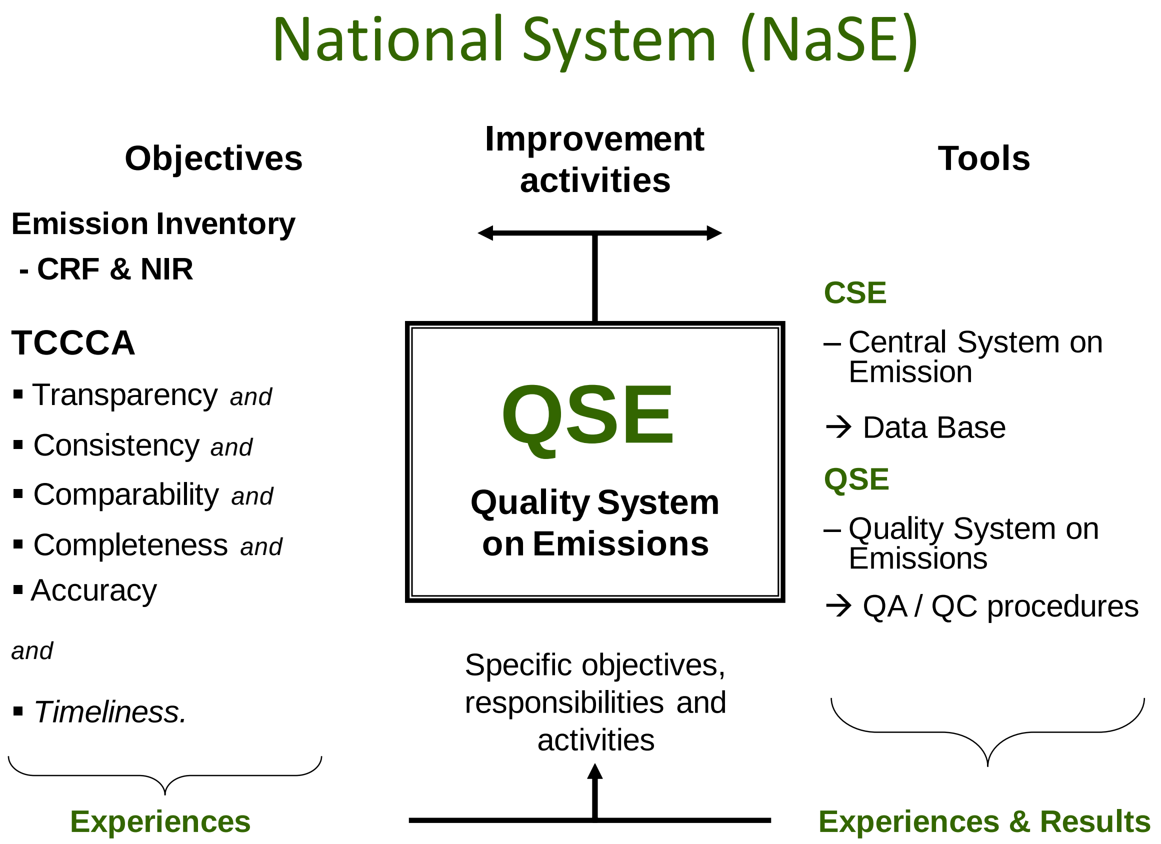


Figure 5: NaSE – Objectives and instruments

1.2.1.3 Working Group on Emissions Inventories, in the Federal Environment Agency

In its inventory work, and especially in work relative to emission factors, the Single National Entity receives significant support from other working units of the Federal Environment Agency. In addition, associations, companies and other independent organisations are integrated within the National System primarily via the Federal Environment Agency's specialised units that are responsible for the specific issues involved in each case.

In 2003, a *Working Group on Emissions Inventories* was set up to co-ordinate relevant work within the Federal Environment Agency; it liaises with all of the agency's employees who are involved in inventory preparation.

The Single National Entity convenes meetings of the working group twice a year. In addition, relevant members of the working group are expected to meet as necessary to discuss specific issues and to make the necessary in-house arrangements.

Necessary information is provided via the working group's events and through an intranet site, of the Single National Entity, devoted to emissions reporting.

To inform all of the Federal Environment Agency staff who participate in inventory preparation about any relevant changes, the Single National Entity also issues a monthly e-mail newsletter regarding the CSE database and a quarterly e-mail newsletter on the National System.

1.2.1.4 Co-operation by the Single National Entity with other federal institutions and with non-governmental organisations, in the framework of the National System

In the "National System" policy paper of 5 June 2007 on emissions reporting (which is presented in Chapter 22.1.1), the involved ministries have defined responsibilities relative to the various relevant source and sink categories.

Furthermore, the relevant resolution sets forth that involved federal ministries are to undertake suitable activities to close data gaps that fall within their areas of responsibility. As necessary, data gaps are to be closed via provision of pertinent data, or via relevant calculations. In some cases, required data may be provided by reliable third parties.

For some of the data streams moving to the Single National Entity from other federal institutions, special agreements have to be concluded between a) the relevant institution in the case in question and b) the Single National Entity.

With regard to **data provision by the *Federal Statistical Office***, relative to emissions reporting, a legal arrangement was made in 2009, in the framework of the 3rd SME Relief Act (Mittelstandsentlastungsgesetz 3; MEG 3), that enables provision of data, for purposes of emissions reporting, that are subject to statistical secrecy. On that basis, on 13 January 2010 an administrative agreement between the Federal Environment Agency and the *Federal Statistical Office* came into force that specifies data deliveries for emissions-reporting purposes. In anticipation of the agreement between the Federal Environment Agency and the *Federal Statistical Office*, data was already provided in 2009 on the basis of the agreement, however. The agreement provides for annual reviews of the Federal Environment Agency's data requirements. The list of provided data was revised for the first time in June 2010. No changes in data requirements emerged in 2011.

Furthermore, the "National System" policy paper of 5 June 2007 on basic principles for emissions reporting assigns responsibility for the area of agriculture and LULUCF to the BMELV. This includes reporting on agriculture and on LULUCF, for purposes of the UN Framework Convention on Climate Change and the Kyoto Protocol (including reporting pursuant to Art. 3.3 KP). In addition, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) is responsible for reporting crediting, as opted for by state-secretary resolution of 22 December 2006, of forestry activities pursuant to Art. 3 (4) KP. That responsibility includes pertinent required data collection, emissions calculation and provision for reporting (in CRF tables), and for the relevant chapters in the National Inventory Report.

Via a directive of 29 August 2007, the Federal Agricultural Research Institute (FAL) has been commissioned to carry out this task within the portfolio of the BMELV. Following a restructuring of the BMELV's departmental research, and with effect as of 1 January 2008, responsibility for this task has been transferred to the **Johann Heinrich Von Thünen Institute (vTI)**.

On 13 February 2008, the vTI concluded an agreement with the Federal Statistical Office on provision of emissions data on the basis of agricultural statistics. In addition, a research and development agreement between the vTI and the *Association for Technology and Structures in Agriculture* (KTBL) has been in place since 7 July 2009. That agreement specifies the necessary supporting work for emissions reporting.

In keeping with an ERT requirement that emerged in the 2010 In-Country-Review, the BMELV and vTI extensively revised the concept for preparation of emissions and carbon inventories in source and sink groups 4 and 5 (agriculture and forestry), including the quality-assurance concept KP-LULUCF (Arts. 3.3. and 3.4 KP).

Furthermore, a working group on emissions reporting has been established within the vTI, to serve as liaison to the Single National Entity within the Federal Environment Agency. That working group also has responsibility for planning and QC/QA for source categories CRF 4 and CRF 5. The establishment of the new body addresses the reference provided in Paragraph 16 of the 2007 Initial Review. In addition, an action plan has been prepared that addressed the reporting problems identified by the ERT in the 2010 Review and describes how the problems are to be eliminated. The action plan is included in Chapter 19.5.2.7 in the NIR 2011.

Responsibility for co-ordination of the Working Group on Emissions Reporting lies with the vTI's Institute of Agricultural Climate Research (AK). Responsibility for reporting on agriculture and LULUC lies with the same institute, while responsibility for reporting on forests pursuant to the Convention and Kyoto Protocol Arts. 3.3 and 3.4 lies with the vTI's Institute of Forest Ecology and Forest Inventory (WOI).

The working group on emissions reporting at the vTI is integrated within the National System via direct (inter-departmental) participation within the Single National Entity's communications structures. The working group at the vTI is also part of the working group on emissions inventories (Arbeitskreis Emissionsinventare - AKEI) within the Federal Environment Agency.

At least twice per year, additional co-ordinating meetings take place between the working group at the vTI and the Single National Entity, for purposes of co-ordination and information-provision - for example, with regard to inventory improvements and research projects.

Involvement of economic associations, companies and other independent organisations is achieved primarily via those departments of Federal Environment Agency divisions I and III that are responsible for pertinent concrete issues. The *Single National Entity* supports the departments in discussion of reporting requirements and in determination of requirements for data-sharing by associations. The data flows are continually reviewed by the Single National Entity and, where necessary, are safeguarded by suitable agreements between the Single National Entity and associations / business enterprises.

The Working Group on Energy Balances (AGEB) is contractually obligated, via the Federal Ministry of Economics and Technology (BMWi), to provide Energy Balances. Use of a co-ordinated schedule ensures that a provisional Energy Balance for the last reported year is prepared on time, and is transmitted to the Federal Environment Agency, by 31 July of each year, for purposes of inventory preparation.

In 2006, a sample agreement was prepared for inclusion of non-governmental agencies within the National System. That agreement is used to involve stakeholders, under binding terms, within preparation of inventories. The sample agreement is adapted to the various data suppliers' own requirements and needs as is necessary. In July 2009, the Federal Ministry of Economics and Technology (BMWi), and the Federal Environment Agency, concluded an agreement with the German Chemical Industry Association (VCI) and German producers regarding data provision in the source categories Ammonia (2.B.1) and Nitric acid (2.B.2). In addition, agreements on data provision were reached with producers of adipic acid (2.B.3) located in Germany. Furthermore, an association agreement was concluded with the VDD industry association for bitumen paper and bitumen roof sheeting relative to the source category Bitumen for roof sheeting (2.A.5). Since 2009, data for the aforementioned source categories for emissions reporting have been provided on the basis of these agreements. In addition to ensuring long-term data availability, the agreements with the VCI and the VDD associations have led to considerable improvements of data quality in the relevant source categories. With these efforts, the Single National Entity is addressing the reference provided in Paragraph 18 of the 2007 Initial Review.

In June 2011, the Single National Entity, acting with the support of the responsible ministry, the Federal Ministry of Economics and Technology (BMWi), entered into a cooperation agreement with the Wirtschaftsvereinigung Stahl German steel industry association. That agreement had become necessary because the Federal Statistical Office had discontinued its data collection and publication activities for Fachserie 4 Reihe 8.1 (iron and steel statistics) as of 31 December 2009, due to the expiration of the pertinent legal basis (Raw materials act; Rohstoffstatistikgesetz). That move had considerably reduced the availability of the bases for calculations in that area, and it created a significant gap in the pertinent data streams. The new cooperation agreement closed that gap. The agreement assures data provision by both member companies of the assocation and by non-member companies.

Since the end of 2006, the Single National Entity has been working with **EUROCONTROL, the European Organisation for the Safety of Air Navigation**, on an agreement for provision of air-transports data. That agreement is to be concluded in the form of an agreement, under international law, between the Federal Republic of Germany and EUROCONTROL. A draft of the agreement was sent to EUROCONTROL in 2008. EUROCONTROL did not confirm the draft, however. Since a number of other European countries faced similar problems, the European Commission concluded an agreement with EUROCONTROL for all Member States. While in October 2011 EUROCONTROL provided a first delivery of data on that basis, it was not possible to use the data for the 2012 report. Details on use of air-transports data of EUROCONTROL are provided in Chapter 3.2.10.1.

1.2.1.5 Directive 11/2005 of the Federal Environment Agency

In 2005, via its *in-house directive (Hausanordnung) 11/2005*, the Federal Environment Agency established a *Quality System for Emissions Inventories* (QSE) (cf. Chapter 1.3.3.1), within the Agency. The QSE provides the necessary framework for compliance with good inventory practice and for execution of routine quality assurance. This system is structured in accordance with the requirements of the *IPCC Good Practice Guidance*, and it has been adapted to national circumstances in Germany and to the internal structures and procedures of the Federal Environment Agency, the reporting institution. The in-house directive (Hausanordnung 11/2005) issues binding provisions on relevant competencies within the Agency, lists deadlines for the various inventory-preparation steps and describes the necessary relevant review actions for purposes of quality control / quality assurance.

The directive has fulfilled requirements, pursuant to Paragraph 10 (a) of the *Guidelines for National Systems*, for specification of relevant procedures, and for definition, pursuant to Paragraph 12 (c), of specific responsibilities at the Agency level.

1.2.1.6 Binding schedule in the framework of the National System

The binding schedule for preparation of emissions inventories and of the NIR is announced to all relevant internal and external stakeholders via the Federal Environment Agency's intranet site and via publication within the NIR itself:

11 May	The Federal Environment Agency's national co-ordinating agency (Single National Entity) requests responsible experts to submit data and report texts
31 July	Delivery of energy data of the Working Group on Energy Balances (AGEB), of statistical data of the Federal Statistical Office and of data provided under agreements with associations and companies, where such data serve as the basis for further calculations
by 1 September	Deliveries of ready-to-use inventory data from the Federal Environment Agency and from external institutions of the NaSE
as of 2 September	Validation / discussion of deliveries by responsible experts and quality managers, taking account of review results
by 1 October	Deliveries of ready-to-use text blocks, for the National Inventory Report, from the Federal Environment Agency and from external institutions of the NaSE
as of 1 October	Preparation of CRF time series and of national trend tables; final editing by the Single National Entity within the Federal Environment Agency
8 November	In-house consultations at the Federal Environment Agency
as of 15 November	Final quality assurance by the QSE/CSE/NIR co-ordinator
25 November	Report of the Single National Entity to the BMU, for commencement of inter-ministerial co-ordination relative to the CRF data and the National Inventory Report
20 December	Approval via departmental co-ordination (initiated by the BMU)
2 January	Final editing by the Federal Environment Agency's national co-ordinating agency (Single National Entity)
15 January	Report (CRF and certain parts of the NIR) goes to the European Commission (in the framework of the CO_2 Monitoring Mechanism) and to the European Environment Agency
15 March	Report (corrected CRF and complete NIR) goes to the European Commission (in the framework of the CO_2 Monitoring Mechanism) and to the European Environment Agency

15 April	Report goes to the FCCC Secretariat
May	Initial check by the FCCC Secretariat
June	Synthesis and assessment report I (by the UN FCCC Secretariat)
August	Synthesis and assessment report II (country-specific; by the UN FCCC Secretariat)
September - October	Inventory review by the UN FCCC Secretariat

1.2.2 Overview of inventory planning

Inventory preparation draws on the expertise of *research institutions*, via execution of research projects in the UFOPLAN (environmental research plan) framework. This occurs via work on specific issues, and it takes place via overarching projects, which primarily support a) harmonisation of individual results, for the overall inventory, as well as b) identification and closure of gaps in surveys of emission-relevant activities. In each of the UFOPLANs for the 2002-2009 period, the Single National Entity had a global project on *updating emissions-calculation methods*, a framework for initiating measures for continuous inventory improvement. In 2010 and 2011, measures for continuous inventory improvement were financed completely via the budget title for expert services. The Federal Environment Agency promised to provide the Single National Entity with funding, from the budget title for expert services (Title 526 02, Chapter 1605), for short-term contracting for purposes of inventory improvement under the responsibility of the Agency. The funding, provided as of 2005, in the interest of emissions reporting, comes in addition to the research funding available from the UFOPLAN.

1.2.3 Overview of inventory preparation and management, including overview of supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

The emissions-reporting process is a regular, annual process. Since it is a decentralised process, carried out by a range of different persons, it can differ for different parts of the inventory. Prior to the introduction of the QSE (in 2005), this process was intensively studied and analysed. As a result of that work, within the overall emissions-reporting process, the QSE differentiates the following main processes, which are described in detail in Chapter 1.3.2:

- Definition of the bases for calculation,
- Data collection,
- Data processing and emissions calculation, and
- Report preparation.

These main processes are broken down into sub-processes (cf. Figure 6).

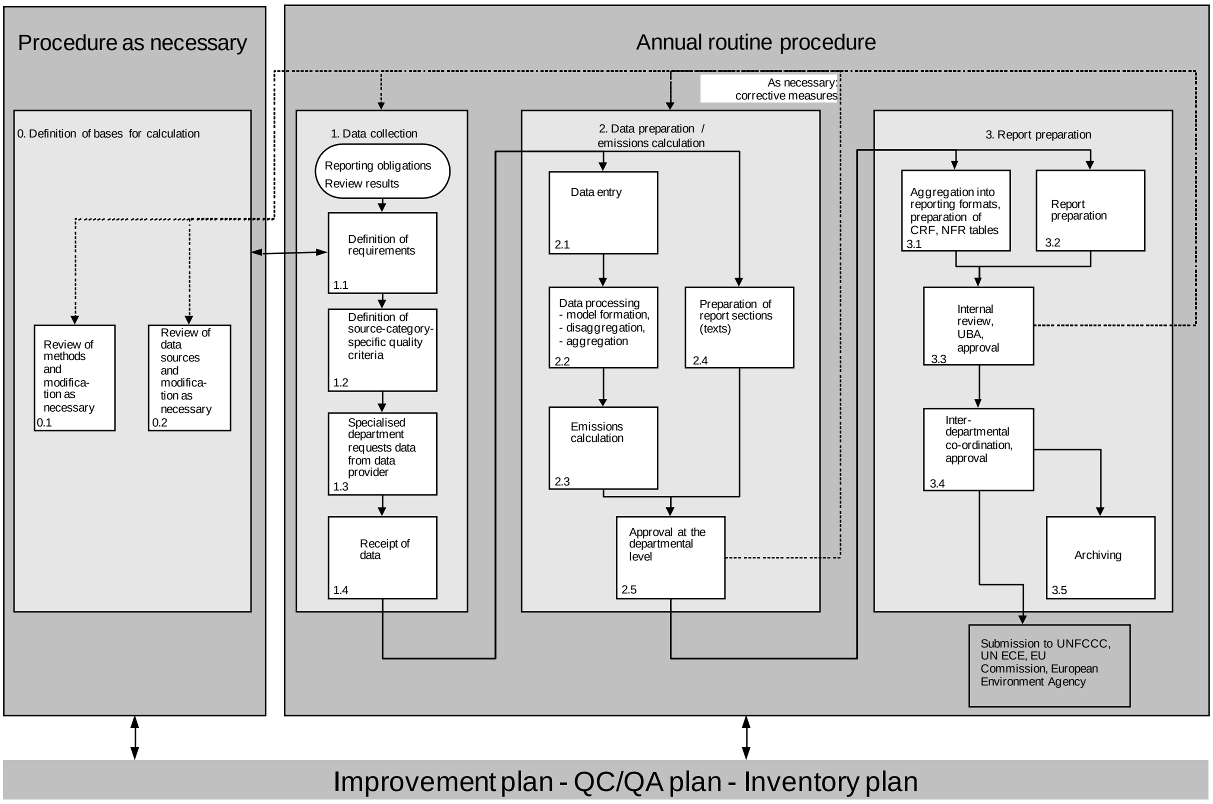


Figure 6: Overview of the emissions-reporting process

Experience has shown that workflow in the inventory planning and preparation process can affect inventory quality, i.e. that the order in which relevant steps are taken is important. That is one of the reasons why the inventory-preparation process is closely tied to quality assurance and control measures. Suitable QC/QA measures have thus been assigned to each sub-process, to ensure that quality assurance not only safeguards the quality of inventory data in its final form, but also safeguards such quality on the pathways leading to that final form. This, in turn, makes it possible to carry out periodical internal evaluations of the inventory-preparation process pursuant to paragraph 15 (d) of the *Guidelines for National Systems*.

The process, including QC/QA measures, fulfills the requirements of paragraphs 14 (a) to (g), with regard to inventory preparation, of the *Guidelines for National Systems*.

The workflow for inventory preparation is described in detail in Chapter 1.3.

The reporting processes address all requirements pursuant to Article 7 of the Kyoto Protocol.

1.3 Inventory preparation

As the overview in Chapter 1.2.3 shows, inventory preparation functions in accordance with a regular, annual scheme. The processes for preparation of greenhouse-gas inventories, KP-LULUCF inventories and National Inventory Reports, and for execution of quality control and quality assurance measures, are very closely linked.

At the same time, the upstream processes for inventory preparation (cf. Chapter 1.3.1.1), including definition of bases for calculation (cf. Chapter 1.3.2.1), and data collection, processing and storage (cf. Chapter 1.3.2), remain distinct from those for quality control and quality assurance (cf. Chapter 1.3.3).

1.3.1 Greenhouse-gas and KP-LULUCF inventories

The upstream processes of inventory preparation and definition of the bases for calculation are identical for greenhouse-gas inventories and for KP-LULUCF inventories.

1.3.1.1 Preliminary/upstream processes

Apart from the sub-processes for emissions reporting, as outlined in Figure 6, certain upstream (preliminary) processes are carried out – in each case, between a pair of emissions-reporting cycles.

The following sub-processes are considered preliminary/upstream processes:

- Continuous review and assurance of data streams from data suppliers to the Federal Environment Agency, via improvement of institutionalisation of the National System;
- Implementation of improvements in inventory planning and inventory preparation;
- Determination of key categories (pursuant to Tier 1, in keeping with Chapter 7.2 of the *IPCC Good Practice Guidance*);
- Calculation and aggregation of uncertainties relative to emissions, using Monte Carlo simulation (pursuant to Tier 1 or Tier 2, in keeping with the *IPCC Good Practice Guidance*);
- Expanded identification of key categories, via Monte Carlo simulation (pursuant to Tier 2, in keeping with Chapter 6.4 of the *IPCC Good Practice Guidance*).

1.3.1.1.1 Tasks of the National System

The National System builds on existing data streams, and it provides for suitable measures to assure long-term data provision where such assurance is lacking (cf. Chapter 1.2.1.2). Consequently, data streams continually have to be reviewed between pairs of reporting cycles.

Where voluntary commitments expire, discussions have to be carried out with the relevant data suppliers in order to secure the commitments' renewal. Where continued data provision is not assured, relevant commitments or co-operation agreements have to be obtained. In cases of any doubt, relevant legal provisions relative to data provision have to be reviewed and implemented.

Existing agreements have to be adapted as necessary to new circumstances and reporting requirements (for example, to changes in reporting procedures). Such efforts help assure the consistent high quality of the National System and the inventory preparation process.

Changes and improvements in the National System, during the current reporting cycle, are described in Chapter 13.

1.3.1.1.2 Implementation of improvements in inventory planning and inventory preparation;

Paragraphs 13 and 15(d) of the Guidelines for National Systems (Decision 19/CMP.1) obligate all Annex I countries to strive for continual improvement of inventories and inventory planning.

Wherever possible, the required improvements identified in quality control and quality assurance, and the results of reviews, are implemented between reporting cycles.

A detailed description of the quality control and quality assurance procedures is provided in Chapter 1.6. The improvements achieved for the present report are described in the relevant source-category chapters.

1.3.1.1.3 Determination of key categories (pursuant to Tier 1)

In order to be able to focus the many and detailed activities and capacities required for inventory preparation and improvement on the principal source categories of the inventory, the IPCC has introduced the definition of a "key category". Key categories are source/sink categories that play an especially prominent role in the national inventory because their emissions/removals have a significant influence on the total emissions of direct greenhouse gases – because of their absolute quantities, because of their contribution to the emissions trend over time, because of their uncertainties, or because they have been assessed by an expert as an important category.

The Single National Entity identifies key categories once per year, prior to the emissions-reporting process. Whereas in the reporting framework results are reported for year x, they cannot be taken specifically into account until inventory preparation for the year x+1. A source category's designation as a key category helps decide what calculation method (Tier approach) must be used for the category and, as a result, how detailed emissions modelling for the source category must be. In addition, the key-source / key-category selection process is used to identify any source categories to which priority must be given in inventory improvement.

The *IPCC Good Practice Guidance* (2000) specifies the methods to be applied in identifying key categories. These methods identify the relevant key categories with the help of analysis of the inventory for one year with regard to emissions levels for individual source categories (Tier 1 level assessment), time-series analysis of inventory data (Tier 1 trend assessment) and detailed analysis of inventory data with error evaluation (Tier 2 level and trend assessment with consideration of uncertainties).

The key categories have been defined by applying two Tier 1 procedures, Level (for the base year and for the last year reported) and Trend (for the last year reported, as compared to the base year), to German greenhouse-gas emissions. In keeping with IPCC provisions, analyses have taken account of both emissions from sources and removals of greenhouse gases in sinks.

1.3.1.1.4 Calculation and aggregation of uncertainties relative to emissions

Uncertainties are a basic component of emissions inventories; an emissions inventory's uncertainties are determined in order to quantitatively assess the inventory's accuracy. While uncertainties are determined in connection with data gathering, and thus are part of the "data collection" section of the emissions-reporting process, they can be aggregated only after an inventory – or the pertinent emissions-reporting cycle – has been completed.

In calculation and aggregation of uncertainties, uncertainties for activity data and emission factors, which are normally estimated by experts at the lowest source-category level of the CSE, are converted into uncertainties for emissions and then aggregated. Uncertainties pursuant to Tier 1 are aggregated once per year, at the end of the report-preparation cycle for the current report year. Every three years, uncertainties are additionally determined pursuant to the Tier 2 method.

In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 1 method. For uncertainties determination, the individual uncertainties have been estimated, wherever possible to date, by data-supplying experts of the relevant Federal Environment Agency specialised sections and by external institutions.

1.3.1.1.5 Expanded determination of key categories

Aggregated uncertainties serve as a basis for expanded identification of key categories (Tier 2 key-categories determination).

1.3.2 Data collection, processing and storage, including data for KP-LULUCF inventories

1.3.2.1 Definition of bases for calculation

Selection and review of, and (where necessary) changes in, the calculation methods used to determine emissions affect the entire emissions-reporting process. For this reason, the main process "determination of the bases for calculation" must begin with review of the suitability of the methods to be used. The *IPCC Good Practice Guidance* specifies, via use of decision trees, what methods are to be used for the various source categories. In each case, such methods selection depends on whether the group in question is a key category or not. Any use of different – country-specific – methods, instead of the prescribed methods, must be justified in the NIR. In each case, an outline of why the method in question is of equivalent or higher value is to be provided, along with clear documentation.

Another factor that is critical to the success of the overall process is **selection and review of, and (where necessary) changes in, data sources**, since the quality of results of all downstream processes (data preparation, calculation, reporting) cannot be better than that of the primary data used. Data sources may be oriented to the activity data, emission factors or emissions for/of a specific source category. In many cases, the data sources used have been relied on for a number of years. It can become necessary to select new data sources – for example, as a result of required changes in methods, of the elimination of an existing data source, of a need for additional data or of findings from quality checks of previously used data sources.

The suitability of a given data source depends on various criteria. These include:

- Long-term availability,
- Institutionalisation of data provision,
- Good documentation,
- Execution of quality assurance and control measures, by the persons/organisations providing data,
- Identification of uncertainties,
- Representative nature of the data in question, and
- Completeness of the expected data.

In each case, it is vital that the reasons for choosing a particular data source be documented and, where the data source has significant deficits, that suitable measures for improving the data be planned.

Providers of data must always be given requirements relative to quality control, quality assurance and documentation; where research projects are commissioned, this requirement is particularly relevant, since the Federal Environment Agency, as the customer for such services, must be able to influence such projects.

1.3.2.2 Data collection

Data collection and documentation take place under the responsibility of the relevant experts. One way of collecting data is to evaluate official statistics, association statistics, studies, periodicals and third-party research projects. Other ways of obtaining data include carrying out own research projects, applying personally available information and exchanging data via relevant Federal/Länder channels. Often, work results obtained by other means are also reused for the purposes of emissions reporting.

Data collection comprises the following steps:

- Definition of requirements,
- Determination of the source-category-specific quality criteria for the data,
- Requesting of data from data providers (carried out by the relevant experts' group), and
- Receipt of data.

In each case, the National Single Entity (national co-ordinating agency) also requests inventory input from the experts responsible for the source category in question, via the experts' superiors. A master file, specifying the structure for such input, is provided for NIR preparation. The requirements for later data input are provided by the relevant CSE (ZSE) specifications (direct entry or fill-in of the import format). Reporting requirements (including pertinent QC/QA measures), along with the results of all inventory reviews, the databases for the various specific source categories and the current results of key-category identification, are all communicated to the responsible experts via informational events held by the *Federal Environment Agency's Working Group on Emissions Inventories*, via the Federal Environment Agency's intranet and share-point sites for emissions reporting and via an electronic inventory description (cf. Chapter 1.3.3.1.4). On this basis, responsible experts **define requirements** relative to data sources and to calculation methods.

Such requirements influence the upstream process of defining the bases for calculation (review and selection of methods and data sources) – a process which always takes place when requirements have not yet been fulfilled or have changed.

Before any third parties begin with data collection – after the requirements pertaining to data sources and methods have been defined – the **source-category-specific quality criteria for such third-party data should be defined**, in order to support the QC process on the data level.

When a responsible expert **requests data** from a third party able to supply data, the expert is expected to accompany his or her request with a description of the amount of data expected from the prospective data supplier, of the relevant data-quality requirements and of the relevant data-documentation requirements. Upon **receipt of data**, the data are checked for completeness, compliance with quality criteria and currentness. Data validation is carried out by the relevant expert.

1.3.2.3 Data preparation and emissions calculation

The process of data preparation and emissions calculation comprises the following steps:

- Data entry,
- Data preparation (model formation, disaggregation, aggregation),
- Calculation of emissions,
- Preparation of report sections (texts), and
- Approval by the relevant experts.

Report texts are prepared along with the time series for activity data, emission factors, uncertainties and emissions. As a result, the term "data" is understood in a broad sense. In addition to number data, time series, etc., it also includes contextual information such as the sources for time series, and descriptions of calculation methods, and it also refers to **preparation of report sections** for the NIR and documentation of recalculations.

Considerable amounts of **data entry and processing** (processing of data, and emissions calculation) take place in the CSE. This considerably enhances transparency and consistency, and it opens up the possibility of automating required data-level quality-control measures in the CSE (such as checking of orders of magnitude and of completeness, and specification of checking parameters in CalQlator). In cases that lend themselves to such automation, certain QC measures then do not have to be carried out manually. At the same time, plausibility cross-checks, with simplified assumptions, should be applied to results of calculations with complex models.

After all checks have been carried out, and the relevant parties have been consulted where necessary, the **emissions are calculated** in the CSE by means of an automated procedure, based on the following principle:

activity data * emission factor = emission

If upstream calculation routes are also stored in the CSE, these calculations are initiated first, before the actual calculation of emissions takes place.

In each case, the relevant expert responsible for QC also has responsibility for **issuing expert-level approvals**, for written texts and for calculation results, prior to any further use of such texts and results by the Single National Entity. Such issuance normally takes place in connection with transmission to the Single National Entity, and it is carried out via approval of completed QC/QA checklists.

1.3.2.4 Report preparation

Report preparation includes the following steps:

- Aggregation of emissions data for the national trend tables and reporting formats, preparation of data tables for the NFR, export / import of XML files into the CRF reporter,
- Compilation of submitted report texts to form a report draft (NIR), and editing of the complete NIR,
- Internal review of the draft (national trend tables and NIR) by the Federal Environment Agency, followed by approval as appropriate,
- Handover to the BMU, for interdepartmental co-ordination, leading to approval by the co-ordinating committee, followed by the final steps of

- Handover to the UNFCCC Secretariat, the EU Commission and the UNECE Secretariat, and
- Archiving.

Following complete preparation of data, report sections and QC/QA checklists by the responsible experts, and transmission of those materials to the Single National Entity, the materials are reviewed by source-category-specific, specialised contact persons at the Single National Entity, on the basis of a QC checklist. The results of this review are then provided to the relevant responsible experts, to enable these experts to revise their contributions (if necessary, following suitable consultation) accordingly.

Before emissions data can be transferred into the report formats for the Framework Convention on Climate Change (CRF = Common Reporting Format), the Kyoto Protocol and the UN ECE Geneva Convention on Long-range Transboundary Air Pollution (NFR = New Format on Reporting), emissions data from CSE time series (in the data-collection format) **must be aggregated** into the CRF/NFR source-category **report formats**. This is accomplished via hierarchical allocation within the CSE, a process that, in Annex 3, is described in detail for the various key categories. Where no changes with respect to the previous year have occurred, the aggregations are carried out automatically.

Following calculatory aggregation, activity data and emissions are read, via export in XML-file form, into the CRF reporter, which automatically prepares the IPCC CRF reporting tables. Nonetheless, quality control still has to be carried out to ensure that the emissions inventory and the CRF-Reporter tables agree with respect to relevant values and to the implied emission factors calculated by the CRF Reporter. Furthermore, suitable explanatory remarks have to be provided for any recalculations and notation keys.

CO_2 equivalents for greenhouse gases are calculated in accordance with Art. 20 of the *IPCC Guidelines on Reporting and Review* (FCCC/CP/2002/8), on the basis of the GWP published in the *Second Assessment Report* and listed in the table below, which are based on effects of greenhouse gases out to a 100-year time horizon.

Table 3: Global Warming Potential (GWP) of greenhouse gases

Greenhouse gas	Chemical formula	1995 IPCC GWP
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbons (HFC)		
HFC-23	CHF_3	11700
HFC-32	CH_2F_2	650
HFC-41	CH_3F	150
HFC-43-10mee	$C_5H_2F_{10}$	1300
HFC-125	C_2HF_5	2800
HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1000
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1300
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3800
HFC-227ea	C_3HF_7	2900
HFC-236fa	$C_3H_2F_6$	6300
HFC-245ca	$C_3H_3F_5$	560
Perfluorocarbons (PFC)		
Perfluoromethane	CF_4	6500
Perfluoroethane	C_2F_6	9200
Perfluoropropane	C_3F_8	7000
Perfluorobutane	C_4F_{10}	7000
Perfluorocyclobutane	c-C_4F_8	8700
Perfluoropentane	C_5F_{12}	7500
Perfluorohexane	C_6F_{14}	7400
Sulphur hexafluoride		
Sulphur hexafluoride	SF_6	23900
Additional Greenhouse Gases		
HFC 245fa	*$C_3F_5H_3$ ($CF_3CH_2CHF_2$)*	*950*
HFC 365mfc	*$C_4F_5H_5$ ($CF_3CH_2CF_2CH_3$)*	*890*
NF_3	*NF_3*	*8000*

Source (except for entries in italics): FCCC/CP/2002/8, p.15

At the same time, the report co-ordinator **compiles the checked report texts to produce the draft** of the NIR.

Review and approval, **within the Federal Environment Agency**, of the completed report tables and the NIR, and of the inventory plan to be included in future, is provided via co-signing in the framework of the Federal Environment Agency's **internal co-ordination process**. Then, the materials are **forwarded** to the BMU, for the second approval phase within the framework of **interdepartmental co-ordination**. In a concluding step, the co-ordinating committee approves the report tables and the NIR for submission to the UNFCCC Secretariat. The ministry arranges for translation of the NIR and for its **submission to the UNFCCC Secretariat**.

The data tables and the related NIR, in the version provided for ministerial co-ordination, are then transferred onto a CD and archived with clear identification information. The content of the CSE database used for calculation purposes is likewise copied and archived. The final version submitted to the Secretariat of the Framework Convention on Climate is also **archived**.

1.3.3 Procedures for quality assurance and quality control (QA/QC), and detailed review of greenhouse-gas and KP-LULUCF inventories

1.3.3.1 The Quality System for Emissions Inventories

The QSE takes account of provisions of the *IPCC Good Practice Guidance*, of national circumstances in Germany and of the internal structures and procedures of the Federal Environment Agency (UBA), the reporting institution. The QSE's procedures are flexible enough to be able to routinely incorporate future changes in requirements. The QSE's scope of application comprises the entire emissions-reporting process.

The QSE covers all participants of the NaSE. Within the Federal Environment Agency, the QSE has been made binding via the agency's in-house directive (UBA-Hausanordnung) 11/2005 (cf. Chapter 1.2.1.5). Details regarding assurance of the QSE's binding nature for other NaSE participants are provided in Annex 22.1.1.

1.3.3.1.1 Minimum requirements pertaining to a system for quality control and assurance

The requirements pertaining to the system for quality control and quality assurance (QC/QA system) and to measures for quality control and quality assurance are defined primarily by Chapter 8 of the *IPCC Good Practice Guidance*.

From those provisions, the Federal Environment Agency has derived its own "General minimum requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting" (cf. Chapter 22.1.2.1). Other National System participants adopted the minimum requirements after representatives of the participating federal ministries approved them in the framework of the National Co-ordinating Committee for the National System of Emissions Inventories (cf. Annex Chapter 22.1.1).

Further information regarding the Federal Environment Agency's necessary organisational measures for implementing these requirements is provided in the following chapters and in a complementary section in the Annex, 22.1.2.1.11.

1.3.3.1.2 Start-up organisation for establishing the Quality System for Emissions Inventories

Within the QSE framework, a concept for a start-up organisation was developed that defines binding responsibilities, for the Federal Environment Agency, for implementation of the necessary QC and QA measures. The defined roles and responsibilities have the purpose of facilitating effective information exchange and directive-conformal execution of QC and QA (cf. Table 4).

Table 4: QSE – Roles and responsibilities

Role	Task	Responsible
Responsible expert at the operational level (FV)	Data collection, entry and calculation, in keeping with the prescribed methods Definition of source-category-specific quality and review criteria Execution of QC measures Decentralised archiving of source-category-specific inventory information	All staff appointed by the head (FGL)
QC/QA section representative (QKV)	QC for data and report sections delivered to the Single National Entity (SNE) Approval of report sections Ensuring that necessary inventory work, QC measures and documentation are carried out at the operational level Definition of specific sectional emissions-reporting responsibilities, and follow-up to ensure they are properly carried out	All responsible heads (Federal Government and the Länder)
Specialised contact person (source-category-specific) in the SNE (FAP)	Facilitation of specialised and technical support (inventory work and reporting) Independent QC/QA for supporting work of the various sections	An appointed staff member of the Single National Entity (SNE)
Report co-ordinator (NIRK)	Co-ordination of supporting textual work, preparation of the NIR from the various relevant contributions, overarching QC and QA for the NIR	An appointed staff member of the Single National Entity (SNE)
CSE co-ordinator (ZSEK)	Overarching QC and QA throughout the entire inventory process Ensuring the integrity of databases Emissions reporting and data aggregation into report formats	An appointed staff member of the Single National Entity (SNE)
QC/QA co-ordinator (QSEK)	Overarching QC and QA throughout the entire reporting process Maintenance and further development of the QSE Management and updating of the QC and QA plans, QC checklists and QSE manual Management and updating of the improvement plan, and management of relevant adoption in the inventory plan	An appointed staff member of the Single National Entity (SNE)
NaSE co-ordinator (NaSEK)	Ensuring of on-time, requirements-conformal reporting Initiation of overarching measures from the inventory plan Selection of institutions and collection of relevant informational materials and legal agreements Ensuring that all inventory information is archived, carrying out central archiving of inventory information Preparation of execution and post-processing of inventory reviews	An appointed staff member of the Single National Entity (SNE)

1.3.3.1.3 Organisation for establishing the Quality System for Emissions Inventories

Procedures for QC/QA measures in the QSE are oriented to the emissions-reporting process described in Chapter 1.2.3. At the same time, quality management is directly linked with the various steps in the inventory process. Suitable QC measures, assigned to the various process players, have been allocated to each step of the inventory-preparation process (cf. Figure 7).

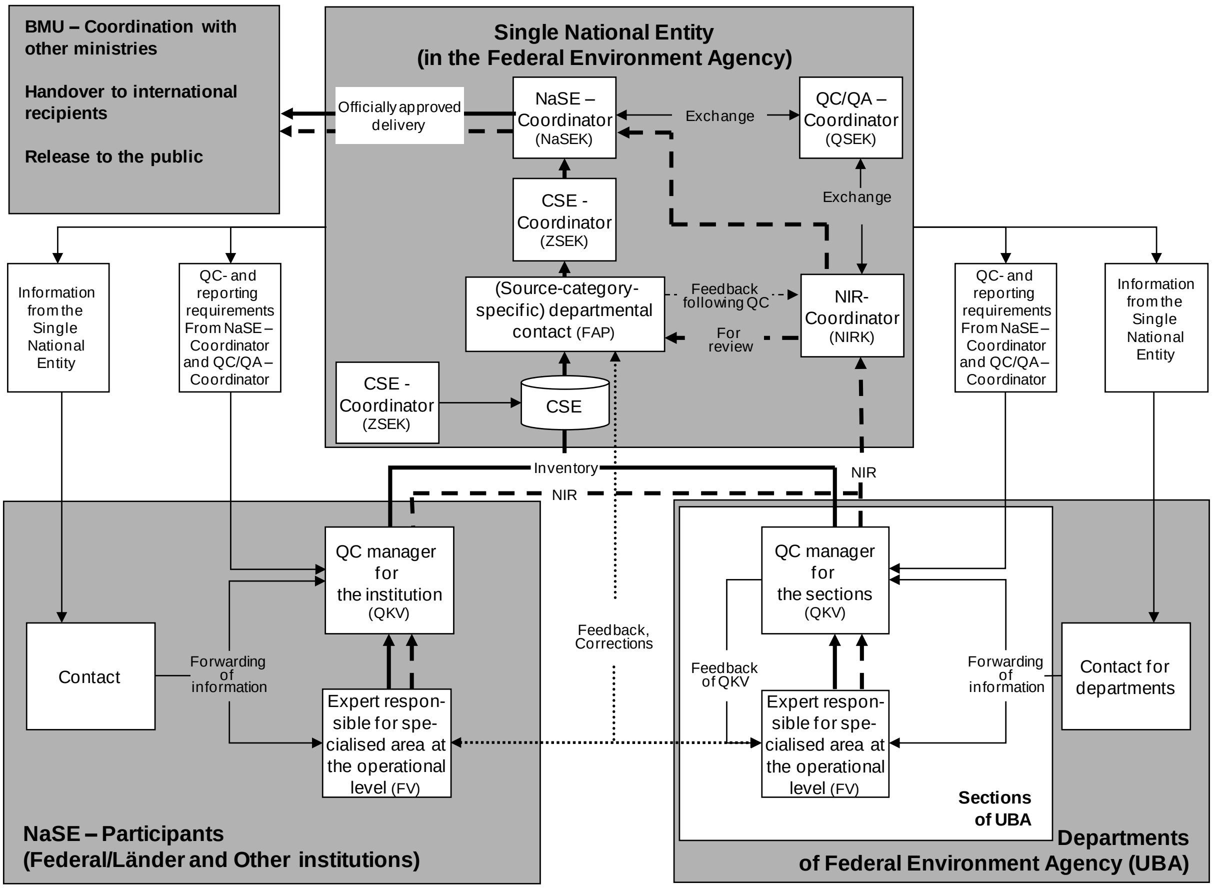


Figure 7: QSE – Roles, responsibilities and workflow

The required quality reviews pursuant to Paragraph 14 (g) of the *Guidelines for National Systems* are provided, in the form of quality checklists and along with data requirements, to the FV, QKV, FAP and NIRK (cf. Table 4). They are completed in the course of the relevant supporting work.

1.3.3.1.4 Documentation in the Quality System for Emissions Inventories

The requirements pertaining to the execution, description and documentation of QC/QA measures, as formulated in connection with the minimum requirements for a QC/QA system (cf. Chapter 22.1.2.1) are largely being fulfilled in conjunction with production of the pertinent inventory contributions. For the QSE, a documentation concept was developed that represents all such measures and related actions in an integrated form tailoured to the specific parties and tasks concerned. The various components of such documentation are shown in Figure 8.

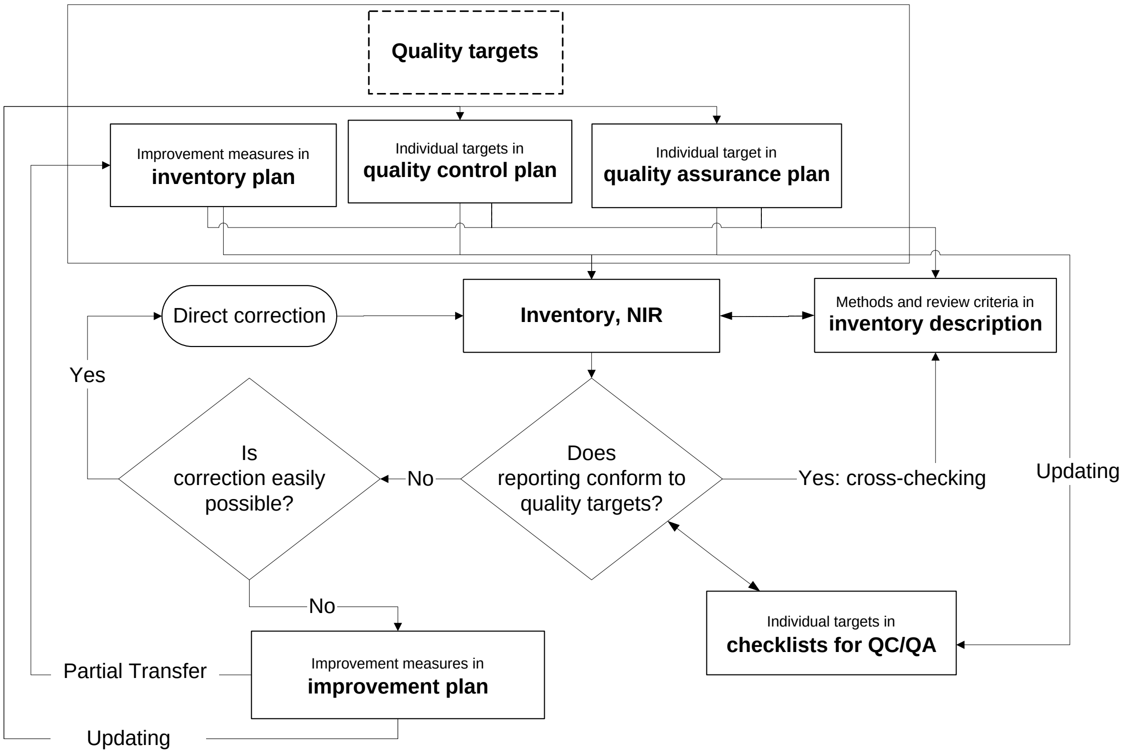


Figure 8: NaSE & QSE – Control and documentation

A general description of the **quality targets** is provided in the QSE handbook; the description is derived from the *IPCC Good Practice Guidance*[12]. In addition, individual operational objectives, relative to quality control and quality assurance, have to be derived for the various source categories from comparison of the requirements from the *IPCC Good Practice Guidance*, the results of independent inventory review and assessment of inventory realities.

Pursuant to the IPCC Good Practice Guidance requirements and Paragraph 12 (d) of the *Guidelines for National Systems*, the necessary QC/QA measures for emissions reporting should be summarised in a QC/QA plan. Such a QC/QA plan is to serve the primary purpose of organising, planning and monitoring such QC/QA measures. To permit transparent, effective control of execution and monitoring of measures for achieving these objectives, the measures are set forth in a **quality control plan (QC plan)** and a **quality assurance plan (QA plan)** with respect to specific roles – and, if necessary – specific source categories. Quality assurance objectives may be focused on the inventory, the reporting process or the QSE itself. Furthermore, the quality assurance plan includes scheduling of quality assurance measures to be performed by independent, external third parties. Both plans may be understood as sets of specifications.

As to their document structure, the QC and QS plans are combined with the **checklists for quality control and quality assurance**, which are used to review and document successful execution of quality controls. In this context, quality checks are actually defined not as checks but as quality objectives; in each case, either compliance with the objectives must be confirmed or non-compliance must be justified. Such QC/QA checklists are to be filled out by

[12] For relevant explanations / definitions, see also Annex 3 (Glossary) of the *IPCC Good Practice Guidance*

NaSE participants[13] along with inventory preparation. They are designed to provide information about the quality of the data and methods on which the inventory is based. The first time the Federal Environment Agency carried out systematic QC/QA, in the form of checklists, and in co-operation with the NaSE participants, was for the 2006 report. Since the 2007 report, these checklists have been used in electronic form. Also as of the 2007 report, in a first step, Tier 1 QC checks have been expanded to include category-specific QC checks in accordance with Tier 2, for key categories. For the 2008, 2009 and 2010 reports, the checklists for the experts involved in the various specialised areas, and for specialised contact persons, have been comprehensively revised. Such revision has been aimed at further enhancing the clarity, practical usefulness and logical structure of the checklists. To ensure the success of the pertinent improvements, a number of persons from the affected group of persons were selected for inclusion in the revision process. No changes were made in content-relevant requirements, which are derived from the IPCC Good Practice Guidance. Just as the checklists have been annually revised and improved, so have the QC and QA plans been continually refined.

Taken together, the two plans and the QC checklists are an instrument for reviewing fulfillment of international requirements, and they make it possible to control inventory quality via initiation of quality assurance measures pursuant to Paragraph 13 of the *Guidelines for National Systems*.

The **improvement plan** documents all potential improvements identified in the framework of the relevant last completed emissions-reporting cycle, as well as the findings that result from independent inventory review. In the plan, such improvements and findings are correlated with feasible corrective measures. The Single National Entity categorises the corrective measures, prioritises them and then, via consultations with the relevant responsible experts, integrates them as necessary within the **inventory plan**. There, they are linked with deadlines and responsibilities. As an annex to the NIR, the inventory plan undergoes a co-ordination and release process. It is thus a binding set of specifications for improvements to be carried out in the coming reporting year.

The Single National Entity also maintains an **inventory description**, a central document record for the various source categories. The description covers all key aspects of inventory preparation. It includes descriptions of all work that pertains to specific source categories and that is relevant to preparation of source-category-specific inventories. The inventory description is really a collection of background information. It is divided into a **paper-form inventory description** and an **electronic inventory description** (eIB). The two versions are identical in structure. Both are managed by the Single National Entity, and both cover all of the document types currently used in everyday inventory work. The obligation to prepare defined documentation was introduced in the Federal Environment Agency via an in-house directive (cf. Chapter 1.2.1.5). It provides the key basis for archiving inventory information pursuant to the provisions of Paragraph 16 (a) of the *Guidelines for National Systems*.

[13] These persons include specialised experts (Fachverantwortliche - FV), specialised contact persons (Fachliche Ansprechpartner - FAP), quality control managers (Qualitätskontrollverantwortliche - QKV), the co-ordinator for the national inventory report (Koordinator für den Nationalen Inventar Report - NIRK), the co-ordinator for the National System (Koordinator für das Nationale System - NaSEK), the co-ordinator for the Central System of Emissions (Koordinator für Das Zentrale System Emissionen - ZSEK) and the co-ordinator for the Quality System for Emissions Inventories (Koordinator für das Qualitäts-System Emissionsinventare - QSEK)

For a range of reasons, the documentation concept, in a departure from Paragraph 17 of the *Guidelines for National Systems*, does not provide for an exclusively central archive. The key reasons for this decision were:

- The body of data that provides the basis for calculating the German inventory is extensive, and non-centralised,
- Responsibility for that data is distributed,
- Confidentiality aspects that, for legal reasons, preclude provision of individual data, for archiving purposes, to a central agency.

The central archive also includes a suitable reference system for relevant, but non-archived data. That system records "who has non-centrally archived what data where", and in what form such data were aggregated for the inventories.

1.3.3.1.5 The QSE handbook

The international requirements for quality assurance and quality control measures in emissions reporting have been set forth, for the National System of Emissions Inventories (NaSE) in Germany, in the "Handbook for quality control and quality assurance in preparation of emissions inventories and reporting under the UN Framework Convention on Climate and EU Decision 280/2004/EC" ("Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU Entscheidung 280/2004/EG". That document, which is binding for the Federal Environment Agency, describes the Quality System for Emissions Inventories (QSE).

The QSE handbook has entered into force via an in-house directive of the Federal Environment Agency (cf. Chapter 1.2.1.5). It has been published, along with pertinent, co-applicable documents, in the Federal Environment Agency's intranet.

The pertinent, co-applicable documents include:

- a list of specialised contact persons in the Single National Entity,
- a list of relevant contact persons in the agency's departments,
- a list of responsible persons in the Federal Environment Agency's relevant sections (section contacts – Fachverantwortliche),
- the quality control plan,
- the quality assurance plan,
- the role-specific QC/QA checklists,
- the improvement plan and the inventory plan,
- the requirements for reporting from the Guidelines,
- the results of inventory reviews,
- the available specific data for each source category (inventory description),
- a guide to using the inventory description.
- the results of determination of the key categories (pursuant to Tier 1 and (if necessary) Tier 2),
- the NIR,
- the guide for calculation of uncertainties,
- a form for proposals relative to ongoing improvement of the QSE, and
- a guide to using the QSE checklists.

1.3.3.1.6 Support provided by expert-review groups

In addition to the Federal Environment Agency's own quality control and assurance measures, inventory review by expert review groups provides important impetus for inventory improvement. It is thus in the Single National Entity's own interest to fulfil the provisions of Paragraphs 16 (b) and (c) regarding provision of archived inventory information for the review process and for responding to questions of expert review groups. This relationship has been given priority in the design of the QSE. For this reason, all tabular-form correspondence relative to inventory reviews, along with the pertinent German answers, and together with relevant documents from national QC/QA, is archived in a searchable format.

1.3.3.1.7 Use of EU ETS monitoring data for improvement of GHG-emissions inventories

Monitoring data from European emissions trading will be used to improve the quality of annual national emissions inventories with respect to source categories that include installations subject to reporting obligations under the CO_2 Emissions Trading Scheme (ETS).

The comparisons have confirmed, in principle, the usefulness of such comparisons for verifying individual source categories and identifying data gaps. A formalised procedure, with defined deadlines and workflow, has been agreed for their regular use and for the relevant annual required data exchanges.

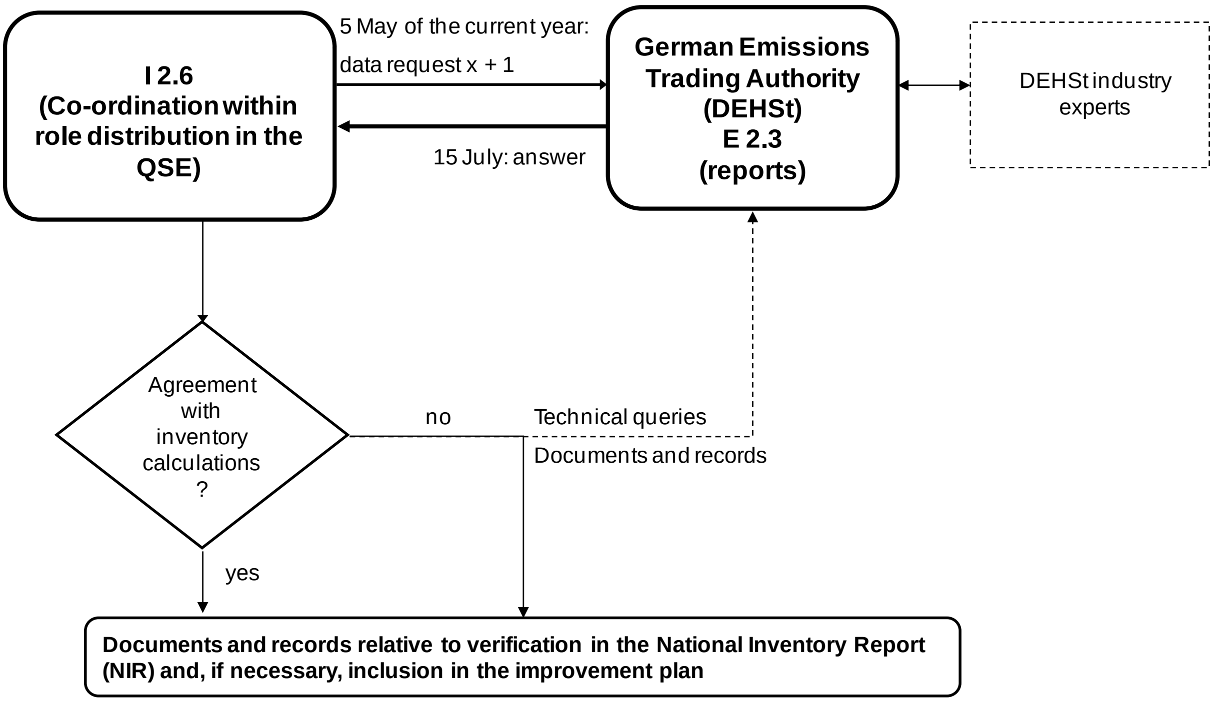


Figure 9: Procedural flow for annual inventory verification using ETS monitoring data

1.4 Short, general description of the methods and data sources used

1.4.1 Greenhouse-gas inventory

1.4.1.1 Data sources

1.4.1.1.1 Energy

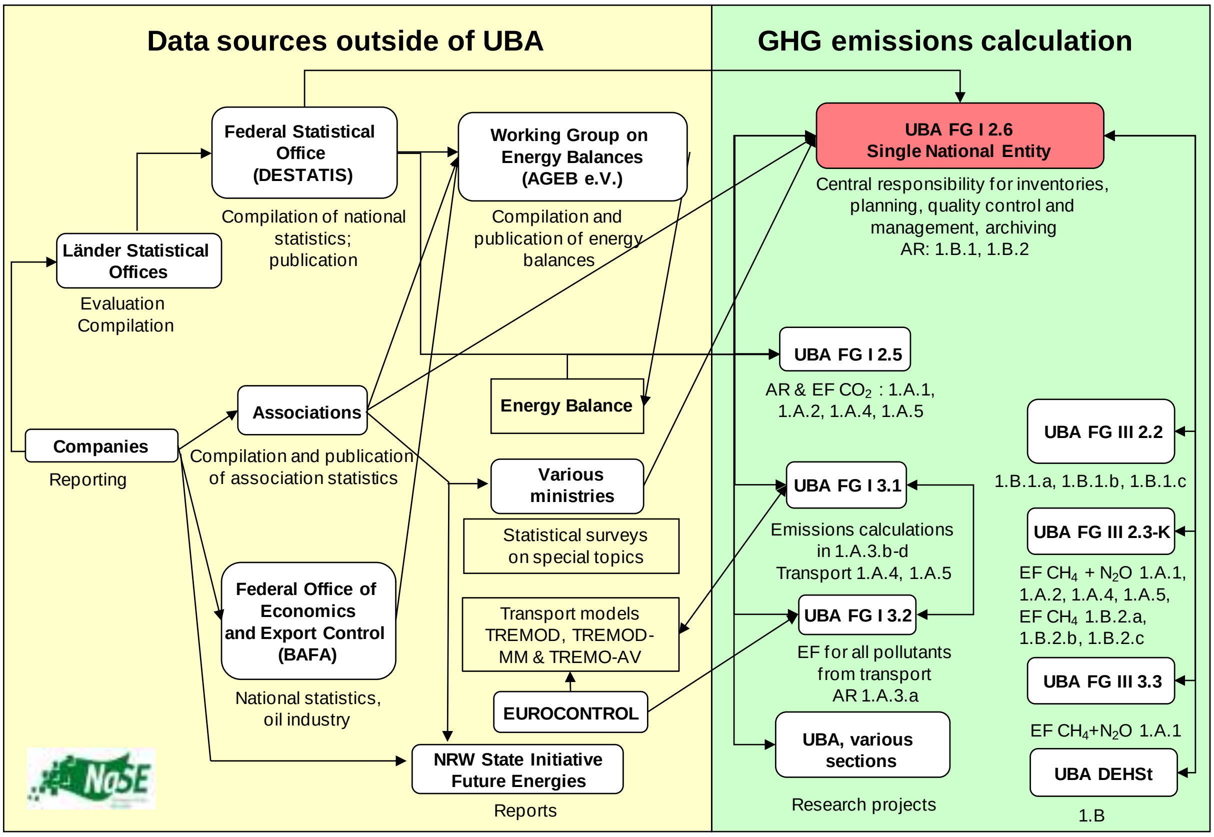


Figure 10: Responsibilities and data flows for calculation of greenhouse-gas emissions in the energy sector

In all likelihood, the most important data sources for determination of activity data for source category 1.A are the *"Energy Balances of the Federal Republic of Germany"* ("Energiebilanzen der Bundesrepublik Deutschland"), hereinafter referred to as: Energy Balance), which are published by the *Working Group on Energy Balances* (Arbeitsgemeinschaft Energiebilanzen - AGEB). An energy balance provides an overview of the links within Germany's energy sector, and it supports breakdowns in accordance with fuels and source categories. An energy balance receives data from a wide range of other sources.

In commissioning the Energy Balances 2007 – 2012, the BMU obligated the Working Group on Energy Balances (AGEB) to comply with minimum requirements pertaining to quality assurance for the National System. In addition, for the most recent year's Energy Balance, quality reports of the German Institute for Economic Research (DIW) and of Energy Environment Forecast Analysis GmbH Co. KG are available that describe relevant measures for quality assurance and quality control.

Along with the main Energy Balance, a *Satellite Balance of Renewable Energies* (Satellitenbilanz Erneuerbare Energieträger; hereinafter referred to as: Satellite Balance) also appears. This balance describes the growth and use of renewable energies in detail. The Satellite Balance appears together with the Energy Balance.

Also along with the Energy Balance, the Working Group on Emissions Balances (AGEB) also publishes "*Evaluation Tables for the Energy Balance*" (Auswertungstabellen zur Energiebilanz (hereinafter referred to as: evaluation tables). In the area of fuels, these tables only list those fuels with the highest activity levels and aggregate lower activity levels to form sum values (such as *other solid fuels*). Breakdowns according to specific source categories are limited largely to source categories that consume final energy (such as *manufacturing sector* or *transport*). Some source categories are not listed (such as *production of district heat*). The evaluation tables are published relatively promptly (in the summer of the relevant subsequent year). The tables can be used to determine aggregated activities at the source-category levels for the most commonly used fuels. Further disaggregation can be achieved via formation of relevant differences using other statistics.

Another important data source for determination of activity data consists of *Fachserien 4 Reihe 4.1.1, Reihe 6.4*, and, for waste data, Fachserie 19 of the *Federal Statistical Office*. These publications contain data on production, and on facilities and plants, in the manufacturing and mining sectors. These data are published relatively promptly after collection (about one year), and they are broken down finely in accordance with various areas of the manufacturing sector. To support further data differentiation, and clarification of details, the Federal Statistical Office provides special evaluations.

For the iron and steel sector, as of the 2012 report, data of the Wirtschaftsvereinigung Stahl German steel industry association are being used. Inter alia, these data replace the so-called "BGS form" (Fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) locally connected to such operations), a section of the "Fachserie 4, Reihe 8.1", publication of which was discontinued as of 31 December 2009.

The series STATISTIK DER KOHLENWIRTSCHAFT ("Coal industry statistics"), especially its annual publication "Der Kohlenbergbau in der Energiewirtschaft der Bundesrepublik Deutschland" ("Coal mining in the energy sector of the Federal Republic of Germany"), is used as an additional data source. In addition, the special evaluations provided by the Bundesverband Braunkohle (DEBRIV; federal German association of lignite-producing companies and their affiliated organisations) are used for differentiation of the different types of raw lignite coal that are burned. Furthermore, DEBRIV provides the necessary data for calculation of fuel inputs for lignite drying.

Yet another data source is the publication "*Mineral-Oil Data*" (Mineralöl-Zahlen) of the Association of the *German Petroleum Industry* (Mineralölwirtschaftsverband; (*MWV*) e.V. (hereinafter also referred to as: MWV Statistics)). This publication contains data on supply and consumption of petroleum in Germany, and it is broken down by source categories. The statistical data as published is very current (publication takes place within just a few months after the relevant survey).

The quantities of secondary fuels used for energy generation (listed under CRF 1.A.2) are taken from the annual report of the German Pulp and Paper Association (Verband der Papierindustrie) and from reports of the German Cement Works Association (Verband der Zementindustrie – VDZ).

The emission factors for source category 1.A were provided by research projects, initiated by the Federal Environment Agency, of the Öko-Institut (Institute for Applied Ecology) and the Franco-German Institute for Environmental Research (DFIU).

For collection of transport emissions data (1.A.3), *Official Mineral-oil Data* (amtliche Mineralöldaten) of the *Federal Office of Economics and Export Control (BAFA)* and *Mineral-oil Data* (Mineralöl-Zahlen) of the *Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry (MWV)* e.V. are used, in addition to Energy Balance data.

Road-transport emissions are calculated primarily with the TREMOD model ("*Transport Emission Estimation Model*"; currently: Version 5.2, IFEU, 2011)[14]. For calculations carried out in TREMOD, extensive basic data from generally accessible statistics and special surveys are used, co-ordinated, and supplemented. A precise description of the data sources for emission factors is provided by the "Handbook of road-traffic emission factors" ("Handbuch Emissionsfaktoren des Straßenverkehrs"; INFRAS 2010).

For air transports, in addition to data of the aforementioned sources, data of *EUROCONTROL, the European Organisation for the Safety of Air Navigation*, and of the *Federal Statistical Office* are used: Year-specific split factors, determined on the basis of actual aircraft movements, are used to break down fuel consumption and emissions data by national and international air transports. For years as of 2003, the split factors are provided by Eurocontrol. For all earlier years, they are derived via aircraft-movement data (numbers of take-offs and landings) collected by the Federal Statistical Office. The aircraft-movement data collected by the Federal Statistical Office is also used to break down consumption and emissions data in accordance with the different phases of flight. For the first time, further processing of the many different types of input data is being carried out within the newly developed TREMOD-AV module, a separate TREMOD module for air transports. In addition, Eurocontrol provided country-specific consumption and emissions data from the PAGODA model, for the first time. While that data arrived too late for the current report, there were used for verification of our own surveys.

Data on emissions of other mobile sources (in 1.A.4.b & c and 1.A.5.b) are also collected from figures of the Working Group on Energy Balances (AGEB), of BAFA and of the Association of the German Petroleum Industry (MWV). Military transports (1.A.5.b) play a special role in this context; all of the consumption data for those transports are taken from the Official Mineral-oil Data of BAFA, since such data are no longer listed separately in the Energy Balances.

Data for source categories of category 1.B.1 are taken from publications of Statistik der Kohlenwirtschaft e.V. (coal-industry statistics), the Federal Ministry of Economics and Technology (BMWi), the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations, Deutsche Montan Technologie GmbH (DMT), the German Society for Petroleum and Coal Science and Technology (DGMK) and Interessenverband Grubengas e.V. (IVG; association for the pit-gas sector).

The publication "Statistik der Kohlenwirtschaft" (coal-industry statistics) is especially important in this context. It is processed with the help of federal and Land (state) ministries,

14 To make it possible to derive and assess reduction measures, energy consumption and CO_2 emissions for the various vehicle categories are also calculated with TREMOD. The resulting values are subsequently checked against total consumption and total CO_2 emissions.

including their authorities (such as supreme state mining authorities), and with use of reports and expert opinions of the "Landesinitiative Zukunftsenergien" NRW ("NRW State Initiative for Future Energies"; here, the AG Grubengas pit-gas working group). Inventory preparation is co-ordinated with the support of the Association of the German hard-coal mining industry (Gesamtverband Steinkohle; formerly, Gesamtverband des deutschen Steinkohlebergbaus - GVSt).

Data for source categories in category 1.B.2 are taken from publications of the *Federal Statistical Office*, the Association of the German Petroleum Industry (MWV), the German Society for Petroleum and Coal Science and Technology (DGMK), the Association of the petroleum and natural-gas industry (Wirtschaftverband Erdöl und Erdgasgewinnung e.V. – WEG), the German Technical and Scientific Association for Gas and Water (DVGW), the Federal association of the German gas and water industry (Bundesverband der deutschen Gas- und Wasserwirtschaft – BDEW; gas statistics) and the German Emissions Trading Authority (DEHSt). Processing in this area now takes account of responses (statements of position) of the WEG.

1.4.1.1.2 Industrial processes

Activity data for the mineral industry are obtained primarily from association statistics. The data for the cement industry (2.A.1) were provided by the German Cement Works Association (Verband der Zementindustrie – VDZ), especially by that association's research institute, as well as by the Federal association of the German cement industry (Bundesverband der Deutschen Zementindustrie e.V. - BDZ). For the most part, the data in question consist of data published in the framework of CO_2 monitoring under the industry's voluntary climate-protection commitment. The figures for lime and dolomite-lime production (2.A.2) are collected by the German Lime Association (BVK) on a per-plant basis and then provided annually in aggregated form. Use of limestone and dolomite (2.A.3) is reported in other source categories (included elsewhere), and the relevant data sources are mentioned in the pertinent categories in each case. The total quantity of soda ash production (2.A.4.a) is determined via surveys of the Federal Statistical Office, while soda ash use (2.A.4.b) is determined via assessment by experts of the Federal Environment Agency. The production quantities for bitumen paper and bitumen roof sheeting (2.A.5) are provided by the VDD industry association for bitumen paper and bitumen roof sheeting. Production quantities of asphalt for road paving (2.A.6) are provided by the German asphalt association (Deutscher Asphaltverband - DAV). Glass-production figures (2.A.7.a Glass) are taken from the regularly published annual reports of the Federal glass industry association (Bundesverband Glasindustrie), although relevant orientational figures on glass recycling are taken from other statistics. Production trends in the ceramics industry (2.A.7.b Ceramics) are determined via official statistics and via conversion factors provided by the Federal association of the German brick industry (Bundesverband der Deutschen Ziegelindustrie).

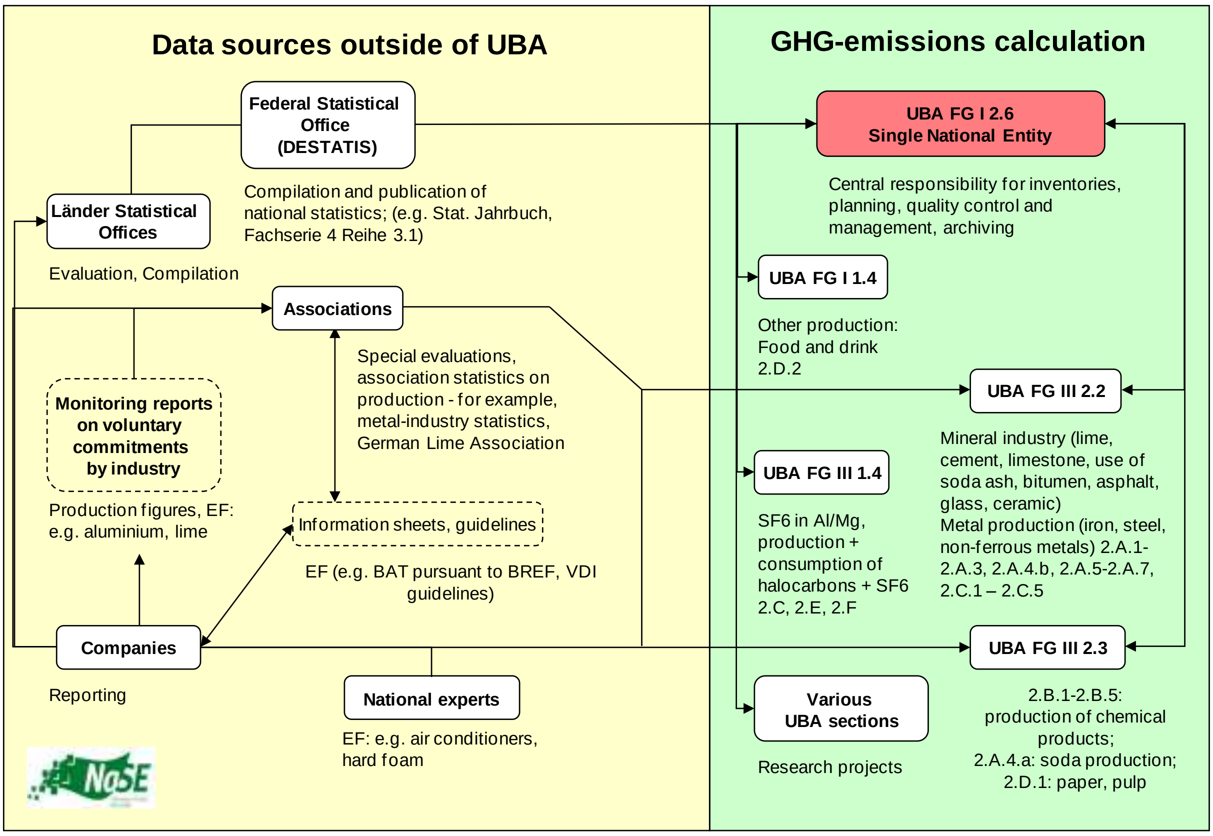


Figure 11: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of industrial processes

A range of different sources are used to determine emission factors for the mineral industry. The emission factor used for calculation of emissions from cement-clinker production (2.A.1) is based on a calculation of the German Cement Works Association (VDZ) carried out by aggregating plant-specific data. CO_2 emissions from lime production (2.A.2) and from soda-ash use (2.A.4.b) are calculated with the help of stoichiometric factors. Soda ash production (2.A.4.a) via the Solvay process is considered CO_2-neutral with regard to the raw materials used. The emission factors for production and laying of bitumen paper and bitumen roof sheeting (2.A.5), and for production of asphalt for road paving (2.A.6) refer only to NMVOC, and they have been taken from research reports. The CO_2-emission factors for various types of glass (2.A.7.a) have been derived from glass-composition data, while CO_2-emission factors for the ceramics industry (2.A.7.b) have been derived, by Federal Environment Agency experts, from raw-material inputs.

The activity data for source category 2.B Chemical industry are determined from activity data of the *Federal Statistical Office*, of the *Mineralölwirtschaftsverband* Association of the German Petroleum Industry and directly from figures of industry associations and producers. The latter group (industry data) is confidential. The relevant emission factors have been determined by experts in the Federal Environment Agency, via research projects or by the pertinent producers. Until 2008, activity data for 2.B.1 Ammonia production and 2.B.2 Nitric acid production were collected by the *Federal Statistical Office*. Since 2009, data for ammonia and nitric-acid production have been collected by producers themselves – plant-specifically, on the basis of an agreement with the chemical industry and for the entire time series as of 1990. These data are forwarded to the association, which aggregates them and forwards them to the Federal Environment Agency. The emission factors for 2.B.2 have been determined by the producers. For 2.B.1, producers provide the activity data and emissions data. Until the mid-1990s, plant-by-plant activity data were supplied for 2.B.3 Adipic acid production. The default emission factor for N_2O was applied to that data. Now, plant operators are supplying emissions data directly to the Federal Environment Agency, on a confidential basis. For the area of adipic-acid production, data delivery has also been assured for the long term, via an agreement from 2009. At present, producers in Germany find the IPCC's default emission factors for NO_X, CO and NMVOC rather puzzling. This is the reason why emissions of these substances have not been reported to date. Since there is only one calcium carbide (2.B.4) producer in Germany, the relevant data are confidential. The Federal Environment Agency obtains these data directly from the producer. Under 2.B.5 Other, greenhouse-gas emissions from several different production processes are reported: coke burn-off in catalyst regeneration, transformation losses and production of carbon black. Emissions of precursor substances are reported for production of sulphuric acid, titanium dioxide and organic substances. The activity data have been obtained via research projects, data of the Federal Statistical Office and publications of the Association of the German Petroleum Industry. The emission factors have been obtained from experts' assessments, research projects and default figures in the IPCC Guidelines.

The activity data for the metal industry (2.C) are provided by the *Federal Statistical Office* and the relevant associations (Steel Institute VDEh, Wirtschaftsvereinigung Metalle (metals industry association) and Gesamtverband der Aluminiumindustrie (aluminium industry association). The emission factors for the metals industry (2.C) are normally calculated by experts in the Federal Environment Agency; in some cases, IPCC default values are used as well.

One exception in this regard is the source category Ferroalloys (2.C.2); for it, activity data from statistics of the U.Ss Geological Survey are used, while the relevant emission factors have been provided by a research project.

In the area of Other production: Pulp and paper production (2.D.1), data from the production report of the German Pulp and Paper Association (Verband Deutscher Papierfabriken VDP) are used. In the area of Other production: Food and beverages (2.D.2), data of the Federal Food Industry Association (Bundesvereinigung der Deutschen Ernährungsindustrie; BVE), of the Federal Statistical Office (Statistisches Bundesamt) and of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) are used.

In the area of production of halocarbons and SF_6 (2.E), data are obtained from *producers' figures and surveys of producers*. For the most part, activity data are researched in the framework of research projects, directly in accordance with the inventory's requirements. In some cases, producers supply only emissions data. Only small numbers of companies are involved in the various sub-source categories, and thus data in these areas are confidential.

The activity data for consumption of halocarbons and SF_6 (2.F) are determined from figures of producers and associations, from surveys of the Federal Statistical Office and of other federal authorities and with the help of calculation models. In individual cases, producers provide emissions data directly. The data are classified into several sub - source categories. Furthermore, a distinction is made between production, use and disposal emissions. The data in some parts of 2.F are also confidential.

Emission factors for source categories 2.E and 2F are obtained in part from national and international fact sheets and directives or via surveys of experts; where necessary, IPCC default values are used.

More detailed pertinent information regarding emission factors is presented in the descriptions of methods for the various source categories.

1.4.1.1.3 Solvent and other product use

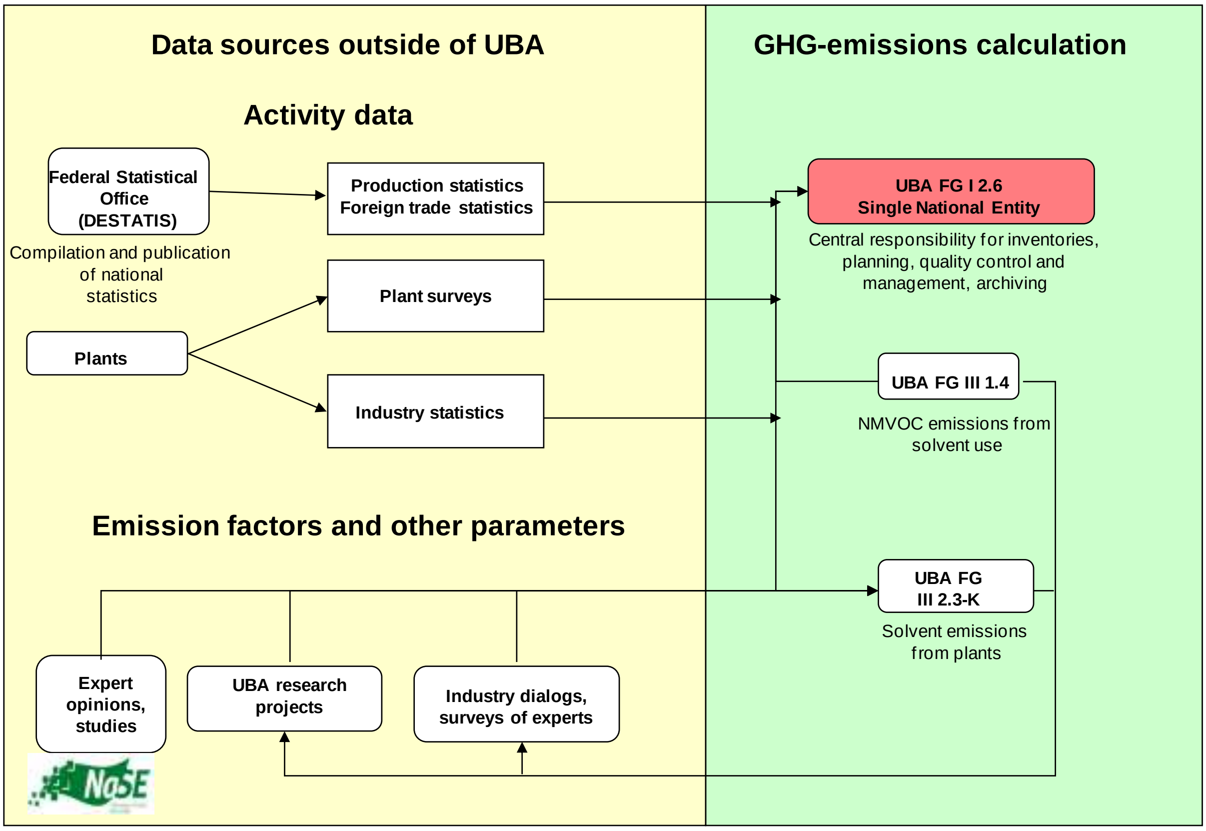


Figure 12: Responsibilities and data flows for calculation of greenhouse-gas emissions from use of solvents and other products

The Federal Environment Agency's Section (FG) III 1.4 *Substance-related Product Issues* is responsible for calculating NMVOC emissions from the area of solvent and other product use. With regard to the sub - source category of solvent emissions from plants, the Federal Environment Agency's Section for *Substance-related Product Issues* is supported by the agency's Section FG III 2.3-K, *Chemical Industry, Energy Production* in the framework of the latter section's "global responsibility". The Federal Environment Agency has not yet specified internal responsibilities for determining N_2O emissions from products.

Activity data are drawn mainly from published statistics of the Federal Statistical Office, especially from its statistics on production and foreign trade. The activity data are supplemented with industry statistics and information supplied by experts. For N_2O emissions, research-project results and companies' figures are used.

Emission factors, along with other parameters that enter into calculation of emissions from solvent and other product use, are taken from national studies, experts' opinions and research projects directly commissioned by the Federal Environment Agency; in some cases, they are also based on information provided by experts in the context of dialogs with industry.

1.4.1.1.4 Agriculture

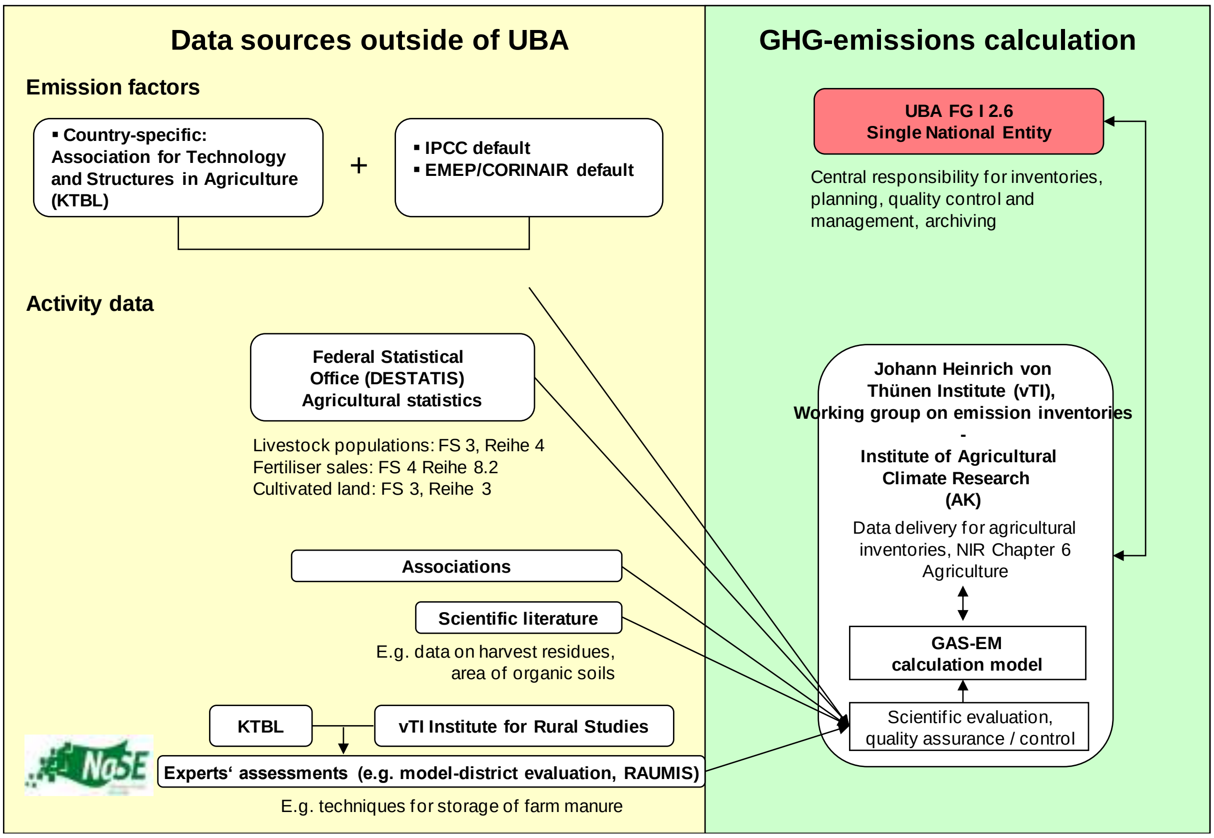


Figure 13: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of agriculture

Emissions calculations for source category 4 (Agriculture) are carried out by the von Thünen Institute (vTI). For calculation of agricultural emissions in Germany, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) initated a suitable joint project, in the framework of which the former Federal Agricultural Research Institute (FAL) developed a modular model for relevant spread-sheet calculation (GASeous Emissions, GAS-EM) (DÄMMGEN et al, 2002 & HAENEL et al. 2012). The BMU and BMELV now have a framework ministerial agreement in place for management of relevant data and information exchange and for operation of a joint database at the UBA and the FAL.

Agricultural statistics of the Federal Statistical Office are another important data source for calculation of agricultural emissions. Animal statistics have been obtained from the *Federal Statistical Office* (*STATISTISCHES BUNDESAMT,* FS3 R4); other Fachserien (technical series) provide data on amounts of fertiliser sold and agricultural land under cultivation. In some areas, such data are supplemented by figures from the pertinent literature (for example, crop residues and recommended fertiliser quantities). Additional data are available from experts' assessments (for example, an evaluation of model districts with regard to techniques for storing farm fertilisers).

In many areas, calculations for the agriculture sector are based on highly differentiated activity data obtained via national data sources. Also in many areas, such data are combined with the standard emission factors given in the 1996b and 2006 IPCC Guidelines or the EMEP/EEA manual of the United Nations Economic Commission for Europe (UN ECE).

1.4.1.1.5 Land-use changes and forestry

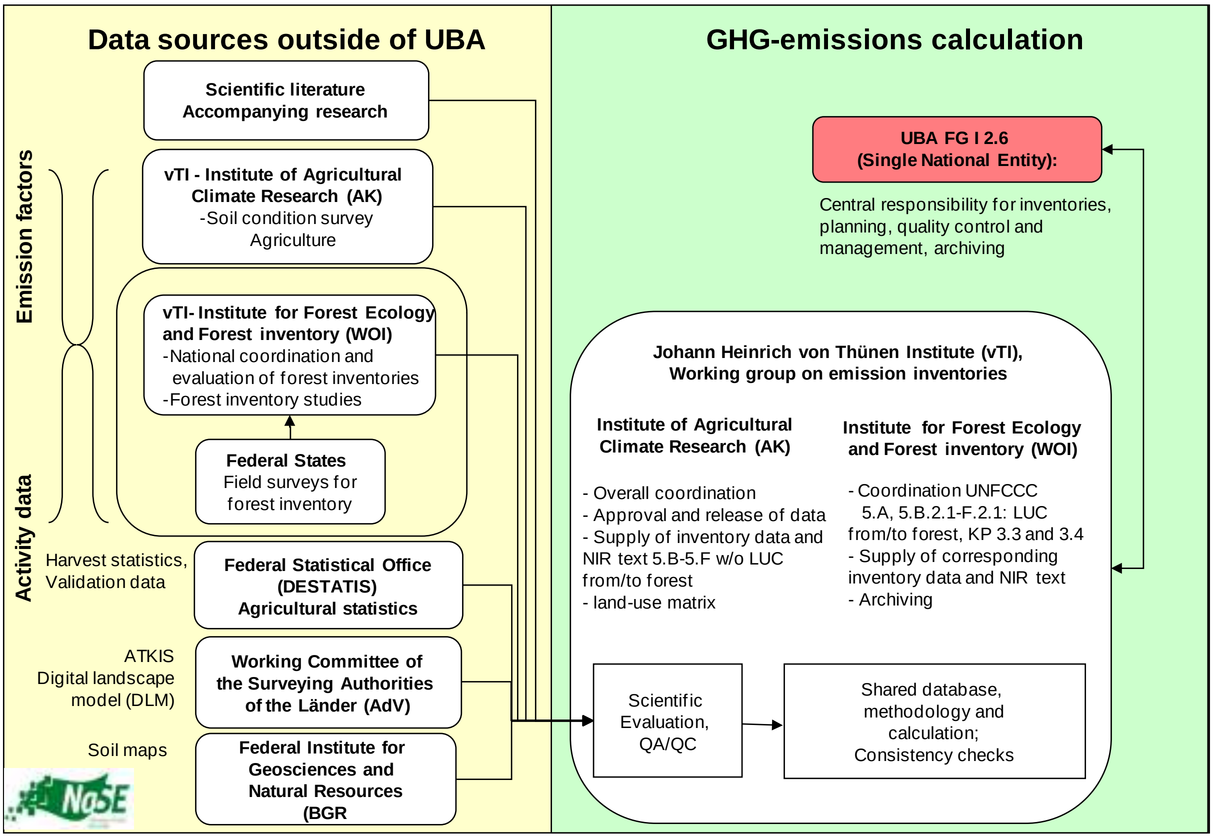


Figure 14: Data flows for calculation of greenhouse-gas emissions from the areas of land-use changes and forestry (LULUCF) and KP-LULUCF

Uses and land-use changes in the categories cropland, grassland, wetlands, settlements and other land, were determined for the first time with the same grid-based sampling method used for forestry activities.

Soil carbon stocks are estimated with the help of soil maps (differentiated to show usages) and soil-profile data provided by the Federal Institute for Geosciences and Natural Resources (BGR), while use-change-related changes in these stocks are estimated on the basis of changes in the mean stocks per land-use category.

Changes in biomass carbon stocks are estimated on the basis of harvest statistics, the main survey on soil use (Bodennutzungshaupterhebung) and specific factors given in the pertinent scientific literature (and used in conjunction with area data). Emissions from liming of soils are determined with the help of data, taken from Federal fertiliser statistics, on domestic sales of mineral fertilisers that contain lime and other nutrients. The fertiliser industry is legally required to disclose its sales.

Projects for improvement of activity data, and especially for determination of country-specific emission factors for carbon and nitrogen, and for CO_2, CH_4 and N_2O – for example, the project "Organic Soils" (since 2009), the agricultural soil survey (Bodenzustandserhebung Landwirtschaft; since 2011) and others – will help validate and improve national estimates of emissions and removals.

1.4.1.1.6 Waste and wastewater

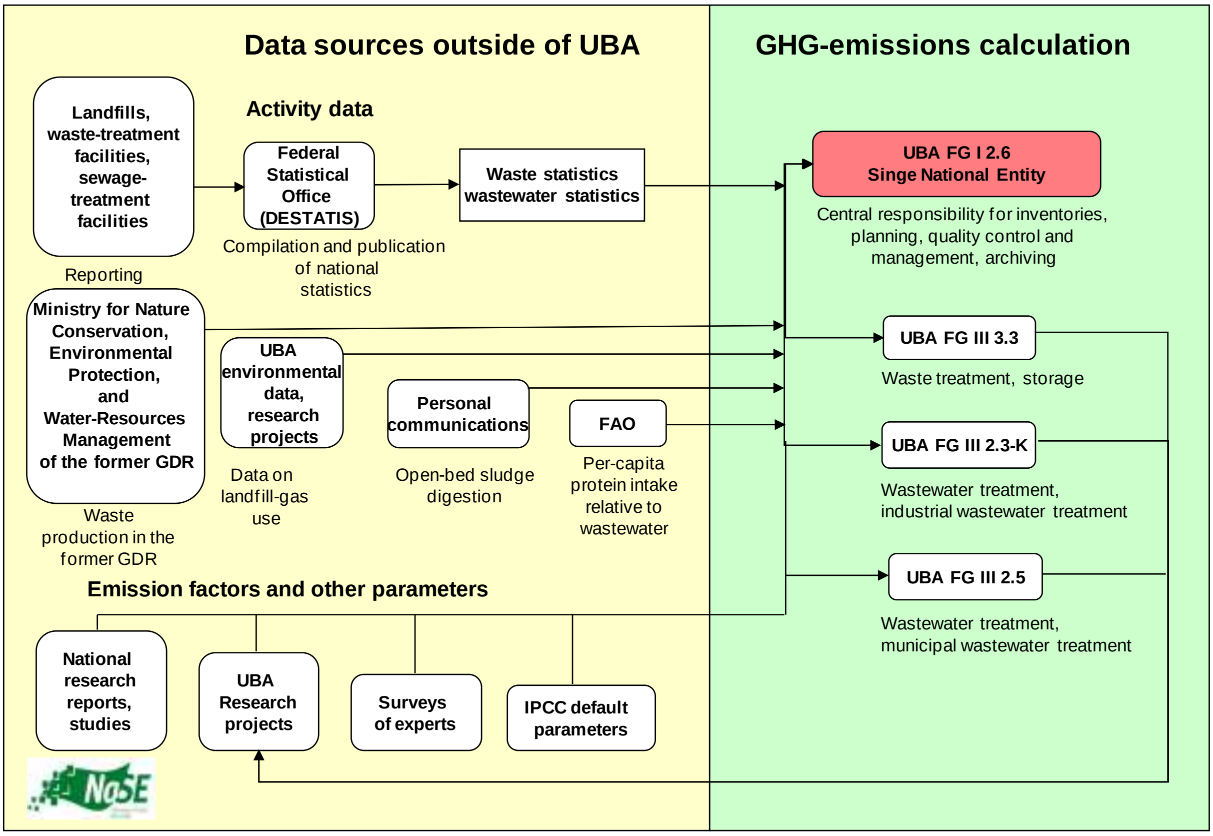


Figure 15: Data flows for calculation of greenhouse-gas emissions from the area of waste and wastewater

Federal Environment Agency Section FG III 3.3 *Waste treatment, waste storage* is responsible for selecting the methods, parameters and data for calculating emissions from the waste sector. In recalculation of landfill emissions in 2003 (development of the Tier 2 method for the Federal Republic of Germany), and in refinement of the Tier 2 method in 2006, the Federal Environment Agency was supported by a research project (ÖKO-INSTITUT, 2004b).

Activity data in the waste sector are drawn mainly from published data of the Federal Statistical Office, which provides detailed, disaggregated time series. The section on waste provides precise information as to what statistical series and sources were used. The Federal Statistical Office has not published any data on amounts of waste produced in the former GDR. In this area, an official source of the former GDR's ministry for nature conservation, environmental protection and water-resources management was used. The calculations relative to landfill-gas use are based on data from the Energy Balances and from Fachserie 19 of the Federal Statistical Office.

The emission factors and other parameters that enter into calculation of emissions from waste landfilling, from mechanical-biological waste treatment and from composting were taken from national studies and research reports conducted/prepared in research projects commissioned directly by the Federal Environment Agency. IPCC default parameters were also used for this purpose. Selected experts were also consulted regarding a few of the relevant parameters (for example, half-life selection). The relevant chapter presents the sources for the various parameters, in detail.

The Federal Environment Agency's Section III 2.3-K *Chemical Industry, Energy Production* is responsible for selecting the methods, parameters and data for calculating emissions from the industrial wastewater / sewage sludge handling sector (6.B.1). The Federal Environment Agency's Section III 2.5 *Monitoring Methods, Waste Water Management* is responsible for selecting the methods, parameters and data for calculating emissions from the municipal wastewater handling sector (wastewater and sewage sludge) (6.B.2).

Activity data in the wastewater sector are drawn mainly from published data of the Federal Statistical Office, which provides detailed, disaggregated time series. The section on wastewater provides precise information as to what technical series and sources were used. The data on per-capita protein intake are taken from FAO data.

The emission factors and other parameters that enter into calculation of emissions from wastewater treatment were taken from national studies and research projects commissioned directly by the Federal Environment Agency. IPCC default parameters are also used. Various experts were consulted directly regarding a few parameters and methodological issues (for example, production of CH_4 emissions in aerobic wastewater-treatment processes).

1.4.1.2 Methods

The methods used for the individual source categories are outlined in the overview tables for the various source categories and in summary tables 3s1 and 3s2 of the CRF reporting tables. A distinction is made between calculations made with country-specific ("CS") methods and calculations made, in the various source categories, with IPCC calculation methods of varying degrees of detail (of varying "Tiers")[15]. The manner in which a calculation is assigned to the various IPCC methods depends on the pertinent source category's share (expressed as equivalent emissions) of total emissions. Such assignment is carried out via an instrument known as "key-category analysis" (cf. Chapter 1.5 in this regard).

In the present report, emissions from air transports are calculated, for the first time, completely in accordance with the IPCC's Tier 3 method, i.e. separately national and international transports, and using specific emission factors for the different flight phases and aircraft classes involved. Further information regarding the procedure used is presented in Chapters 3.2.2.2 and 3.2.10.1.

Greenhouse-gas emissions from road transports are calculated with the help of the TREMOD model, which is based on a bottom-up Tier-2/3 approach. In that model, fuel consumption figures, checked against the Energy Balance, are distributed among individual vehicle and road categories. The relevant emissions are calculated within the CSE database, on the same level of detail, following transfer of those specific consumption data, and of corresponding emission factors. Further information regarding this procedure is provided in Chapters 3.2.10.2 and 19.1.3.2 of this inventory report.

In the area of industrial processes, chemical-industry emissions of source categories 2.B.1 through 2.B.4 are calculated in accordance with the IPCC Tier 3 method. Emissions of source category 2.B.5 are calculated via country-specific and IPCC-Tier-2 methods. Detailed IPCC tiers are also used in many areas relative to the greenhouse gases HFCs, PFCs and

15 Tier 1 refers to the simpler calculation methods that may be used with fewer input data, whereas Tier 2 and Tier 3 require more differentiated input data and hence generally lead to more accurate results.

SF_6. This is possible, in particular, because emissions for these greenhouse gases have been surveyed specifically for emissions reporting, within the context of an R&D project, and the relevant data have been collated specifically with a view to application of the IPCC methods.

NMVOC emissions from solvent use, converted into indirect CO_2, are calculated on the basis of a product-consumption approach pursuant to the IPCC Guidelines 1996.

For agriculture, emissions were calculated primarily on the basis of the CORINAIR Guidebook, using IPCC default emission factors. Calculations for key categories were carried out using an IPCC-Tier 2 procedure, with country-specific emission factors. Country-specific methods were applied only for agricultural soils (4.D).

Calculation for the waste sector was modified in line with the IPCC Tier 2 approach, and relevant new national data sources were developed (ÖKO-INSTITUT, 2004a).

All other source categories were listed in the IPCC Summary Tables as having country-specific calculation methods. In this respect, it should be noted that the German inventories are currently being subjected to an intensive review process in which compliance of the applied methods with the IPCC approach is being systematically reviewed for the first time, and methodological changes are being implemented in order to conform to the *Good Practice Guidance*. As this methodological review is not yet complete, certain methods in the Summary Tables have been listed as country-specific even if it is not yet known whether IPCC conformity exists or which Tier has been used. However, in the case of energy-related activity data, it can be assumed that Tier 1 has been used as a minimum. For other areas, too, classification will change from "country-specific" to IPCC Tiers, since methodological conformity will either be confirmed or achieved during the course of the year.

1.4.2 KP LULUCF activities

The data sources and methods used for KP reporting do not differ from the data sources and methods used for reporting for source category 5.A in the UNFCCC framework. There are thus no differences with regard to the present purpose. Cf. also Chapter 1.4.1.1.5 and Chapter 7.2 and Annex Chapter 19.5.

1.5 Brief description of key categories

1.5.1 Greenhouse-gas inventory (with and without LULUCF)

The key categories were defined by applying two Tier 1 procedures, Level (for the base year, for 1990 and for 2010) and Trend (for 2010, as compared to the base year), to German greenhouse-gas emissions. In addition, the Tier 2 method was used. In keeping with the pertinent IPCC specifications for the Tier 1 method, analysis focussed both on emissions from sources and on removals of greenhouse gases in sinks. The analyses are first carried out solely for emissions from the sources listed in Annex 1 of the UN Framework Convention on Climate Change and, then, in a second step, for storage of greenhouse gases in sinks. All specified key categories result from work in 2010 – either from level analysis for 2010, or from trend assessment, or from Tier-2 key-category analysis on the basis of current uncertainties determination. No new key categories have been added as a result of assessment of qualitative aspects (explanations regarding this aspect are provided in Annex Chapter 17.1.2).

For 2010, the Tier 1 approach identified 39 source categories, out of a total of 120 source and sink categories studied, as key categories. Only 25 of these were identified, by both trend and level analysis, as key categories. In addition, 8 source categories were identified as key categories solely by trend analysis, and 6 source categories were so identified solely by level analysis. Via the Tier 2 approach, 7 additional key categories were identified (cf. Table 8).

Ultimately, 46 key categories were defined. These are summarised in Table 5.

Table 5: Number of source categories and key categories

Category		**120**	
			Key categories
by Level	Level & Trend	Trend	
6	25	8	**39 (Tier 1)** **+7 (Tier 2)** **46 (total)**

Table 7 provides an overview of the results of Tier-1 key-category analysis. Table 8 shows the additional key categories identified via Tier 2 analysis. Annex 1 (Chapter 17) of this report presents detailed explanations of the key-category analysis carried out.

Only few changes have occurred with respect to the results obtained in the previous year. The number of key categories pursuant to Tier-1 analysis, at 39, has remained the same. Only the number of key categories in terms of trend has decreased, from 34 to 33. CH_4 emissions from Fugitive emissions from natural gas (1.B.2.b) and CO_2 emissions from grassland (5.C) are no longer key categories in terms of Trend. CO_2 emissions from Manufacturing – iron and steel (1.A.2.a) are now a key category by Trend. The number of key categories by Tier-2 analysis has remained the same, at seven. CO_2 emissions from Fugitive emissions from natural gas (1.B.2.b) is no longer a key category in accordance with Tier 2, while N_2O emissions from Agricultural soils (4.D.2) have now joined the group as a key category in terms of Tier 2.

Germany uses all recommended procedures for identifying and evaluating source categories. The IPCC Guidelines require 95% of emissions from sources / removals in sinks to be classified in key categories. In keeping with the fact that Germany identifies key categories by combining the results of all all analysis procedures and evaluations, emission-causing activities accounting for 97.6% of the inventory have been identified as key categories.

1.5.2 Inventory with KP-LULUCF reporting

As a result of the analysis, as described in the previous chapter, of the UNFCCC inventory, CO_2 emissions / removals in the categories *Forest Land* (5.A), *Cropland* (5.B) and *Grassland* have been identified as key categories. For these categories, additional detailed analyses were carried out, in line with the methodological specifications set forth in chapter "5.4 methodological choice – identification of key categories" of the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC, 2003). As a result, the sub-categories listed in Table 6 were identified as key categories for the KP-LULUCF inventory pursuant to Article 3.3. The key factors in such selections were the relevant emissions-contribution levels and emissions trends. With the help of Table 5.4.4, the activities selected in accordance with Article 3.4 were then correlated with these categories. Under this article of the Kyoto Protocol, Germany has selected only the category "forest management". These results, as well as the criteria used for the selection, are presented in CRF Table NIR.3 (Table 307 in Chapter 17.1.4).

Table 6: Results of KP-LULUCF key-category assessment

IPCC Source Categories	Emissions / Sinks of	1990	2010	Key category assessment
5.A.1 Forest Land remaining Forest Land	**CO_2**	-66121.25	19586.63	●
5.A.1 Forest Land remaining Forest Land	CH_4	0.43	0.15	
5.A.1 Forest Land remaining Forest Land	N_2O	0.19	0.21	
5.A.2 Land converted to Forest Land	**CO_2**	-7286.76	5473.98	●
LIME CROPLAND	CO_2	1158.93	1638.09	
5.B.1 Cropland remaining Cropland	**CO_2**	22255.68	23381.36	●
5.B.1 Cropland remaining Cropland	N_2O	IE	IE	
5.B.2 Land converted to Cropland	CO_2	5346.52	3253.37	
5.B.2 Land converted to Cropland	N_2O	0.64	0.60	
5.C.1 Grassland remaining Grassland	**CO_2**	11704.87	10709.95	●
5.C.2 Land converted to Grassland	CO_2	-142.95	1660.02	
5.D.1 Wetlands remaining Wetlands	CO_2	2061.77	2005.60	
5.D.2 Land converted to Wetlands	CO_2	186.63	150.88	
5.E.1 Settlements remaining Settlements	CO_2	1964.47	2016.45	
5.E.2 Land converted to Settlements	CO_2	787.16	534.92	
5.F.1 Other Land remaining Other Land	CO_2	0.00	0.00	
5.F.2 Land converted to Other Land	CO_2	0.00	0.00	
5.G Other	CO_2	116.78	58.29	

Table 7: Key categories for Germany pursuant to the Tier 1 method

IPCC Source Categories	Activity	Emissions of	Level						Trend		Emission Base Year	Emission 2010
			Base Year	Base Year +sinks	LEVEL 1990	1990 +sinks	LEVEL 2010	2010 +sinks	2010	2010 +sinks		
1A1a Public electricity and heat production	All fuels	CH4	-	-	-	-	-	-	●	●	185.8	1,684.0
1A1a Public electricity and heat production	All fuels	CO2	●	●	●	●	●	●	●	●	339,017.9	315,557.5
1A1a Public electricity and heat production	All fuels	N2O	-	-	-	-	-	●	-	-	3,610.0	3,498.9
1A1b Petroleum Refining	All fuels	CO2	●	●	●	●	●	●	●	●	20,005.9	19,857.2
1A1c Manufacture of Solid Fuels and Other Energy Industries	All fuels	CO2	●	●	●	●	●	●	●	●	64,393.8	13,645.8
1A2a Manufacturing Industries and Construction: Iron and Steel	All fuels	CO2	●	●	●	●	●	●	●	●	34,742.0	34,269.1
1A2e Manufacturing Industries and Construction: Food Processing	All fuels	CO2	-	-	-	-	-	-	●	●	1,989.2	458.6
1A2f Manufacturing Industries and Construction: Other	All fuels	CO2	●	●	●	●	●	●	●	●	137,298.8	77,896.2
1A3b Transport: Road Transportation	All fuels	CO2	●	●	●	●	●	●	●	●	150,358.3	145,437.9
1A3c Transport: Railways	All fuels	CO2	-	-	-	-	-	-	●	●	2,880.8	945.4
1A3e Transport: Other Transportation	All fuels	CO2	●	●	●	●	●	●	-	-	4,751.7	4,140.5
1A4a Other Sectors: Commercial/institutional	All fuels	CH4	-	-	-	-	-	-	●	-	1,216.1	61.5
1A4a Other Sectors: Commercial/institutional	All fuels	CO2	●	●	●	●	●	●	●	●	63,949.6	36,399.3
1A4b Other Sectors: Residential	All fuels	CO2	●	●	●	●	●	●	●	●	129,474.0	101,946.5
1A4c Other Sectors: Agriculture/Forestry/Fisheries	All fuels	CO2	●	●	●	●	●	●	●	●	11,059.8	6,211.5
1A5 Other: Include Military fuel use under this category	All fuels	CO2	●	●	●	●	-	-	●	●	11,811.1	1,297.6
1B1a Fugitive Emissions from Fuels: Coal mining and handling	Solid fuels	CH4	●	●	●	●	-	-	●	●	18,415.2	2,769.9
1B1c Fugitive Emissions from Fuels: Other (Abandoned Mines)	Solid fuels	CH4	-	-	-	-	-	-	●	●	1,806.8	15.1
1B2b Fugitive Emissions from Fuels: Natural gas	Gaseous fuels	CH4	●	●	●	●	●	●	-	-	7,400.1	6,173.9
2A1 Mineral Products: Cement Production	Clinker production	CO2	●	●	●	●	●	●	●	●	15,145.8	12,187.7
2A2 Mineral Products: Lime Production	Limestone and dolomite	CO2	●	●	●	●	●	●	-	-	6,176.5	5,019.3
2B1 Chemical Industry	Ammonia production	CO2	●	●	●	●	●	●	●	●	5,745.0	7,437.0
2B3 Chemical industry	Adipic acid production	N2O	●	●	●	●	-	-	●	●	18,804.6	716.4
2B5 Chemical Industry	Other	CO2	●	●	●	●	●	●	●	●	6,888.2	8,826.9
2C1 Metal Production: Iron and Steel Production	Steel (integrated production)	CO2	●	●	●	●	●	●	●	●	22,711.9	18,208.0
2C3 Aluminium Production		PFC	-	-	-	-	-	-	●	●	1,551.7	134.6
2E Production of Halocarbons and SF6	Production of HCFC-22	HFC	●	●	●	●	-	-	●	●	4,218.5	165.6
2F Industrial Processes	Consumption of Halocarbons and SF6	HFC	-	-	-	-	●	●	●	●	C	C
2F Industrial Processes	Consumption of Halocarbons and SF6	SF6	●	●	●	●	-	-	●	●	6,414.8	3,052.5
3D Total Solvent and Other Product Use		N2O	-	-	-	-	-	-	●	●	1,924.6	299.2
4A1 Enteric Fermentation	Dairy cattle	CH4	●	●	●	●	●	●	-	●	13,498.4	10,898.6
4A1 Enteric Fermentation	Non-dairy cattle	CH4	●	●	●	●	●	●	-	-	11,843.5	8,294.0
4D1 Agricultural Soils	Direct soil emissions	N2O	●	●	●	●	●	●	●	●	29,161.4	24,757.1
4D3 Agricultural Soils	Indirect emissions	N2O	●	●	●	●	●	●	●	●	16,463.1	13,268.0

IPCC Source Categories	Activity	Emissions of	Level						Trend		Emission Base Year	Emission 2010
			Base Year	Base Year +sinks	LEVEL 1990	1990 +sinks	LEVEL 2010	2010 +sinks	2010	2010 +sinks		
5A Forest Land		CO2		●		●		●		●	**-73,408.0**	**-25,060.6**
5B Cropland		CO2		●		●		●		●	**28,761.1**	**28,272.8**
5C Grassland		CO2		●		●		●		-	**11,561.9**	**9,049.9**
6A Solid Waste Disposal on Land	Managed Waste Disposal on Land	CH4	●	●	●	●	●	●	●	●	**38,598.0**	**8,967.0**
6B Wastewater Handling	Domestic and Commercial Wastewater	CH4	-	-	-	-	-	-	●	●	**2,226.2**	**70.9**

Table 8: Key categories for Germany identified solely via the Tier 2 approach

IPCC Source Categories	Activity	Emissions of
4B1a Manure Management: Other	Dairy cattle	CH_4
4B1a Manure Management: Other	Dairy cattle	N_2O
4B8 Manure Management: Swine	Swine	CH_4
4D2 Agricultural Soils	Pasture, Range and Paddock Manure	N_2O
5D Wetlands		CO_2
5E Settlements		CO_2
6B Wastewater Handling	Domestic and Commercial Wastewater	N_2O

1.6 Information regarding the quality assurance and quality control plan , the inventory plan (including verification) and management of confidential information

1.6.1 Quality assurance and quality control procedures

1.6.1.1 QC/QA plan

Pursuant to the IPCC Good Practice Guidance requirements, the necessary QC/QA measures for emissions reporting should be summarised in a QC/QA plan. Such a QC/QA plan is to serve the primary purpose of organising, planning and assuring the proper execution of such QC/QA measures.

Organisation:

A general description of the manner in which the quality assurance and control process is organised – with regard to both establishment and workflow – is provided in Chapter 1.3.3.1. That section also describes the principles by which QC/QA measures are controlled, as well as the sorts of documents and records kept in the process.

Planning:

The requirements for quality assurance and quality control measures in emissions reporting are described in detail in the "Handbook for quality control and quality assurance in preparation of emissions inventories and reporting under the UN Framework Convention on Climate and EU Decision 280/2004/EC" ("Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU Entscheidung 280/2004/EG" (Federal Environment Agency, 2007b, unpublished). The most important specifications set forth in the handbook consist of quality reviews carried out primarily during inventory preparation.

Execution:

The quality checks are carried out with the help of checklists (for the relevant content, cf. Chapters 1.3.3.1.4 and 22.1.2.1.11). These lists currently comprise some 100 role-specific individual targets and some 50 optional targets.

Currently, some 50 Federal Environment Agency and external staff, in various functional roles, and in four layered, cumulative QC/QA review levels, are involved in emissions reporting. The review levels are represented, in each case, by the relevant expert (Fachverantwortlicher - FV), his superior, the quality control manager (Qualitätskontrollverantwortlicher - QKV), a specialised contact person, within the Single National Entity, for the relevant source category (Fachlicher Ansprechpartner - FAP) and, finally, the co-ordinators responsible for achieving a consistent overall result comprising the NIR, the inventory, the QSE and uncertainties estimates.

In inventory preparation, role-specific QC/QA reviews are linked with general quality targets (cf. Chapter 22.1.2.1.10.3) and individual process steps (cf. Chapter 1.2.3), so that final evaluation can take account of such targets and steps. As a whole, the reviews cover the entire inventory-preparation process.

Subsequent evaluation of the checklists identifies source categories that need to be reviewed – and, possibly, revised – with regard to fulfillment of specific inventory requirements. Such fulfillment is achieved via addition of pertinent further information. The great majority of all identified review requirements are added to the binding inventory plan. The inventory plan undergoes internal and interdepartmental approval processes and is then published in aggregated form.

1.6.1.2 Inventory plan

For preparation of the inventory plan, the QC/QA checklist results for all source categories are evaluated. Those results are combined with any results of improvement activities mentioned in the NIR (cf. Chapter 10.4.1), evaluations of results of the various review procedures of the UNFCCC and the EU Commission and other required improvements. The inventory plan comprises a range of individual measures that are to be implemented by the various roles within the QSE (FV, QKV, FAP, ZSEK, QSEK and NaSEK; cf. the role concept within QSE, Chapter 1.3.3.1.2) and by the Federal German ministries involved in emissions reporting (cf. Chapter 1.2.1.4). In the interest of clarity, the measures as shown in the table are not grouped in accordance with pertinent areas of responsibility (such as federal ministries, the Federal Environment Agency or the roles FV, QKV, FAP, NaSEK, etc), with emissions parameters (AR, EF, emissions, etc.) or with sources of individual measures. The relevant individual measures have been combined to yield the overarching measures shown in Table 9. The inventory plan is regularly updated, within an ongoing process.

Regularly, as inventory-plan measures are implemented, large numbers of the included individual measures are processed to the point where they can be removed from the list.

Table 9: Inventory plan 2012

Category (CRF code)	Planning for inventory improvement / required actions
2.F.1, 4.A.+B, 6.B.2	Check whether requirements of IPCC Good Practice Guidance pertaining to selection of calculation method and to procedures for applicable methods changes are fulfilled or if it´s necessary to adjust already existing calculation methods/modells.
5.A.(b)	Check whether there are any gaps in the available data for time series as of 1990.
2.A.5, 6.A.1	Check whether the source category is completely covered by the relevant data source and whether the defined data sets for EF and AR are consistently delimited.
1.A.3.a.ii, 1.A.3.b+c, 1.A.4.c.iii, 1.A.5.b, 2.A.6, 6.B.2	Check whether uncertainties have been determined and are complete.
1.A.2.f, 1.A.3.a.ii, 1.A.3.b+c+d.ii+e.ii, 1.A.4., 1.A.4.c.ii+iii, 1.A.5.b, 1.B.1+2, 1.C.1.b, 6.B.2	Check whether obligations pertaining to keeping of records and documentation are fulfilled and whether the relevant documents are complete and meaningful.
1.A.3.b, 2.A.6, 2.C.2, 5, 5 (III), 5.A.(f), 5.B-F, 6.B.2	Check whether data suppliers and contracted supporting entities are carrying out suitable routine quality controls, and whether the emissions-reporting requirements defined by the Single National Entity have been provided to such suppliers and entities and are being fulfilled.
1, 1.A.1+2, 1.A.4, 1.A.4.c.ii+iii, 1.B.1+2, 2.A.1+2+4+6+7(a), 5.B-E, 6.B.2	Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.
4.A+B, 6.B.2	Check whether it was possible to take pointers from inventory reviews and inventory plan into account.
1.A.3.b, 6.B.2	Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.
1.A.3.e.ii, 4.B	Check whether the EF are plausible and complete (have no gaps and are completely documented).
1.A.4, 2.A.7.(a), 4.B, 4.D, 5, 5.A-C, 6.D.2	Check whether the AR are plausible and complete (have no gaps and are completely documented).
1.A.2.f.(a+c+d), 1.B.2.a, 6.B.2	Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).
1.A.3.d, 1.A.4, 1.B.2.d, 2.A.5, 2.C.1, 2.D.1, 4.A+B+D	Various types of required action.
1.B.1, 1.B.2.b, 2.A.4.(b), 2.A.5, 2.B.5.(e), 3.D.1+4	Check whether pertinent responsibilities need to be updated.
1.A.1, 1.A.2.f, 1.A.3.c-e, 1.B.2, 1.C.1.b, 2.A.6, 4.B, 5.B+C+E, 6.A.1, 6.D.1	Initiated research projects for inventory improvement.

In the following, additional information relative to the inventory plan is provided, in accordance with various Review Teams' recommendations to the effect that transparency be enhanced.

The first inventory plan was published together with the 2007 Submission. Since then, some 2,300 needs for action or improvement have been addressed within the quality system. Since that total is too unwieldy to be presented in any clear manner, we simply provide an overview of the development of the IP over the past 3 years (2010-2012).

As of the end of the 2012 reporting year, the inventory plan comprises some 1,000 needs for action or improvement. Those items span about 160 source categories.

A total of 540 of the improvement items have been successfully addressed. The focuses of the improvements include the areas of documentation, verification and review results. The focuses of the some 435 improvement items that are still open or still undergoing processing include documentation, QC with regard to data suppliers and verification.

The overviews in Table 10 and Table 11 present detailed information on the improvement items – those that have been successfully addressed and those that are still open. The tables include the review results from the years 2006-2011, the statements made in the NIR relative to planned improvements in 2011 and 2012, the other improvement items from 2008-2012 and the CHKL results from 2010-2012 (earlier years will have to be integrated within the overview at a later date).

Detailed information regarding individual improvements, with respect to source categories, priorities, deadlines, responsibilities, gases, fuels, quality targets, needs for action, etc., cannot be provided here, due to the sheer scope of the information involved. Additional excerpts from the inventory plan, relative to review results that have been successfully addressed, are presented in Table 281 (Compilation of successfully addressed review recommendations documented in the IP), while the statements made in the NIR relative to planned improvements are presented in Table 282 (Summary of planned improvements as described in the source-category chapters).

Table 10: Inventory plan - Needs for action/improvements that have been successfully addressed

Main category	Category (CRF-Code)	Planned improvement / required action	Source	Source: year of reporting
Energy	1.A	Check whether requirements of IPCC Good Practice Guidance pertaining to selection of calculation method and to procedures for applicable methods changes are fulfilled or if it´s necessary to adjust already existing calculation methods/modells.	ARR	2008
Industrial Processes	2.B.5, 2.E.3		S&A I	2006
Energy	1.A.2	Check whether the data source (s) used will be available throughout the long term.	CHKL	2011
Agiculture	4.A.(a), 4.B.(a)		CHKL	2010
LULUCF	5		Sonstige	2008
Energy	1.A.3.c	Check whether there are any gaps in the available data for time series as of 1990.	CHKL	2010
Industrial Processes	2.C.2+3		CHKL	2010, 2011
Agiculture	4.A.(b), 4.D		CHKL	2010, 2011
Energy	1.A.2	Check whether uncertainties have been determined and are complete.	CHKL	2011
Industrial Processes	2.A.5, 2.C.2+3		CHKL, NIR	2010, 2011
LULUCF	5, 5(III+IV), 5.A.(c+f), 5.B-F		Sonstige, CHKL, NIR	2010, 2011
Waste	6.A.1		CHKL	2011
Energy	1.A, 1.A.1+2, !.A.3.a.ii, 1.A.3.B+C, 1.A.3.d.ii, 1.A.3.e, 1.A.4, 1.A.5.a+b, 1.B.1, 1.C.1.b	Check whether obligations pertaining to keeping of records and documentation are fulfilled and whether the relevant documents are complete and meaningful.	CHKL	2010, 2011
Industrial Processes	2.C.2+3, 2.D.1+2		CHKL	2010, 2011
Agiculture	4.A.(a), 4.B.(a)		CHKL	2010
LULUCF	5(IV), 5.A		CHKL	2010
Waste	6.A.1, 6.B.2, 6.D.		CHKL	2010, 2011
Energy	1.A.2, 1.A.3.a.ii, 1.A.3.b+c, 1.A.3.d.ii, 1.A.3.e.ii, 1.A.4.c.ii, 1.A.5.b, 1.C.1.b	Check whether data suppliers and contracted supporting entities are carrying out suitable routine quality controls, and whether the emissions-reporting requirements defined by the Single National Entity have been provided to such suppliers and entities and are being fulfilled.	CHKL	2010, 2011
Industrial Processes	2.C.2		CHKL	2011
Agiculture	4.A.(a), 4.B.(a+b), 4.D		CHKL	2010, 2011
LULUCF	5(III), 5.B-F		CHKL	2010
Waste	6.B.2		CHKL	2010, 2011
Alle	Alle	Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.	ARR	2008
Energy	1.A, 1.A.1+2, 1.A.3.a, 1.A.3.b-d, 1.A.3.d.ii, 1.A.3.e, 1.A.5.b, 1.B.1+2, 1.C.1.a		ARR, Eu-Rev, S&A I, CHKL	2006, 2007, 2008, 2010, 2011
Industrial Processes	2.A.2, 2.A.7.(b), 2.B.1, 2.C.1-3, 2.D.2,		CHKL	2010, 2011
LULUCF	5(III), 5.B-F		CHKL	2010
Waste	6.A.1		CHKL	2011

Main category	Category (CRF-Code)	Planned improvement / required action	Source	Source: year of reporting
Alle	Alle	Check whether it was possible to take pointers from inventory reviews and inventory plan into account.	ARR, IRR	2006, 2007, 2009, 2010
Energy	1, 1.A, 1.A.1.a, 1.A.2, 1.A.2.a, 1.A.2f, 1.A.3.b-d, 1.B.2, 1.BU.1, 1.C.1		ARR, IRR, SL	2006, 2007, 2008, 2009, 2010
Industrial Processes	2, 2.A.1-4, 2.B.1-3, 2.C.1-4, 2.E, 2.F		ARR, IRR, CHKL	2006, 2007, 2008, 2009, 2010
Solvents	3.A – 3.D		ARR	2008
Agiculture	4, 4.A-B, 4.D		ARR, IRR	2006, 2008, 2009, 2010
LULUCF	5, 5.A-D		ARR, IRR	2006, 2008, 2009, 2010
Waste	6, 6.A, 6.B, 6.B.2, 6.C, 6.D		ARR, IRR	2006, 2008, 2009, 2010
Energy	1.A.1+2, 1.A.3.b+d, 1.A.4, 1.B.1.a, 1.B.2	Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	EU-Rev, S&A I, CHKL	2006, 2007, 2010, 2011
Industrial Processes	2, 2.A.5, 2.B.2+5, 2.C.1, 2.D.1.(b), 2.F.1		EU-Rev, CHKL	2007, 2010, 2011
Agiculture	4, 4.D		ARR	2008
LULUCF	5.A.2, 5.B.1, 5.C.1		EU-Rev	2007
Waste	6.A.1, 6.B.2		EU-Rev, CHKL	2007, 2011
Energy	1.A.1, 1.A.2, 1.A.4, 1.A.5.a, 1.C.1.b	Check whether the EF are plausible and complete (have no gaps and are completely documented).	EU-Rev, S&A I, NIR	2006, 2007, 2011
Industrial Processes	2.B.1, 2.F		EU-Rev	2007
Agiculture	4.B.(b)		EU-Rev	2007
LULUCF	5.C.2		EU-Rev	2007
Energy	1.A.1; 1.A.2; 1.A.4; 1.A.5.a, 1.B.1c	Check whether the AR are plausible and complete (have no gaps and are completely documented).	EU-Rev, S&A I, NIR	2006, 2007, 2011
Agiculture	4.B+D		NIR	2011
Waste	6.B.2	Check whether data has been entered into the CSE correctly, including whether all numbers, units and conversion factors have been correctly entered and properly integrated.	CHKL	2011
Energy	1.A.2.f.(a+c), 1.B.1.c	Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	ARR, CHKL	2008, 2011
Industrial Processes	2.C, 2.C.2+3, 2.D.1.(b)		EU-Rev, CHKL	2007, 2010, 2011
Energy	1, 1.A.1+2+4	Check whether any recalculations are required. If they are they must be documented in a logical manner.	EU-Rev, S&A I	2006, 2007
Industrial Processes	2		EU-Rev, S&A I	2006, 2007
Agiculture	4		S&A I	2006
Waste	6.D		EU-Rev	2007
Alle	Alle	Various types of required action.	Sonstige	2010
Energy	1.A., 1.A.3.a+e		NIR, Sonstige	2009, 2011
Industrial Processes	2.A.5		CHKL	2010
Solvents	3.A+B, 3.D.1+4+5		CHKL	2010
LULUCF	5.A-D		ARR, NIR	2008, 2011
Energy	1.A.2.d, 1.A.3.e.i	Check whether pertinent responsibilities need to be updated.	CHKL	2010
Industrial Processes	2.A.6, 2.D.1		CHKL	2010
Waste	6.B.2		CHKL	2010
Energy	1.B.1.c	Initiated research projects for inventory improvement.	NIR	2011
Industrial Processes	2.A.1		NIR	2011
LULUCF	5.A+E		NIR	2011

Table 11: Inventory plan - Needs for action that are still open or still undergoing processing

Main category	Category (CRF-Code)	Planned improvement / required action	Source	Source: year of reporting
Industrial Processes	2.F.1+6	Check whether requirements of IPCC Good Practice Guidance pertaining to selection of calculation method and to procedures for applicable methods changes are fulfilled or if it´s necessary to adjust already existing calculation methods/modells.	NIR, CHKL	2010, 2012
Agiculture	4.A.+B		NIR, Sonstige	2009, 2012
Waste	6.B.2		CHKL	2011, 2012
Waste	6.D.(b)	Check whether the data source (s) used will be available throughout the long term.	CHKL	2010
LULUCF	5.A.(b)	Check whether there are any gaps in the available data for time series as of 1990.	CHKL	2012
Energy	1.A.3.e.ii	Check whether the source category is completely covered by the relevant data source and whether the defined data sets for EF and AR are consistently delimited.	CHKL	2011
Industrial Processes	2.A.5		CHKL	2012
Waste	6.A.1, 6.B.2		CHKL | NIR	2011, 2012
Energy	1.A.3.a.ii, 1.A.3.b+c, 1.A.4.c.iii, 1.A.3.e.ii, 1.A.5.b	Check whether uncertainties have been determined and are complete.	CHKL	2010, 2011, 2012
Industrial Processes	2.A.6, 2.C.1		CHKL	2011, 2012
Waste	6.B.2		CHKL	2010, 2011, 2012
Energy	1.A.2.e, 1.A.2.f, 1.A.3.a.ii, 1.A.3.b+c+d.ii+e.ii, 1.A.4., 1.A.4.c.ii+iii, 1.A.5.b, 1.B.1+2, 1.C.1.b	Check whether obligations pertaining to keeping of records and documentation are fulfilled and whether the relevant documents are complete and meaningful.	CHKL	2010, 2011, 2012
Industrial Processes	2.C.1, 2.D.1+2		CHKL	2010, 2011
LULUCF	5, 5 (III), 5.B-F		CHKL	2008, 2010
Waste	6.A.1, 6.B.2, 6.D.(b)		CHKL	2010, 2011, 2012
Energy	1.A.1, 1.A.3.b	Check whether data suppliers and contracted supporting entities are carrying out suitable routine quality controls, and whether the emissions-reporting requirements defined by the Single National Entity have been provided to such suppliers and entities and are being fulfilled.	CHKL	2010, 2011, 2012
Industrial Processes	2.A.6, 2.C.2		CHKL	2012
Agiculture	4, 4.A(b)+B(b), 4.D		CHKL, Sonstige	2008, 2010, 2011, 2012
LULUCF	5, 5 (III), 5.A.(f), 5.B-F		CHKL, Sonstige	2008, 2010, 2012
Waste	6.B.2		CHKL	2012
Energy	1, 1.A, 1.A.1+2, 1.A.3.b+e, 1.A.4, 1.A.4.c.ii+iii, 1.A.5.a, 1.B.1+2	Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.	CHKL, NIR	2010, 2011, 2012
Industrial Processes	2.A.1+2+4+6+7(a)		CHKL, NIR	2011, 2012
LULUCF	5.B-E		CHKL	2010, 2012
Waste	6.B.2		CHKL	2010, 2011, 2012
Alle	Alle	Check whether it was possible to take pointers from inventory reviews and inventory plan into account.	IRR, ARR	2006, 2010
Energy	1, 1.A, 1.A.1.b, 1.A.3.d, 1.B.1, 1.B.2.b		IRR, ARR	2006, 2009, 2010
Industrial Processes	2.A.2, 2.C.1		ARR	2010
Agiculture	4, 4.A+B		ARR, NIR	2008, 2010, 2012
LULUCF	5, 5.A.1		ARR, SL	2008, 2009, 2010
Waste	6.B.1+2		ARR, CHKL	2008, 2010, 2011, 2012
Energy	1.A., 1.A.3.b, 1.A.4.c.ii	Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	ARR, CHKL	2008, 2011, 2012
Industrial Processes	2.A.6		CHKL	2010
Waste	6.B.2		CHKL	2011, 2012
Energy	1.A.3.e.ii	Check whether the EF are plausible and complete (have no gaps and are completely documented).	CHKL	2011, 2012
Agiculture	4.B		NIR	2012

Main category	Category (CRF-Code)	Planned improvement / required action	Source	Source: year of reporting
LULUCF	5.B-.D		NIR	2011
Alle	Alle	Check whether the AR are plausible and complete (have no gaps and are completely documented).	Sonstige	2008
Energy	1.A.3.a, 1.A.4		NIR, CHKL	2011, 2012
Industrial Processes	2.A.7.(a)		NIR	2011, 2012
Agiculture	4.A (b), 4.B, 4.D		NIR	2011, 2012
LULUCF	5, 5.A-C		NIR	2011, 2012
Waste	6.A.1, 6.D.2		NIR	2011, 2012
Energy	1.A.2.f.(a+c+d), 1.B.2.a	Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	CHKL	2012
Industrial Processes	2.A.6		CHKL	2010
Waste	6.B.2		CHKL	2010, 2011, 2012
Energy	1.A.3.b+d, 1.A.3.e.ii, 1.A.4, 1.A.5.b, 1.B.1, 1.B.2.d	Various types of required action.	CHKL | NIR	2010, 2011, 2012
Industrial Processes	2.A.5, 2.C.1, 2.D.1		NIR	2011, 2012
Agiculture	4, 4.A+B+D		NIR	2011, 2012
LULUCF	5, 5.A		NIR	2011
Energy	1.B.1, 1.B.2.b	Check whether pertinent responsibilities need to be updated.	CHKL	2010, 2011, 2012
Industrial Processes	2.A.4.(b), 2.A.5+6, 2.B.5.(e), 2.B.5.GER.2		CHKL	2010, 2011, 2012
Solvent & Other	3.D.1+4		CHKL	2010, 2011, 2012
Energy	1.A.1, 1.A.2.f, 1.A.3.c-e, 1.B.2, 1.C.1.b	Initiated research projects for inventory improvement.	NIR	2011, 2012
Industrial Processes	2.A.6		NIR	2011, 2012
Agiculture	4.B		NIR	2012
LULUCF	5.A-E		NIR	2011, 2012
Waste	6.A.1, 6.D.1		NIR	2011, 2012

1.6.2 Activities for verification

1.6.2.1 Procedure for using monitoring data from European emissions trading

In efforts to fulfil mandatory quality criteria, a need has been seen – especially within the EU – to use data from the EU Emissions Trading Scheme (EU ETS) to improve greenhouse-gas emissions inventories. All Member States are now called upon to use ETS data to improve the quality of their annual national emissions inventories.

A reliable database from emissions trading, showing relevant annual emissions, is available for the period since ETS monitoring commenced. This data can be used, in aggregated form, to draw source-category-specific conclusions regarding the completeness and consistency of certain parts of emissions inventories. In addition, it provides a basis for reviewing emission factors used and for verifying activity data. Since emissions calculations for all components are all based on the same activity data, such verification is of significance for all reported emissions inventories.

Emissions-trading data required for improvement of inventory data subject to reporting are available in electronic form, in the installations database of the German Emissions Trading Authority (DEHSt). In 2005, agreement was reached regarding a general procedure for individual data queries related to inventory preparation. In the main, this procedure involves direct communication between the Single National Entity and the German Emissions Trading Authority's section E 2.3.

Monitoring data from European emissions trading will be used to improve the quality of annual national emissions inventories with respect to source categories that include installations subject to reporting obligations under the CO_2 Emissions Trading Scheme (ETS). To make it possible to use this "resource" on a regular basis, a formalised procedure for the pertinent required annual data exchanges, including deadlines and defined workflows, has been agreed.

In a research project (ÖKO-INSTITUT, 2006b), allocation rules were developed that make it possible to compare data from verified emissions reports with data from the inventories' database, on a year-by-year basis. The comparisons, which have been carried out only once to date, have confirmed, in principle, the usefulness of such comparisons for verifying individual source categories and identifying data gaps. A follow-on project begun in 2011, "D.E.N.K.", is studying whether the allocation rules can be improved and the relevant procedure could be further automated. It has become clear that the data the ETS provides for inventory calculations are resources-critical and time-critical. When discrepancies occur in existing aggregates that fulfill requirements for confidentiality of business and operational secrets, the underlying data sets for individual operational steps have to be checked. At an international workshop held within the project framework, experts of other countries confirmed that issue's importance for the German situation. The number of ETS data sets is so large – 35,000 – that the limits of capacities for checking such sets (instead of automatically using the pertinent aggregates) are being reached. Consequently, it will not be possible to bring the procedure used in this area into line with the procedures used in other countries.

1.6.2.2 Workshop on the National System (Peer Review)

In November 2004, the Federal Environment Agency held a first workshop on the National System of Emissions Inventories. This created a forum that significantly promoted inclusion of associations and other independent organisations, as well as supporting implementation of Paragraph 15 (b) of the *Guidelines for National Systems*, which requires that inventories be reviewed by third parties (peer review).

In May 2009, a second workshop on the National System was held, with the purpose of facilitating another review of the inventories by independent third parties, pursuant to Paragraph 15 (b) of the *Guidelines for National Systems*. That second workshop focussed on specific source categories within the inventory. The selected areas included "N_2O from product use", "emissions from non-energy-related use of fossil fuels" and "SF_6 emissions from the photovoltaics industry". The persons invited to the discussion of inventory areas included experts from the various sectors, industry representatives and independent experts. For example, with regard to the area of use of N_2O, the invited participants included sellers of industrial gases, and representatives of the Berufsverband deutscher Anästhesisten (BDA; Professional Association of German Anaesthetists) and of the Federal Institute for Materials Research and Testing (BAM). With regard to the area of non-energy-related uses, discussions were held with representatives of the Association of the German Chemical Industry (VCI) and of affected chemical producers. Participants with a focus on photovoltaics production included representatives of producers, industrial-gas sellers, systems builders, universities and research establishments. The topics were comprehensively and intensively discussed. The workshop contributed significantly to overall improvement of the data and of the quality of reporting.

In May 2011, an international experts' workshop on the German LULUCF-reporting system took place. That workshop reviewed the methodological changes made as a result of the In-Country Review of September 2010. All of the recommendations made by experts in that framework have been fully implemented. The key results of the experts' workshop are presented in Chapter 19.5.5.

1.6.2.3 Cross-Country Review on fluorinated gases

In February 2011, a group of experts met in Vienna for a cross-country review focussing on reporting on F gases. The participating countries included the UK, Austria and Germany. After basic presentations of data collection in the three countries, the various individual areas of application concerned were considered in detail and compared in terms of data sources, precision, emission factors and other criteria. In the process, it emerged that, of the three countries, Germany has the most extensive specialised knowledge resources and presumably is thus best able to assess the completeness and plausibility of the available data.

One of the key results that emerged from the cross-country review is that all three countries have to commit high levels of manpower to reporting on F gases. Any reduction in such resources commitments would mean that reporting would no longer be IPCC-conformal.

As a result of the meeting, a report was prepared that is to be forwarded to the EU Commission and the IPCC, inter alia. To save time, important aspects affecting the UNFCCC were forwarded promptly to the UNFCCC Secretariat.

1.6.3 Handling of confidential information

When the Federal Statistical Office began providing data in connection with the entry into force of the 3rd SME Relief Act (Mittelstandsentlastungsgesetz 3; MEG 3), the Federal Environment Agency received access to data subject to statistical secrecy.

In addition, from associations and companies, the Single National Entity receives activity data, emission factors and emissions data that reflect operational and business secrets and that are otherwise confidential.

In storing and using such data, therefore, the Single National Entity must take special precautions, and apply special procedures, to protect the confidentiality of the data.

In particular, it must provide for strict separation (both spatial and in terms of staff assignments) of statistical work / analysis and any enforcement of legal provisions pertaining to the installations for which data are collected.

The Single National Entity has taken a range of measures to fulfil these requirements. For example, as a basic rule, persons charged with enforcement of laws in a specific area are never permitted to carry out specialised tasks relative to emissions reporting in the same area.

In 2008, the Single National Entity commissioned a legal study with the aim of precisely assessing the requirements and possibilities pertaining to use and management of data for emissions reporting. The results entered into revision and refinement of the Single National Entity's concept for handling confidential data.

Previously, access to the Central System on Emissions (CSE) database was already limited to a specified group of authorised persons. That measure represents the key precaution for dealing with confidential data. In particular, it makes it practicable to separate - in terms of the persons involved - the tasks of data analysis and legal control. In addition, in 2009 a special access-restricted area was set up, on a central server of the Federal Environment Agency, for confidential electronic data that are not centrally stored in the CSE (for example, emissions-control declarations, data relative to large combustion plants, information about production processes, etc.).

Furthermore, data provided by the *Federal Statistical Office* are placed on a password-/access-protected server (i.e. available only for specifically authorised persons) at the *Federal Statistical Office*.

1.7 General estimation of uncertainties

1.7.1 Greenhouse-gas inventory

The IPCC Good Practice Guidance (GPG, 2000) characterises determination of uncertainties as a key element of any complete inventory. As a result of the GPG's focus on continual inventory improvement, uncertainties in the inventories play an important role. Uncertainties information is used primarily as an aid for improving the precision of inventories, as well as for selecting methods and carrying out recalculations for inventories. The declared aim is to minimise uncertainties to the greatest possible degree, in order to maximise the inventories' accuracy. Annex I countries must thus first quantify the uncertainties for all source categories and sinks, in order to enhance their assessment of inventory quality – which assessment, in turn, is the key to effective inventory planning.

Uncertainties are quantified for emission factors and activity data; in some cases, they are also quantified for emissions.

In general, two methods for determining uncertainties are differentiated. The Tier 1 method combines, in a simple way, the uncertainties in activity data and emission factors, for each source category and greenhouse gas, and then aggregates these uncertainties, for all source categories and greenhouse-gas components, to obtain the total uncertainty for the inventory. The Tier 2 method for uncertainties determination is the same, in principle, but it also considers the distribution function for uncertainties and carries out aggregation using Monte Carlo simulation. In the Tier 2 method, this process also necessarily includes determining a probability density function for both parameters. Ideally, these functions can be determined via statistical evaluation of individual data items (such as measurements for a large number of facilities). In many cases, few relevant values are available, however, and thus the uncertainty must be determined on the basis of experts' assessments.

Research project 202 42 266 (UBA, 2004) determined uncertainties in keeping with the Tier 1 and Tier 2 methods, pursuant to Chapter 6 of the GPG. Since then, the resulting database has been continually improved, and the uncertainties data for the greenhouse-gas inventory have been further improved for the 2009 report. In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 1 method. The uncertainties for the activity data, emission factors and emissions data used were taken from the CSE database. They are based on estimates of experts in relevant departments of the Federal Environment Agency and at external institutions. In cases in which uncertainties information is not yet available in complete form, as an expert's estimate, pertinent figures are added from other sources (such as relevant technical literature), in the framework of a Tier 1 calculation.

1.7.1.1 Tier 1 approach for uncertainties determination

In the Tier 1 method, in keeping with Chapter 6 of the GPG, uncertainties are determined on the basis of the uncertainties for AR, EF and EM, as determined on the lowest sub-category level (primarily by responsible experts of the Federal Environment Agency), and as listed in the CSE. Where asymmetric uncertainties figures are yielded, the larger of the two relevant values is used, under the assumption of a normal distribution, as both the upper boundary and the lower boundary. In each sector, the uncertainties for the individual time series are aggregated to form a total uncertainty for the sector pursuant to the IPCC Good Practice Guidance. In Formula 6.3, sinks are taken into account as emissions quantities ($|x_i|$ in Formula 6.3). A similar approach applies for determination of the combined uncertainties within the inventory (Column H in Table 6.1 of the IPCC Good Practice Guidance, Formula G * |D| / sum |D|).

1.7.1.2 Results of uncertainties assessment

In general, uncertainties for activity data can be assumed to be smaller than those for emission factors. In particular, the uncertainties are smaller for activity data derived from fuel use and based on the Federal Energy Balance. On the other hand, uncertainties for activity data derived from disaggregated fuel use normally increase as the relevant disaggregation increases.

- Pursuant to the results from an R&D project (RENTZ et al, 2002), the uncertainties in emission factors for indirect greenhouse gases in stationary combustion systems (CRF 1.A.1) are relatively small, as a result of regular monitoring of such emissions. Higher uncertainties are listed for N_2O emission factors, since N_2O emissions are not normally monitored. The same applies to the emission factors for CH_4.
- The uncertainties in the Transport source category (primarily CRF 1.A.3) can generally be considered to be small, since precise relevant data on fuel use and vehicle fleets are available, due to taxation obligations, and since that category's emission factors have been very finely modelled and are normally determined via measurements. Some uncertainties may arise via systematic measuring errors or wrong disaggregation.
- In the source category Fugitive emissions from fuels (CRF 1.B), the uncertainties for the activity data for oil and natural gas (CRF 1.B.2) are low, as a result of the fuels' being subject to taxation. Flaring of natural gas represents the only exception. The activity data for Coal mining (CRF 1.B.1) are also well-represented by production volumes. By contrast, the uncertainties for emission factors for fugitive emissions are likely to be higher. On the one hand, this results from the many different technical factors that affect fugitive emissions in transport, storage and processing of oil and natural gas. On the other hand, fugitive CH_4 emissions from coal mining have thus far been taken into account only as lump sums.

- Considerable uncertainties are seen in many areas in the category of industrial processes (CRF 2). Activity data based on production figures that must be reported to the Federal Statistical Office can be subject to uncertainties, especially as a result of discrepancies between reporting structures and relevant industry definitions. Activity data determined from association information are subject to uncertainties that correlate, in each case, with the degree to which the relevant industrial sector is represented in the association in question. For emission factors, uncertainties – which can be considerable, depending on the greenhouse gas in question – result, understandably, from the factors' strong dependence on technology, in combination with extensive technological diversification. Furthermore, equipment-specific emission factors often are tied to business secrets, particularly in sectors with few market players (for example, manufacturing of chemical products (CRF 2.B)), and this tends to make operators hesitant to publish such data or leads them to provide information in consolidated form. In addition, uncertainties can be higher for complex processes in which non-combustion-related activities generate emissions, if relevant emissions-generating processes are inadequately understood and the relevant contributions of pertinent individual activities are not known.
- In the area of production of alcoholic beverages, within the area of Food and drink production (CRF 2.D.2), the activity-rate uncertainties must be considered very small, since production of such beverages is subject to taxation regulations that require very precise determination of production volumes. On the other hand, statistics for sectors with large numbers of small and medium-sized enterprises (such as baked-goods production) tend to be significantly less precise, and thus the activity data for such sectors are subject to higher uncertainties. The uncertainties for the relevant emission factors are also larger, due to the sectors' extensive technological diversification.
- The uncertainties for emissions parameters for the source categories Managed waste disposal in landfills (CRF 6.A.1, 6.D) and Industrial wastewater treatment (CRF 6.B.1) are presumed to be high. This applies especially to the areas of composting, MBT and waste landfilling, which have high waste-type diversity that tends to reduce the reliability of data for the relevant emissions parameters. The reasons for the higher uncertainties seen for activity data include the fact that the underlying statistical data make use of non-standardised waste and recycling definitions. The general assumptions relative to the uncertainties of activity data also apply to thermal treatment of waste.

Pursuant to Tier 1, the inventory's total uncertainty figures for 2010 are 5.9 % (level) and 6.3% (trend).

In comparison to the previous year, the total uncertainty has decreased slightly, primarily as a result of revision of inventories for nitrous oxide emissions from agricultural soils, inventories which are subject to high levels of uncertainties. At the same time, in some other source categories high default uncertainties were replaced with new expert assessments.

Nitrous oxide emissions overall account for a major share of total uncertainty, and that share is defined noticeably by nitrous oxide from agricultural soils (4.D). Significant contributions to the total uncertainty have also come from the areas of CO_2 sinks and sources of the LULUCF sector and methane emissions from animal husbandry (enteric fermentation, 4.A).

The CO_2 emissions of the sector Combustion of fuels (1.A) contribute another important share of the total uncertainty. The predominating components of that share include solid fuels in the sector Public electricity and heat production (1.A.1.a) and mobile sources (1.A.3), especially road transports (1.A.3.b) and combustion in the residential, commercial and institutional sectors (1.A.4.a/b).

- Detailed information about the applicable uncertainties is provided in Annex 7 (cf. Chapter 23).

1.7.2 KP LULUCF inventory

Since reporting for source category 5.A under a) UNFCCC and under b) KP does not make use of separate inventories for the two areas, the uncertainties for both reporting areas are the same. The information provided in the previous chapter and in the relevant source category chapters (cf. Chapter 7.2.5) applies.

1.8 General checking of completeness

1.8.1 Greenhouse-gas inventory

Completeness information for the various individual source categories is presented in CRF Tables 9(a) und 9(b), which, in turn, are summarised in NIR Chapter 21 (Table 340 and Table 341). The following are differentiated in Germany:

- Source-specific emissions and sinks that do not occur (NO – not occurring),
- Source-specific emissions and sinks that are not estimated in Germany, either because they are not quantitatively relevant or because the necessary data for estimates are lacking (NE – not estimated), and
- Source-specific emissions and sinks that are completely accounted for, pursuant to the latest scientific findings, for Germany (All or Full), or that are partly accounted for (Part).

The following section touches on a few source-category-specific approaches for improving the completeness of the inventory.

All combustion-related activities (1 A) from the area of energy are recorded in full. At certain points, the Energy Balance of the Federal Republic of Germany is supplemented if it is evident that complete coverage is not achieved in selected sub-sections (such as the non-commercial use of wood, secondary fuels). In some source categories, separation of combustion-related and non-combustion-related emissions from industry requires further verification. In general, avoidance of duplicate counting is an important part of quality assurance for such categories, however.

In the area of industrial processes, some use is made of production data from association statistics and of manufacturers' information. In the interest of the inventory's completeness and reliability, where emissions reporting is based on such sources, checking of source-category definitions and data-collection methods will continue to receive priority.

The "Not Estimated" (NE) emissions, which are still reported, consist primarily of non-calculated emissions that, pursuant to IPCC GPG (2003, p.1.11), do not have to be calculated by a reporting country, since those emissions are listed in Appendices 3a.2, 3a.3 and 3a.4..

Some of the emissions data available to the Federal Environment Agency are confidential, due to data-protection requirements, and thus are reported only in aggregated form – although they are reported completely.

An agreement covering provision of data to the Single National Entity by the German Emissions Trading Authority (DEHSt) has been concluded in order to assure the regular exchange of data.

1.8.2 KP LULUCF inventory

Since reporting for source category 5.A under a) UNFCCC and under b) KP does not make use of separate inventories, the information provided in the previous chapter applies.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

Table 12 below shows the total emissions, as determined for this inventory, of direct and indirect greenhouse gases and of the acid precursor SO_2. The reference figure defined, in keeping with results of review of the initial report carried out in 2007[16] and of reporting in 2006 pursuant to Article 8 of the Kyoto Protocol – and independently of any further possible improvements in the basic data – for reduction obligations under the Kyoto Protocol is 1,232,429.543 Gg CO_2 equivalent. Pursuant to its obligations under the Kyoto Protocol and EU burden sharing (Council Decision 2002/358/EC), Germany's reduction obligations amount to 21 %. Table 13 shows the annual progress achieved, with respect to 1990, for each pertinent year. With the exception of HFCs, significant reductions in emissions have been achieved for all the emissions calculated here. In total, greenhouse-gas emissions, calculated as CO_2 equivalents, decreased by 24.0 % compared to the aforementioned reference figure.

Table 12: Emissions of direct and indirect greenhouse gases and SO_2 in Germany since 1990

Emissions development (Gg)	1990	1995	2000	2005	2006	2007	2008	2009	2010
Net CO_2 emissions / removals	1,014,192	903,574	864,834	881,490	886,282	864,814	862,545	801,257	835,991
CO_2 emissions (not including LULUCF)	1,042,161	931,040	891,624	865,959	871,041	849,040	846,526	784,297	818,962
CH_4	5,100	4,344	3,497	2,647	2,503	2,404	2,412	2,312	2,271
N_2O	275	258	200	199	196	202	206	205	177
HFCs (CO_2 equiv.)	4,592	6,912	7,040	10,252	10,794	11,369	11,657	12,128	11,597
PFCs (CO_2 equiv.)	2,627	1,773	781	709	571	510	521	359	309
SF_6 (CO_2 equiv.)	4,642	6,779	4,269	3,475	3,396	3,332	3,114	3,059	3,250
CO	12,368	6,556	4,804	3,651	3,571	3,473	3,387	3,002	3,322
NMVOC	3,127	1,805	1,390	1,143	1,131	1,069	1,015	929	1,051
NO_X	2,884	2,176	1,925	1,576	1,562	1,489	1,415	1,318	1,319
SO_2	5,292	1,718	653	517	520	497	490	435	449

[16] "Report of the review of the initial report of Germany", FCCC/IRR/2007/DEU, of 12 December 2007 published at: http://unfccc.int/national_reports/initial_reports_under_the_kyoto_protocol/items/3765.php

Table 13: Changes in emissions of direct and indirect greenhouse gases and SO_2 in Germany, since the relevant reference years

Emissions change with respect to the reference year / previous year (%)	**Reference year**	**Reference year until 2009**	**Reference year until 2010**	**With regard to the previous year (2009 – 2010)**
Net CO_2 emissions / removals	*1990*	-21.0	-17.6	+4.3
CO_2 emissions (not including LULUCF)	*1990*	-24.7	-21.4	+4.4
CH_4	*1990*	-54.7	-55.5	-1.8
N_2O	*1990*	-25.3	-35.5	-13.6
HFCs (CO2 equivalent)	*1995*	+75.5	+67.8	-4.4
PFCs (CO2 equivalent)	*1995*	-79.7	-82.6	-14.2
SF_6 (CO2 equivalent)	*1995*	-54.9	-52.1	+6.2
Total emissions with respect to EU burden-sharing[17]	***Defined base year***	**-26.0**	**-24.0**	**+2.7**
CO	*1990*	-75.7	-73.1	+10.7
NMVOC	*1990*	-70.3	-66.4	+13.2
NO_X	*1990*	-54.3	-54.2	+0.1
SO_2	*1990*	-91.8	-91.5	+3.4

All detailed tables relative to discussion of trends are presented in Annex Chapter 22.3.

Trends, taking account of changes with respect to the previous year of the reporting period

With regard to the previous year, 2009, total emissions rose slightly, by 2.7 %. This resulted from an increase of CO_2 emissions and decreases in releases of methane, nitrous oxide and F gases (overall).

2.1 Description and interpretation of trends in aggregated greenhouse-gas emissions

By 2010, the obligation to reduce greenhouse-gas emissions, in the framework of EU burden-sharing, had been largely fulfilled, via a reduction of 24.0 % also in the third year of the commitment period. The individual greenhouse gases contributed to this development to varying degrees (cf. Table 1). Among the direct greenhouse gases, emissions of those gases that predominate in terms of quantity were markedly reduced, with the strongest reductions occurring for methane. The main reasons for these developments are found in the following areas:

- Transition from use of solid fuels to use of liquid and gaseous fuels, which have lower emissions, in the period since 1990;
- Growing importance of use of renewable energies and of related substitutions of fossil fuels;
- Increased plant (installation) efficiencies;
- Changes in animal-housing methods, and reductions of livestock populations;
- Fulfillment of legal regulations in the waste-management sector;

Such areas are considered in greater detail in the discussion below of trends for the various individual greenhouse gases. The global economic crisis, which had its first impact in Germany at the end of 2008, had a significant effect on emissions, as did the partial economic recovery that occurred in 2010.

[17] Established base-year emissions of 1,232,430 Gg CO_2 equivalent, not including CO_2 from LULUCF. Cf. Chapter 0.2

Releases of carbon dioxide – the great majority of which are caused by stationary and mobile combustion processes – predominate in the overall picture of greenhouse-gas emissions. Due to a disproportionately large decrease in emissions of the other greenhouse gases, the proportion of total greenhouse gases attributable to CO_2 emissions has increased since 1990 (cf. Table 2). All other greenhouse gases together account for only slightly more than one-tenth of greenhouse-gas emissions. The spectrum of distribution of greenhouse-gas emissions is typical for a highly industrialised country.

2.2 Description and interpretation of emission trends, by greenhouse gases

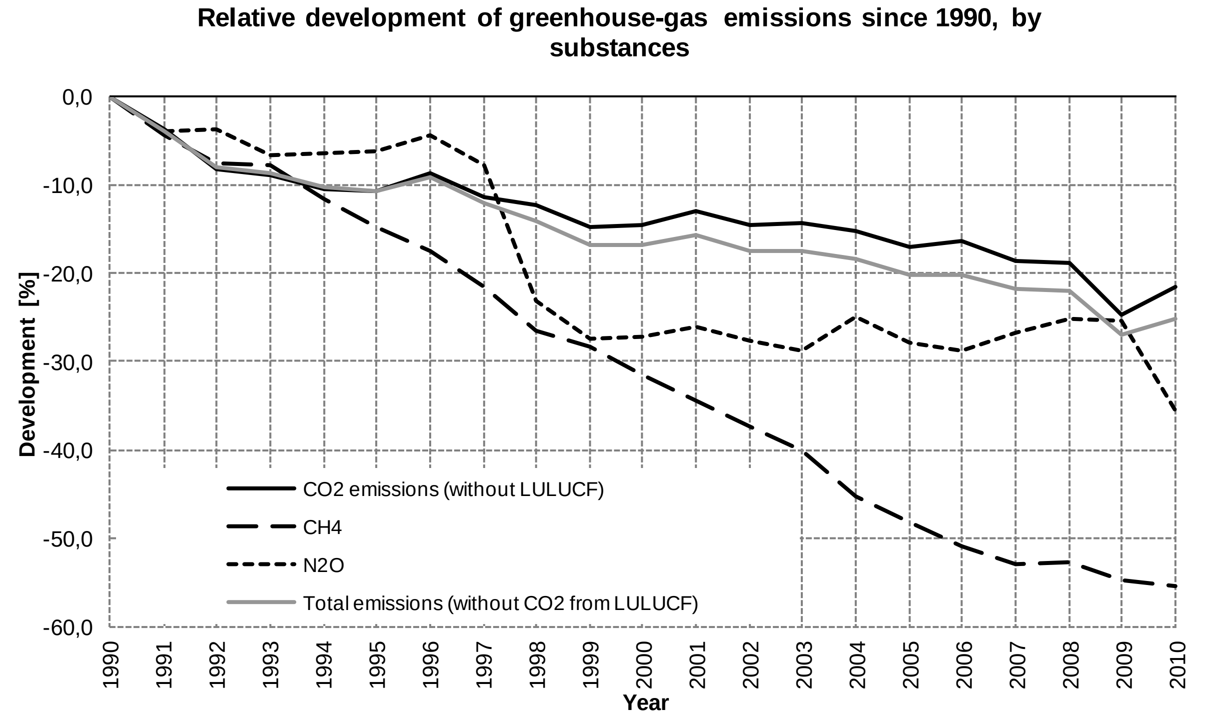


Figure 16: Relative development of greenhouse gases in comparison to their levels in 1990

Figure 16 shows the relative development of emissions of the various greenhouse gases since 1990. In the discussion, it must be remembered that the development of each of these greenhouse gases as shown here is largely dominated by specific developments in a single source category.

2.2.1 Carbon dioxide (CO_2)

The reduction in CO_2 emissions is closely linked to trends in the energy sector. The sharp emissions reduction in this area seen in the early 1990s was primarily the result of restructuring in the new German Länder, including related conversions to cleaner fuels and decommissioning of obsolete facilities. The changes in the fuel mix have continued, to a somewhat lesser degree, through the current report year.

Use of gases, primarily natural gas, as substitutes for solid and liquid fuels is also reflected in emissions trends for stationary combustion systems. While CO_2 emissions from liquid fuels decreased by about one-fourth, with respect to their levels in 1990, and emissions from solid fuels decreased by almost half, emissions from gaseous fuels increased by nearly fifty percent.

When these emissions trends are viewed at the level of individual source categories, a highly consistent picture emerges. In comparison to 1990 levels, emissions in all source categories of energy-related emissions decreased by a total of over 215 million t CO_2.

Comparable, but specific (when seen at the detailed level), developments took place in the transport sector. CO_2 emissions increased slightly from 1990 to 1999. Since then, they have fallen significantly below their outset level, to 153 million t, as a result of decreases in consumption; of shifting, by consumers, of fuel purchases to other countries; by substitution of diesel fuel for petrol; and by increasing use of biodiesel. Diesel fuel's share of total fuel consumption in road transports has increased sharply throughout the entire period in question. In 1990, nearly 2/3 of all road-traffic emissions were still being caused by petrol consumption. Now, the relationship is nearly reversed, and diesel emissions predominate.

Trends, taking account of changes with respect to the previous year of the reporting period

With respect to the previous year, emissions in nearly all economic sectors increased, as a result of economic recovery. These increases have largely outweighted other influencing factors.

In the residential sector, emissions increased with respect to the previous year, as a result of weather factors.

2.2.2 Nitrous oxide N_2O

Since 1990, N_2O emissions have decreased by about 35.5 %. The main emissions areas/sources include agriculture – use of nitrogen-containing fertilisers, and animal husbandry; the chemical industry; and use of fossil fuels. Smaller amounts of emissions are caused by wastewater treatment and product use of N_2O (for example, as an anaesthetic). Industry has had the greatest influence on emissions reductions, especially in the area of adipic acid production in 1997 and 2009. Via technological reduction measures, the chemical industry's emissions were reduced by about 80%, with respect to 1990. Since 1999, emissions trends have been strongly influenced by economic trends in the chemical industry sector. From 2009 to 2010, emissions from adipic acid production decreased drastically as a result of one producer's installation of a second redundant waste-gas-treatment system.

Trends, taking account of changes with respect to the previous year of the reporting period

Emissions in nearly all sectors increased with respect to the previous year as a result of economic factors. Nitrous oxide emissions decreased significantly only in the chemical industry.

2.2.3 Methane (CH_4)

Methane emissions are caused mainly by animal husbandry in agriculture, waste landfilling and distribution of liquid and gaseous fuels; energy-related and process-related emissions, and emissions from wastewater treatment, play an almost negligible role. Methane emissions have been reduced by 55.5 % since 1990. This trend has been primarily the result of environmental-policy measures (waste separation, with intensified recycling and increasing energy recovery from waste) that decreased landfilling of organic waste. A second key reason is that use of pit gas from coal mining, for energy recovery, has increased, while overall production of such gas has decreased (via closure of hard-coal mines). Emissions in this area have decreased by nearly 80 % since 1990. Yet another reason for the emissions reductions is that livestock populations in the new Federal Länder were reduced, especially in the first half of the 1990s. Repairs and modernisations of outdated gas-distribution networks in that part of Germany, along with improvements in fuel distribution, have brought about further reductions of total emissions.

Trends, taking account of changes with respect to the previous year of the reporting period

In comparison to the previous year, emissions decreased by 1.8 %. That development is due primarily to further reductions of landfill emissions.

2.2.4 F gases

Figure 17 shows emissions trends for so-called "F" gases for the period 1995-2010. HFC emissions increased primarily as a result of intensified use of HFCs as refrigerants in refrigeration systems and of increasing disposal of pertinent systems. This more than offset emissions reductions resulting from their reduced use in PUR installation foams. The emissions reductions for PFCs were achieved primarily through efforts of primary aluminium producers and semiconductor manufacturers. The SF_6 emissions reduction until 2003 is due primarily to decreasing use of the gas in automobile tyres since the mid-1990s. In this area, efforts to increase environmental awareness have been successful, resulting in emissions reductions of over 100 t and greenhouse-gas reductions of 2.5 million t of CO_2 equivalents. Similar success has been achieved with soundproof windows, for which production use of SF_6 has been reduced to nearly zero since 1995. At the same time, increasing emissions must be expected in the next few years as a result of increasing disposal of old sound-proof windows. And a large share of current and future emissions of this substance (will) result from open disposal of old windows. Emissions from electricity-transmission facilities also decreased considerably. Important new emissions sources include welding, production of solar cells and production of optical glass fibre. SF_6 emissions have decreased in recent years overall, however.

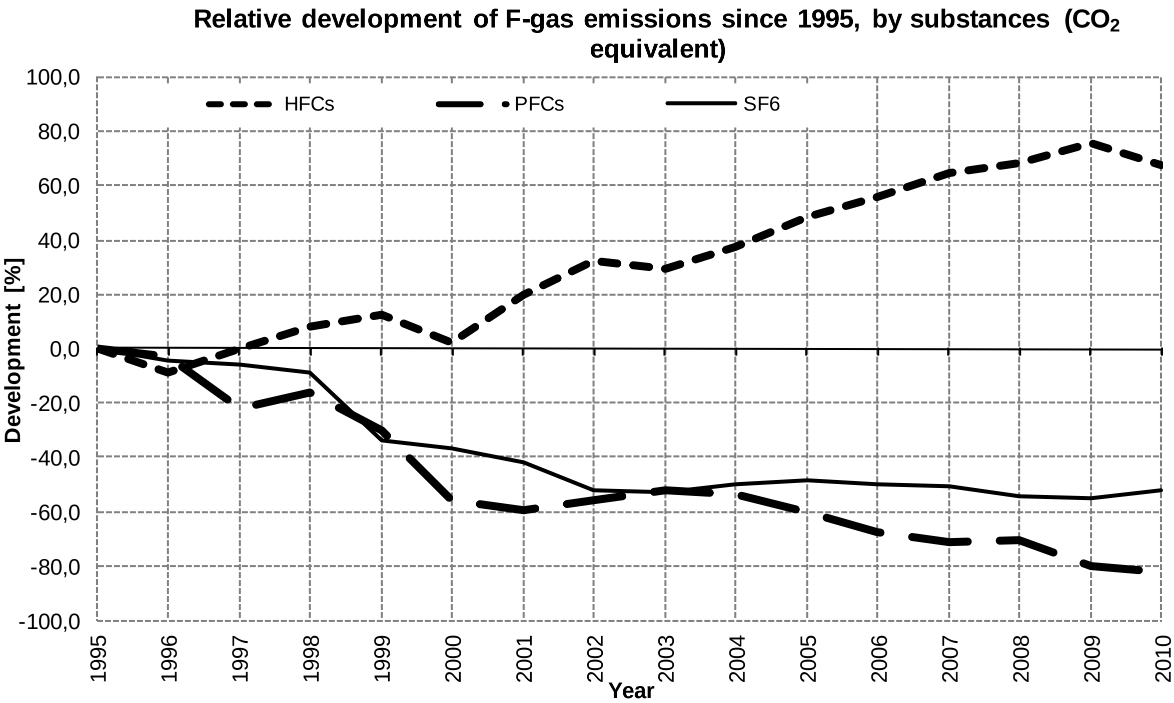


Figure 17: Relative development of F gases in comparison to relevant 1995 levels

2.3 Description and interpretation of emissions trends, by source categories

Energy

In the category of energy-sector emissions, which have been decreasing, combustion-related emissions are governed primarily by CO_2 emissions from stationary and mobile combustion systems (cf. also the results of the key-source analysis). On the other hand, emissions of other greenhouse gases are negligible in this sector. The situation is different solely for emissions that are not combustion-related (source category 1.B.). In this area, CO_2 emissions are very low, while emissions trends are clearly shaped by CH_4 emissions caused by distribution of liquid and gaseous fuels. On the whole, energy-related emissions of all greenhouse gases have decreased by nearly 23.4 % since 1990. The transport-related emissions included in greenhouse-gas emissions have decreased by slightly more than 6 % during the same period, meaning they have decreased somewhat less than emissions from stationary combustion systems have. For combustion-related emissions, this has been achieved through fuel changeovers and higher energy and technical efficiencies, as well through increasing use of zero-emissions energy sources. For distribution emissions, it has resulted from increased use of pit gas, modernisation of gas-distribution networks and introduction of vapour-recovery systems in fuel distribution.

Table 348 in the Annex shows the relevant emissions changes, in comparison to the previous year in each case, for the period since 1990. For CO_2 from the energy sector, for example, it is clear that largely temperature-related fluctuations over time – especially variations in winter temperatures – influence heating patterns. Such fluctuations thus affect energy consumption for space heating, thereby having a major impact on annual trends in energy-related emissions.

Industrial processes

In the area of emissions from industrial processes, carbon dioxide and nitrous oxide are the predominant greenhouse gases. Relatively noticeable changes in emissions of F gases, on the other hand, have no major impacts on overall trends, because such emissions account for only a small share of total emissions. Methane emissions also play an insignficant role in this context.

Emissions from industrial processes are closely tied to production levels. In particular, CO_2 emissions tend to reflect economic trends; emissions tend to increase from the previous year as production increases, especially production in the iron and steel industry and chemical industry.

The trend for N_2O emissions was decoupled from production, as adipic acid producers' emissions-reducing measures began taking effect. From 2009 to 2010, emissions from adipic acid production decreased drastically as a result of one important producer's installation of a second redundant waste-gas-treatment system. Overall since 1990, N_2O emissions have decreased to about one-sixth of their outset level.

Since 1990, emissions for the totality of all industrial processes and greenhouse gases, in GG equivalents, have been reduced by about 26.0 %. In comparison to the previous year, the decrease amounted to 3.3 %. The change with respect to the previous year was primarily the result of the above-mentioned reductions in N_2O emissions; considerably increased steel production caused significant emissions increases.

Solvent and other product use

Also since 1990, emissions in the area of solvent and product use have decreased by 57.9 %. Among the emissions tallied in the present context, indirect CO_2 emissions from use of solvents (NMVOC) predominate (those emissions accounted for a share of about 2/3). Emissions from use of N_2O as an anaesthetic have decreased by nearly 44 % since 1990.

Agriculture

The decrease in agricultural emissions since 1990, amounting to over 18.9 %, is due primarily to reductions in livestock populations, although it is also due to reductions in emissions from agricultural soils and from fertiliser use.

Land use, land-use changes and forestry

The reduction in greenhouse-gas removals via land-use changes and forestry is due primarily to a reduction of the sink function in the category "Forest Land remaining Forest Land". The decrease in forests' function as a sink is due to increasing harvesting of wood for various uses.

Waste and wastewater

The most significant emissions reduction, at 71.6 %, occurred in the area of waste emissions. In that area, intensified recycling of recyclable materials ("yellow sack" for recyclable materials, Ordinance on Packaging, etc.), and the ban, in effect since June 2005, on landfilling of biodegradable waste, have reduced annual quantities of landfilled waste. All in all, these factors have reduced landfill emissions by 77 %. Emissions from wastewater treatment, which also belong to this source category, are produced in considerably lower quantities than landfill emissions are. Nonetheless, they also decreased sharply.

Table 14: Changes in greenhouse-gas emissions in Germany, by source categories, since 1990 / since the relevant previous year

Emissions change with respect to 1990; change in %	1990	1995	2000	2005	2006	2007	2008	2009	2010
1. Energy	0.0	-11.5	-16.0	-19.0	-18.6	-20.8	-20.9	-26.2	-23.4
2. Industrial processes	0.0	2.7	-18.4	-14.6	-13.3	-10.5	-13.2	-20.6	-23.2
3. Solvent and other product use	0.0	-20.6	-35.0	-54.2	-53.7	-56.5	-59.5	-63.7	-57.9
4. Agriculture	0.0	-12.1	-11.2	-16.1	-17.7	-18.7	-15.3	-17.5	-18.9
5. Land use, land-use changes & forestry									
CO2 (net sink)									
N2O & CH4	0.0	-2.1	-1.6	-0.7	-0.3	-1.3	-0.9	-2.5	-5.3
6. Waste	0.0	-7.6	-37.2	-59.2	-63.4	-66.8	-67.1	-69.8	-71.6

Emissions change, in each case with respect to the previous year; change in %	1990	1995	2000	2005	2006	2007	2008	2009	2010
1. Energy	0.0	-0.4	-0.2	-1.9	0.4	-2.7	-0.1	-6.7	3.8
2. Industrial processes	0.0	-1.9	3.8	-3.2	1.6	3.3	-3.1	-8.5	-3.3
3. Solvent and other product use	0.0	0.2	-8.1	-6.5	1.1	-6.0	-7.0	-10.3	15.8
4. Agriculture	0.0	3.1	0.1	-1.2	-1.9	-1.3	4.2	-2.6	-1.7
5. Land use, land-use changes & forestry									
CO2 (net sink)									
N2O & CH4	0.0	-1.3	0.6	0.2	0.4	-1.0	0.4	-1.6	-2.9
6. Waste	0.0	-3.6	-6.0	-9.6	-10.4	-9.1	-1.0	-8.2	-6.0

The relevant detailed data are presented in Table 349 in Annex Chapter 23.

2.4 Description and interpretation of trends in emissions of indirect greenhouse gases and of SO_2

The relative development of emissions of indirect greenhouse gases and SO_2 are graphically depicted, in each case as time series since 1990, in Figure 18 and in Table 13. Over this period, considerable reductions of emissions of these pollutants have been achieved. For example, emissions of SO_2 have been reduced by over 91 %, those of CO by over 73 %, those of NMVOCs by about 66 % and those of NO_X by about 54 %.

The vast majority of emissions of sulphur dioxide, nitrogen oxide and carbon monoxide are caused by stationary and mobile combustion processes. In the category of NMVOC emissions, however, solvent use is the most important emissions factor.

A range of different factors are responsible for this trend. These factors, which differ in the significance and extent of their relevance, include:

- As a result of Germany's reunification in 1990, emissions from the territory of the former GDR in particular made the starting level relatively high.
- In the years that followed, obsolete industrial facilities in the eastern part of Germany were decommissioned. They were replaced, in the great majority of cases, with state-of-the-art new facilities. Non-decommissioned old installations were extensively retrofitted with emissions-reduction and efficiency-enhancing equipment.
- In addition, fuel mixes were changed – in eastern Germany in particular, local-lignite fractions were reduced in favour of energy carriers such as natural gas and petroleum, which produce fewer emissions.

- In the traffic sector, newer vehicles equipped with pollutant-reducing technology were used.
- In the years since 1990, the immission-protection provisions of the former Federal Republic of Germany have become legally binding for eastern Germany. Following the expiration of provisional rulings, applicable laws were repeatedly adapted in keeping with technological progress.
- Established legal regulations and market-economic incentives led to thriftier use of energy and raw materials.
- International legislation, particularly from the European Community, has had an emissions-reducing effect (e.g. the NEC Directive).
- Increasing use of zero-emissions energy sources (electricity/heat from solar and wind systems, and from geothermal systems) has also had an impact on emissions of indirect greenhouse gases, especially in recent years.

Descriptions of the emission calculations for these pollutants, along with additional, detailed parameters influencing the emissions trends for the various individual air pollutants involved, are provided by the Web site of the Federal Environment Agency[18].

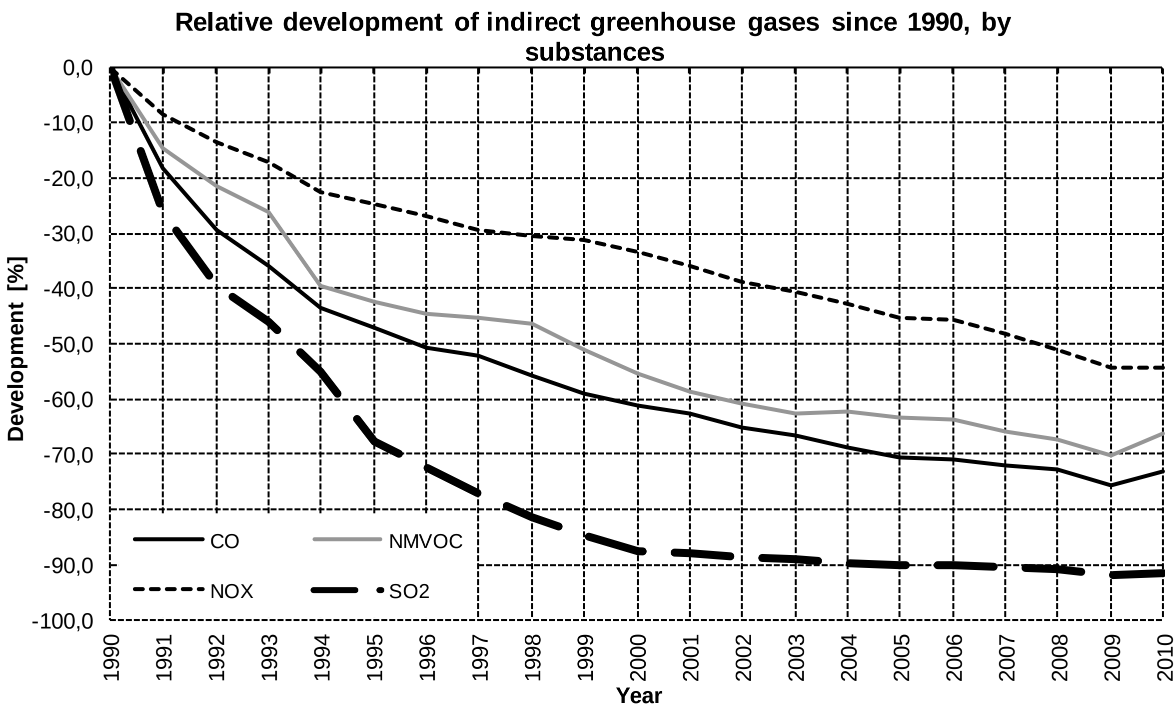


Figure 18: Emissions trends for indirect greenhouse gases and SO_2

2.5 Description and interpretation of emissions trends with regard to the KP-LULUCF inventory, for aggregated emissions and by activity and greenhouse gas

Germany reports under KP-LULUCF Article 3 (3), and it reports in the area of forest management with regard to the selected additional activities pursuant to Article 3 (4) Kyoto Protocol. It reports emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide.

[18] http://www.umweltbundesamt.de/emissionen/index.htm and directly in the Informative Inventory Report (IIR): http://iir-de.wikidot.com/

Under Article 3.3, it reports storage of -5,824.26 Gg CO_2 equivalent. The emissions are composed of CO_2 removals via afforestation and reafforestation, amounting to -5,944.55 Gg CO_2 equivalent, and emissions from deforestation, amounting to 120.29 Gg CO_2 equivalent. In the deforestation category, emissions of 118.51 Gg CO_2, and of 1.78 Gg CO_2 equivalent of N_2O, are reported.

Under Article 3.4, it reports removals of -19,410.3 Gg CO_2 equivalent. The removals are composed of CO_2 removals via afforestation and reafforestation, amounting to -20,092.11 Gg CO_2 equivalent, and emissions of 681.8 Gg CO_2 equivalent. Under Article 3.4, it reports CO_2 removals of -19,479.24 Gg CO_2, N_2O emissions of 65.74 Gg CO_2 equivalent and CH_4 emissions of 3.2 Gg CO_2 equivalent.

Table 15: Emissions in 2009 and 2010 for the KP-LULUCF activities afforestation and deforestation, pursuant to Article 3.3, and for forest management, pursuant to Article 3.4.

Source category	Emissions, 2009 [Gg CO_2 equivalent]	Emissions, 2010 [Gg CO_2 equivalent]
KP 3.3 Afforestation/Reforestation	-5,897.210	-5,944.555
KP 3.3 Deforestation	105.864	120.295
KP 3.4 Forest Management	-19,407.839	-19,410.305

On afforestation areas, a removals increase of -47.34 Gg CO_2 equivalent was determined for the period from 2009 to 2010. In the deforestation category, a slight emissions increase of 14.43 Gg CO_2 equivalent was seen. On the other hand, removals in connection with forest management increased slightly from 2009 to 2010. The increase amounts to -2.47 Gg CO_2 equivalent (cf. Table 15).

3 ENERGY (CRF SECTOR 1)

3.1 Overview (CRF Sector 1)

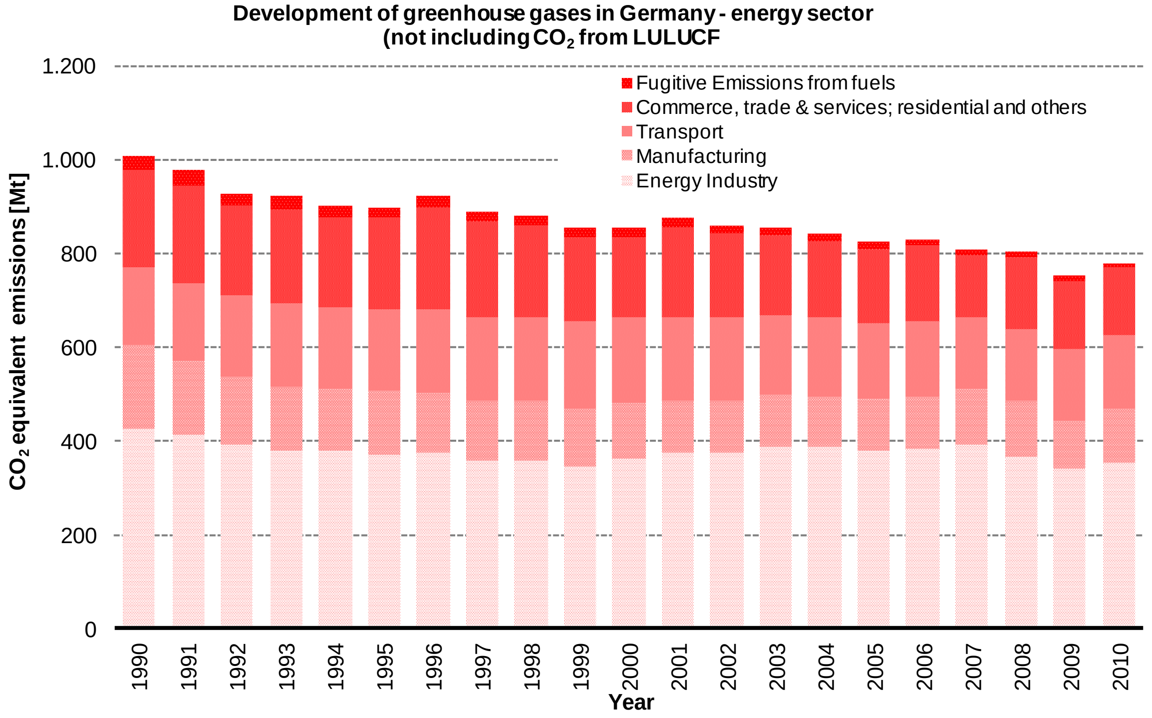


Figure 19: Overview of greenhouse-gas emissions in CRF Sector 1

For determination of activity data from combustion, different models are used for mobile and stationary sources. The model used for stationary sources is the "Balance of Emissions Causes" ("Bilanz der Emissionsursachen" – BEU), while the model used for mobile sources is the "Transport Emission Estimation Model" (TREMOD). In both models, combustion-related activities are determined and then recorded in the "Central System of Emissions" (CSE) emissions database.

Within the CSE, relevant emissions are then calculated by multiplying these combustion-related activities by the pertinent emission factors (as taken from the list of CO_2-emission factors in the National Allocation Plan). In the process, complete oxidation of the carbon contained in the fuels is assumed.

3.2 Combustion of fuels (1.A)

The activity data for stationary combustion are calculated in the "Balance of Emissions Causes" (BEU) model. The database for this model, which was developed by the Federal Environment Agency, consists of the Energy Balance of the Federal Republic of Germany. The Energy Balance is described in detail in Chapters 18.1 through 18.4.

With the help of additional statistics, and of various assumptions, these data are then further disaggregated and supplemented for the relevant energy-transformation and final-consumption sectors. Relevant criteria for this work include permits under immissions-control laws, technologies and differentiation between certain fuels. The model consists of two parts: a sub-model for the old German Länder, covering the years 1987-1994, and a sub-model for all of Germany, covering the years as of 1995. The model for all of Germany has been revised and, in the reports of two research projects (FKZ 203 41 142: ÖKOINSTITUT, 2005 and 204 41 132: ÖKOINSTITUT / DIW, 2007) comprehensively documented. Since 2009, relevant calculations have been carried out with the help of a database-supported system of the BEU that is based on MESAP software and that was developed in the framework of the research projects FKZ 204 42 203/03 and FKZ 360 16 010 (GICON, 2008), via an approach similar to that used for the sub-model for Germany. Data for the new German Länder, for the period 1990-1994, have already been entered into the CSE. The manner in which those data were obtained is described in detail in Chapter 19.1.1.

The following Energy Balance lines are used for determination of emissions-relevant fuel inputs from stationary sources:

A: Transformation inputs (Energy Balance lines 9 through 19)

1. **Public thermal power stations** (line 11) are plants whose operators are sited within the public utlity sector. This category also includes industrial plants which operate their power stations together with electricity utility companies, as joint-venture power stations. The fuel input for electricity generation is reported here. This line of the Energy Balance also includes the fuel input in public thermal power stations attributable to electricity production.
2. **Industrial thermal power stations** (line 12) comprise the following operator groups:
   - hard-coal-mining sector,
   - Power stations in the lignite-mining sector,
   - Power stations in the petroleum-processing sector (refinery power stations),
   - Power stations that generate single-phase power for Deutsche Bahn AG (German Railways) (until 1999, the relevant input amounts for Deutsche Bahn power stations were reported under 1A2f (EB line 12); as of 2000, they have been reported together with public power stations under 1A1a (EB line 11)),
   - Industrial power stations (quarrying, other mining, manufacturing industry).
3. **Hydroelectric, wind-power, photovoltaic systems and other similar systems** (line 14) comprises all systems/plants that generate electricity from biogas, landfill gas, sewage-treatment gas or liquid biomass and feed the electricity into the public grid. Since no cut-off limit applies for such systems, this category includes very small systems in the residential and commercial/institutional sectors.
4. **Thermal (CHP) power stations** (line 15): only the fuel input which can be allocated to district heat generation is given. Adding lines 11 and 15 together produces the total fuel input in public thermal power stations. The district heat generated is fed into the public heating grid. These stations also supply industrial customers with process heat.
5. **District heating stations** (line 16): here, the fuel input for the public district heat supply, from heating stations, is given. The facilities are often used to cover peak loads in district heating networks in which the basic load is met by thermal power stations.
6. **Other energy producers** (line 19) comprises all systems/plants that generate electricity from solid biomass and feed the electricity into the public grid.

B: Energy consumption in the transformation sector (Energy Balance lines 33 through 39)

7. Lines 33 to 39 and the total line 40 (**Energy consumption in the transformation sector**) include the fuel input for heat generation which is needed to operate the transformation stations. No distinction is made here with regard to the type of heat generation involved. This means that fuel inputs for heat generation in combined heating and power stations, steam and hot water boilers and process firing installations are combined. There is an inconsistency in the Energy Balance with respect to

summing-up for lignite pits and briquette plants. Since 1980, this own consumption has been listed together with production-related transformation inputs of briquette plants, in line 10. As a result, the emissions-causing inputs within own consumption can no longer be read out of the Energy Balance; they must be calculated from the transformation input. The fuel inputs used to generate heat in combined heat and power generation stations, together with fuel inputs used for electricity generation by the power stations of hard coal pits, lignite pits and refinery power stations, combine to form the total fuel input in such plants. Deduction, from the total listed in line 40, of fuel inputs for heat generation in power stations leaves the quantity of fuel used in process firing installations, steam and hot water boilers.

C: Final energy consumption (Energy Balance lines 46 through 67)

8. **Final energy consumption by industry** (line 60 of the Energy Balance) refers to the fuel used for heat generation which is required for both production purposes and space heating. Here as well, no distinction is made with regard to the type of heat generation involved. Hence, a part of the final energy consumption in these source categories, together with industrial power stations' fuel input for generating electricity, constitutes the total fuel input in such facilities.
9. The data on **Final energy consumption in the residential sector** (line 66 of the Energy Balance) comprise fuel inputs for heat generation and include the application areas of heating, water heating and cooking.
10. The data on **final energy consumption in the commercial/institutional sector and by other consumers** (line 67 of the Energy Balance) comprise fuel inputs used for hot water production, space heating and process-heat generation in this sector/area.

The Energy Balance data scheme is no longer able to accommodate all of the diverse requirements of national and international energy and emissions reporting. For example, the Energy Balance combines fuel inputs

- In facilities with different requirements under immission protection legislation (e.g. large furnaces, medium-sized furnaces, small furnaces, waste incineration plants)
- In plants that operate according to different technical principles (e.g. steam turbine power stations, gas turbine power stations, combustion-engine stations)
- That exhibit regional peculiarities (e.g. different individual mining regions have different qualities of crude lignite)
- With different source-category allocations in national and international emissions reporting
- That are listed in different Energy Balance lines, in keeping with their intended purpose (for electricity or heat generation), but are used in a single facility group (e.g. steam turbine power stations)

These characteristics have impacts on emissions behaviour. In order to make allowance for the various differing requirements that thus arise, the Energy Balance data in the model *Balance of Emission Causes* (BEU) are disaggregated, using additional statistics as well as the Federal Environment Agency's own calculations. The following Figure 20 provides an overview of the relevant structure:

Balance of emission causes (BEU)
The source categories include: • Public thermal power stations, • Hard coal mining, • Lignite mining, • Deutsche Bahn AG (until 1999), • Petroleum oil refineries, • District heating stations, • Other energy transformation • Quarrying of non-metallic minerals, other mining and manufacturing industry (further sub-classification of process combustion), (The residential, commercial/institutional and other consumers sectors are listed and analysed directly within the CSE, outside of the BEU model.)
The types of facilities involved include: • Steam turbine power stations, • Gas turbine power stations, • Gas and steam turbine power stations, • Motor power stations, • Boiler furnaces (excluding power station boilers), • Process furnaces (sub-classified into 12 processes).
By fuels/energy sources: • About 40 different fuels
On the basis of immission protection legislation provisions, the following are differentiated: • Facilities under the 13th Ordinance on the Execution of the Federal Immission Control Act (13. BImSchV), • Facilities under the 17th Ordinance on the Execution of the Federal Immission Control Act (17. BImSchV), • Facilities under the 1st Ordinance on the Execution of the Federal Immission Control Act (1. BImSchV), • Installations under the Technical Instructions on Air Quality Control (TA Luft)

Abbreviations:
BImSchV Ordinance on the Execution of the Federal Immission Control Act,
TA-Luft First General Administrative Provision on the Federal Immission Control Act (Clean Air Directive)

Figure 20: Characteristics of the Federal Environment Agency's structure of the Balance of Emission Causes, for disaggregation of the Energy Balance

The BEU model is designed to provide a data structure that can be used in meeting a range of different reporting obligations. In particular, finer disaggregation has been needed for determination of emissions of "classical" air pollutants.

Despite the conversion of the Energy Balance to the classification of industrial sectors (WZ 93) and altered grouping of energy resources from the year 1995 onwards, it has been possible to fit the data within the outlined basic structure; this has facilitated preparation of consistent time series. As of 2008, the "WZ 2008" classification of industrial sectors has been used, in energy statistics, instead of the "WZ 2003" classification. Collection of activity data for process combustion, from individual statistics, is now being carried out and recorded in keeping with the key for this transition (STATISTISCHES BUNDESAMT 2008: "Umsteigeschlüssel WZ 2003 auf WZ 2008" (key for the change from WZ 2003 to WZ 2008))

Figure 20 and the following tables (Table 16 through Table 22) show the BEU's structural features. These basic structures are analysed in greater detail in the relevant descriptions of activities. The following should be noted in reading the tables:

The number in the third column is the line number of the Energy Balance from which the basic data for calculation in the *Balance of Emission Causes* table are taken. The column "SWK" (S = fuel input for electricity generation, W = fuel input for heat generation, K = fuel input for machine action) shows the use in question. The last column shows the names of the relevant calculation procedures; in each case, these provide a unique reference to the database of the *Central System on Emissions* (CSE).

With regard to determination of activity data from waste incineration and co-combustion of waste in combustion systems in the sectors Public electricity and heat generation (1.A.1) and Manufacturing (1.A.2), energy statistics and the Energy Balance previously both showed considerably smaller waste quantities than did the waste statistics of the Federal Statistical Office (STATISTISCHES BUNDESAMT, FS 19 Reihe 1). For that reason, the pertinent activity data were taken from the Energy Balance and then supplemented with the difference relative to waste statistics. In recent years, however, the fuel quantities covered by energy statistics have grown continuously. The reasons for this include the fact that in recent years more and more solid biomass (primarily waste and scrap wood) and processed settlement waste have been used for energy generation.

With a view to recording all fuel quantities as completely as possible, the Federal Environment Agency (UBA), in the framework of a research project of its own carried out in 2010/11, thoroughly studied fuel inputs in energy statistics and waste statistics. In that study, the waste quantities in the sectors Public energy generation (1.A.1.a), Mining (1.A.1.c) and Manufacturing (1.A.2) were compared in a breakdown by individual economic sectors. To enable comparison of the two sets of statistics, waste quantities from waste statistics were allocated to the same fuel groups used in energy statistics: solid biomass, other petroleum products, sewage sludge, household and settlement waste and industrial waste. Industrial waste and household waste were classified in keeping with the Ordinance on the European Waste Catalogue (AVV), with industrial waste including all waste with waste-classification numbers beginning with the numbers 01 through 19.

The result shows that relevant fuel quantities in energy statistics are still smaller, overall, than those of waste statistics. In particular, the category public energy generation is not yet being completely covered by energy statistics. For that reason, energy statistics are not equally suitable, as a database for the greenhouse-gas inventory, with regard to all sectors. In one consequence of this finding, supplementary data from waste statistics continue to be used with regard to the sector "Public energy generation".

In addition, for the sector Manufacturing (1.A.2), and for the sectoral classifications iron and steel, paper, cement and lime, substitute-fuel data continue to be used that are provided by the associations German Iron and Steel Institute (VDEh), German Pulp and Paper Association (VDP), the German Lime Association (BV Kalk) and the German Cement Works Association (VDZ).

Figure 21 schematically shows all important sources of data on use of waste as fuel inputs for energy generation.

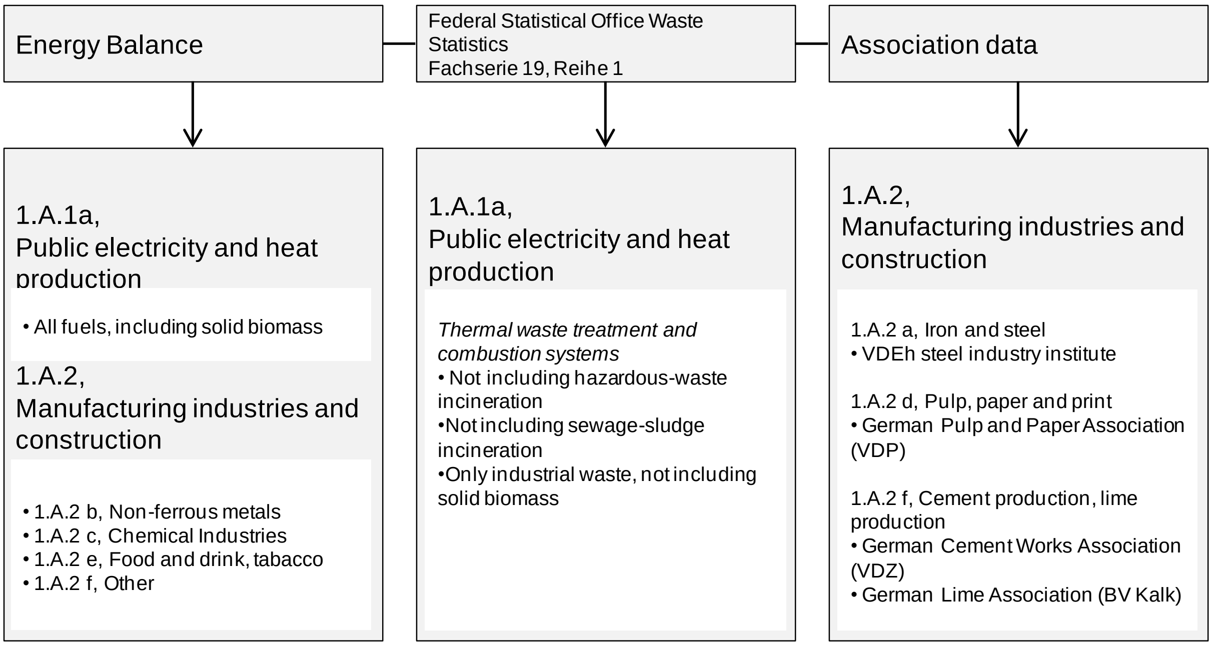


Figure 21: Sources of data, in the context of the inventory of greenhouse-gas emissions, on use of waste as fuel inputs for energy generation

Table 16: Structure of the Balance of Emissions Causes – public services – source category 1.A.1.a

Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]
Public supply					
Electricity generation in large combustion systems of public power stations	11	13. BImSchV	DTKW	Public supply	S
Electricity generation in waste incineration systems of public power stations	11	17. BImSchV	DTKW	Public supply	S
Electricity generation in gas turbines (TA Luft) of public power stations	11	TA Luft	GTKW	Public supply	S
Electricity generation in gas and steam turbine systems (TA Luft) of public power stations	11	TA Luft	GuD	Public supply	S
Electricity generation in large combustion systems of gas turbines of public power stations	11	13. BImSchV	GTKW	Public supply	S
Electricity generation in large combustion systems of gas and steam turbine systems of public power stations	11	13. BImSchV	GuD	Public supply	S
Electricity generation in gas engines of public power stations	11	TA Luft	GMA	Public supply	S
Electricity generation in diesel engines of public power stations	11	TA Luft	DMA	Public supply	S
Electricity generation in public biomass-fired power stations	11	17. BImSchV	DTKW	Public supply	S
Co-combustion in public power stations	11	17. BImSchV	DTKW	Public supply	S
Feed-in into the public grid	14	TA Luft	GMA	Public supply	S
Heat generation in diesel engines of public power stations	15	TA Luft	DMA	Public supply	W
Heat generation in large combustion systems of public power stations	15	13. BImSchV	DTKW	Public supply	W
Heat generation in large combustion systems of public crude-lignite-fired power stations	15	13. BImSchV	DTKW	Public supply	W
Heat generation in waste-incineration systems of public power stations	15	17. BImSchV	DTKW	Public supply	W
Heat generation in gas turbines (TA Luft) of public power stations	15	TA Luft	GTKW	Public supply	W
Heat generation in gas and steam turbine systems (TA Luft) of public power stations	15	TA Luft	GuD	Public supply	W
Heat generation in large combustion systems of gas turbines of public power stations	15	13. BImSchV	GTKW	Public supply	W
Heat generation in large combustion systems of gas and steam turbine systems of public power stations	15	13. BImSchV	GuD	Public supply	W
Heat generation in gas engines of public power stations	15	TA Luft	GMA	Public supply	W
Heat generation in public biomass-fired power stations	15	17. BImSchV	DTKW	Public supply	W
Co-combustion in public power stations	15	17. BImSchV	DTKW	Public supply	W
Heat generation in gas engines of public district heating stations	16	TA Luft	GMA	Public supply	W
Heat generation in large combustion systems of public district heating stations	16	13. BImSchV	FHW	Public supply	W
Heat generation in waste-incineration systems of public district heating stations	16	17. BImSchV	FHW	Public supply	W
Heat generation in TA Luft systems of public district heating stations	16	TA Luft	FHW	Public supply	W
Heat generation in public biomass-fired thermal power stations	16	17. BImSchV	FHW	Public supply	W
Co-combustion in public district heating stations	16	17. BImSchV	FHW	Public supply	W
Feed-in into the public grid	19	TA Luft	DTKW	Public supply	S

1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMA = gas engine stations, DMA = diesel motor power stations, FHW = district heating stations, FA = combustion systems, PF = process furnaces

2) S = electricity generation , W = heat generation, K = power production (direct drive)

Table 17: Structure of the Balance of Emissions Causes – refineries – source category 1.A.1.b

Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]
Refineries					
Electricity generation in large combustion systems of refinery power stations	12	13. BImSchV	DTKW	Manufacture of refined petroleum products	S
Electricity generation in TA Luft systems of refinery power stations	12	TA-Luft	DTKW	Manufacture of refined petroleum products	S
Electricity generation in gas turbines (TA Luft) of refinery power stations	12	TA Luft	GTKW	Manufacture of refined petroleum products	S
Electricity generation in large combustion systems of gas turbine systems of refinery power stations	12	13. BImSchV	GTKW	Manufacture of refined petroleum products	S
Heat production in large combustion systems of refinery power stations	40	13. BImSchV	DTKW	Manufacture of refined petroleum products	W
Heat generation in TA Luft systems of refinery power stations	40	TA-Luft	DTKW	Manufacture of refined petroleum products	W
Heat generation in gas turbines (TA Luft) of refinery power stations	40	TA Luft	GTKW	Manufacture of refined petroleum products	W
Heat generation in large combustion systems of gas turbine systems of refinery power stations	40	13. BImSchV	GTKW	Manufacture of refined petroleum products	W
Heat generation in diesel motors of refinery power stations	40	TA Luft	DMA	Manufacture of refined petroleum products	W
Refinery bottom-heating systems (large combustion systems)	40	13. BImSchV	PF	Manufacture of refined petroleum products	W
Refinery bottom-heating systems (TA Luft installations)	40	TA Luft	PF	Manufacture of refined petroleum products	W

1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMA = gas engine stations, DMA = diesel motor power stations, FHW = district heating stations, FA = combustion systems, PF = process furnaces

2) S = electricity generation , W = heat generation, K = power production (direct drive)

Table 18: Structure of the Balance of Emissions Causes – coal mining and other transformation sector – source category 1.A.1.c

Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]
Coal mining					
Electricity generation in large combustion systems of power stations of the hard-coal-mining sector	12	13. BImSchV	DTKW	Coal mining	S
Electricity generation in TA-Luft systems of power stations of the hard-coal-mining sector	12	TA Luft	DTKW	Coal mining	S
Electricity generation in large combustion systems of mine power stations	12	13. BIMSchV	DTKW	Other coal mining	S
Electricity generation in gas engines of colliery and mine power stations	12	TA Luft	GMA	Coal mining	S
Co-combustion in mine power stations	12	17. BIMSchV	DTKW	Other coal mining	S
Heat generation in large combustion systems of mine power stations	40	13. BImSchV	DTKW	Other coal mining	W
Heat generation in large combustion systems of power stations of the hard-coal-mining sector	40	13. BImSchV	DTKW	Coal mining	W
Heat generation in gas engines of power stations of the hard-coal-mining sector	40	TA Luft	GMA	Coal mining	w
Direct drive via diesel engines of colliery and mine power stations	40	TA Luft	DMKW	Coal mining	K
Co-combustion in mine power stations	40	17. BImSchV	DTKW	Other coal mining	W
Production of hard-coal coke	40	TA Luft	PF	Coal mining / iron and steel industry	W
Other energy transformation					
Heat generation in diesel engines of the other transformation sector	40	TA Luft	DMA	Other energy producers	W
Heat generation in gas engines of the other transformation sector	40	TA Luft	GMA	Other energy producers	W
Heat generation in TA Luft systems (industrial boilers) of the other transformation sector	40	TA Luft	FA	Other energy producers	W
Own consumption of wastewater-treatment plants	40	TA Luft	GMA	Other energy producers	W

1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMA = gas engine stations, DMA = diesel motor power stations, FHW = district heating stations, FA = combustion systems, PF = process furnaces

2) S = electricity generation , W = heat generation, K = power production (direct drive)

Table 19: Structure of the Balance of Emissions Causes – source categories 1.A.1.a-f

Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]
Other BEU structural elements					
Gas turbines (TA Luft) in natural-gas-compressor stations	40	TA Luft	GT	Gas industry	K
Source category 1.A.2.a					
Pig iron production	60	TA Luft	Blast furnaces	Iron and steel industry	W
Sinter production	60	TA Luft	Sintering plants	Iron and steel industry	W
Manufacturing of rolled steel (process combustion)	60	TA Luft	Production of rolled steel	Steel production	W
Production of iron, steel and malleable cast iron (process combustion)	60	TA Luft	Foundries	Foundry industry	W
Production of electrical steel	60	TA Luft	Electric arc furnace	Steel production	W
Source category 1.A.2.b					
Production of non-ferrous heavy metals (process combustion)	60	TA Luft	Foundries for non-ferrous metals	Non-ferrous-metal production	W
Source category 1.A.2.d					
Electricity generation in large combustion systems of power stations of the pulp and paper industry	12	13. BImSchV	DTKW	Pulp and paper industry	S
Heat generation in large combustion systems of power stations of the pulp and paper industry	60	13. BImSchV	DTKW	Pulp and paper industry	W
Source category 1.A.2.e					
Sugar manufacturing (process combustion)	60	TA Luft	Sugar refineries	Sugar production	W
Source category 1.A.2.f					
Lime production (process combustion)	60	TA Luft	Lime-burning furnaces	Lime production	W
Production of cement clinkers (process combustion)	60	TA Luft	Cement furnaces	Cement production	W
Glass production (process combustion)	60	TA Luft	Glass smelting furnaces	Glass production	W
Ceramics production (process combustion)	60	TA Luft	Kilns	Brick production	W
Other process combustion	60	TA Luft	Process combustion	Other mining and manufacturing	W

1) GT = gas turbines, DTKW = steam turbine power stations
2) S = electricity generation , W = heat generation, K = power production (direct drive)

Table 20: Structure of the Balance of Emissions Causes – other industrial power stations and industrial boilers – source category 1.A.2.f Other

Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]
Other industrial power stations					
Electricity generation in large combustion systems of DB power stations	12	13. BImSchV	DTKW	Deutsche Bahn AG (German Railways)	S
Electricity generation in large combustion systems of other industrial power stations	12	13. BImSchV	DTKW	Other mining and manufacturing (not including VAW)	S
Electricity generation in waste incineration systems of other industrial power stations	12	17. BImSchV	DTKW	Other mining and manufacturing	S
Heat generation in TA Luft systems of other industrial power stations	12	TA Luft	DTKW	Other mining and manufacturing	S
Electricity generation in gas turbines (TA Luft) of other industrial power stations	12	TA Luft	GTKW	Other mining and manufacturing	S
Electricity generation in large combustion systems of gas turbines of other industrial power stations	12	13. BImSchV	GTKW	Other mining and manufacturing	S
Electricity generation in gas and steam turbine systems (TA Luft systems) of other industrial power stations	12	TA-Luft	GuDKW	Other mining and manufacturing .	S
Electricity generation in gas and steam turbine systems (large combustion systems) of other industrial power stations	12	13. BImSchV	GuDKW	Other mining and manufacturing .	S
Electricity generation in gas engines of other industrial power stations	12	TA Luft	GMA	Other mining and manufacturing	S
Electricity generation in diesel motors of other industrial power stations	12	TA Luft	DMA	Other mining and manufacturing	S
Incineration of special waste		17. BImSchV	FA	Other mining and manufacturing	S
Heat generation in diesel engines of the other and other mining sectors	60	TA Luft	DMA	Other mining and manufacturing	W
Heat generation in large combustion systems of industrial power stations of the other and other mining sectors	60	13. BImSchV	DTKW	Other mining and manufacturing	W
Heat generation in waste-incineration systems of the manufacturing and other mining sectors	60	17. BImSchV	DTKW	Other mining and manufacturing	W
Heat generation in TA Luft systems of industrial power stations of the manufacturing and other mining sectors	60	TA Luft	DTKW	Other mining and manufacturing	W
Heat generation in gas turbines (TA Luft) of industrial power stations of the manufacturing and other mining sectors	60	TA Luft	GTKW	Other mining and manufacturing	W
Heat generation in gas turbines of industrial power stations of the manufacturing and other mining sectors	60	13. BImSchV	GTKW	Other mining and manufacturing	W
Heat generation in gas and steam turbine systems (TA Luft) of industrial power stations of the manufacturing and other mining sectors	60	TA Luft	GuDKW	Other mining and manufacturing	W
Heat generation in large combustion systems of gas and steam turbine systems of industrial power stations of the manufacturing and other mining sectors	60	13. BImSchV	GuDKW	Other mining and manufacturing	W
Heat generation in large combustion systems (industrial boilers) of the manufacturing and other mining sectors	60	13. BImSchV	FA	Other mining and manufacturing	W
Heat generation in TA Luft systems (industrial boilers) of the manufacturing and other mining sectors	60	TA Luft	FA	Other mining and manufacturing	W
Heat generation in gas engines of industrial power stations of the manufacturing and other mining sectors	60	TA Luft	GMA	Other mining and manufacturing	W

1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMA = gas engine stations, DMA = diesel motor power stations, FHW = district heating stations, FA = combustion systems, PF = process furnaces 2) S = electricity generation , W = heat generation, K = power production (direct drive)

Table 21: Structure of the Balance of Emissions Causes – structural elements already integrated within the CSE – source categories 1.A.4 and 1.A.5.a

Process, fuel	**EB line**	**Allocation under emissions laws**	**Type of facility[1)]**	**Economic sector**	**SWK[2)]**
Source category 1.A.4.a					
Heat generation in TA Luft systems of other small consumers	67	TA Luft	Hot-water boilers	Commercial/institutional	W
Heat generation in small combustion systems of other small consumers	67	1st BImSchV	Hot-water boilers	Commercial/institutional	W
Source category 1.A.4.b					
Heat generation in small combustion systems of households	66	1st BImSchV	Heat producing systems	Residential	W
Residential, mobile sources	66		Drive		
Source category 1.A.4.c					
Heat generation in TA Luft systems in agricultural and horticultural operations	67	TA Luft	Steam / hot-water boilers	Agriculture	W
Heat generation in small combustion systems in agricultural and horticultural operations	67	1st BImSchV	Steam / hot-water production systems	Agriculture	W
Source category 1.A.5.a					
Heat generation in TA Luft systems of military agencies	67	TA Luft	Hot-water boilers	Military agencies	W
Heat generation in small combustion systems of military agencies	67	1st BImSchV	Hot-water boilers	Military agencies	W

Table 22: Structure of the Balance of Emissions Causes – natural-gas-compressor stations – source category: 1.A.3.e

Process, fuel	**EB line**	**Allocation under emissions laws**	**Type of facility[1)]**	**Economic sector**	**SWK[2)]**
Gas turbines (TA Luft) of natural-gas-compressor stations	40	TA Luft	GTr	Gas industry	K
Large combustion systems of gas turbines in natural-gas-compressor stations	40	TA Luft	GT	Gas industry	K

3.2.1 Verification of the sectoral approach for CRF 1.A

3.2.1.1 Comparison with the CO_2 Reference Approach

Reporting on combustion-related CO_2 emissions is centrally important within the context of international climate protection, because such emissions account for such an important proportion of total emissions. To this end, industrialised countries routinely adopt the source-category-specific approach, which addresses the level of individual energy consumption sectors and therefore supports greater differentiation in analysis of emitter structures. To provide a simplified and comparative approach, the IPCC has developed the *Reference Approach*. The CO_2 emissions calculated via that approach, on the basis of primary energy consumption (domestic fuel inputs), have to be compared to the emission results obtained via the *Sectoral Approach*.

The Reference Approach was carried out for all years as of 1990. In each case, the basis for relevant calculations has consisted of the National Energy Balances on primary energy consumption, which have been published for years through 2009. For 2010, only a provisional Balance is currently available.

The results of the Reference Approach are compiled in Table 23. In Figure 22 and Figure 23, the are compared with other available data sets, such as data of the IEA and of individual German Länder. The average discrepancy between the results obtained with the *Reference Approach* and those obtained with the *Sectoral Approach*, for all years under consideration, is 0.2 %. The individual discrepancies vary throughout a range of - 0.9 % (2009) to + 1.4 % (2003).

3.2.1.2 Verification with other data sets available for Germany

Below, for verification purposes, the results of the detailed source-category-based calculation of energy-related CO_2 emissions for Germany, carried out in accordance with the specifications of the *IPCC Good Practice Guidance* (2000), are compared with other available (for Germany) national and international data records on energy-related CO_2 emissions for the years 1990 to 2007. For 2008, most of these comparative data have not yet been published.

In the comparison, the calculation results are compared with data:

- from the IEA (source-category-specific approach and Reference Approach)
- from the CO_2 calculations performed at Länder level.

Table 23 and Figure 22 compare the results of the approaches for calculating CO_2 emission, throughout the different years involved. The key development trends emerge in all calculation approaches, including the Reference Approach, albeit at differing levels. In Figure 23, the relative discrepancies in the data records are depicted in order to illustrate these level differences.

Nevertheless, on the whole, these comparisons confirm the CO_2 emissions calculated for Germany. On an average for the years 1990 to 2009, the total national energy-related emissions calculated with the *Sectoral Approach* (cf. UBA (CRF 1.A)) differ as follows from the relevant comparative data sets:

- IEA (detailed Sectoral Approach): IEA (SA)) 0.4 %

- IEA (Reference Approach: IEA (RA)) 1.4 %
- national Reference Approach (UBA (RA)) 0.2 %
- Results of the Länder[19] 1.0%

[19] Discrepancy with respect to UBA (CRF 1.A), including CO_2 from international air transports (CRF 1.C.1.a); due to differences in data availability, averaged for the period 1990-2008 (cf. the following table)

Table 23: Comparison of CO_2inventories with other independent national and international results for CO_2 emissions

Results [millions of t], *discrepancies [%]*	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
IEA statistics – Sectoral Approach – IEA (SA)	**950.4**	**925.7**	**887.7**	**881.3**	**870.1**	**869.4**	**898.2**	**867.5**	**860.7**	**828.8**
IEA (SA) with respect to UBA (CRF 1.A)	*-2.8*	*-2.0*	*-1.2*	*-1.0*	*-0.1*	*-0.1*	*0.7*	*0.7*	*0.7*	*0.0*
IEA statistics – Reference Approach – IEA (RA)	**971.7**	**940.7**	**901.5**	**888.0**	**877.0**	**877.5**	**903.2**	**877.8**	**872.4**	**837.1**
IEA (RA) with respect to UBA (CRF 1.A)	*-0.6*	*-0.4*	*0.3*	*-0.2*	*0.7*	*0.9*	*1.2*	*1.9*	*2.1*	*1.0*
IEA (RA) with respect to UBA (RA)	*-0.3*	*0.0*	*0.4*	*-0.4*	*0.4*	*1.3*	*1.4*	*1.7*	*1.8*	*0.7*
UBA – Reference Approach – UBA (RA)	**974.3**	**940.8**	**897.5**	**891.9**	**873.5**	**865.9**	**890.9**	**863.1**	**856.8**	**831.5**
UBA (RA) with respect to UBA (CRF 1.A)	*-0.4*	*-0.4*	*-0.1*	*0.2*	*0.3*	*-0.5*	*-0.2*	*0.2*	*0.3*	*0.4*
UBA – Sectoral Approach – UBA (CRF 1.A)	**977.7**	**944.4**	**898.3**	**889.8**	**871.1**	**869.9**	**892.4**	**861.3**	**854.5**	**828.5**
Results of the Länder (energy)	**981.7**	**963.2**	**917.1**	**912.5**	**890.5**	**893.7**	**914.6**	**890.5**	**887.7**	**861.7**
Länder (energy) with respect to UBA (1.A + 1.C.1.a)	*-0.8*	*0.7*	*0.6*	*1.0*	*0.5*	*1.0*	*0.7*	*1.4*	*1.8*	*1.7*
UBA (CRF 1.A) + internat. air transports (CRF 1.C.1.a)	**989.7**	**956.4**	**911.4**	**903.8**	**885.8**	**885.1**	**908.4**	**877.8**	**871.6**	**846.9**
Results [millions of t], *discrepancies [%]*	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
IEA statistics – Sectoral Approach – IEA (SA)	**827.1**	**845.4**	**832.9**	**842.1**	**843.4**	**811.8**	**823.9**	**800.1**	**804.1**	**750.2**
IEA (SA) with respect to UBA (CRF 1.A)	-0.1	-0.5	-0.3	1.2	2.9	0.9	1.9	1.7	2.3	2.2
IEA statistics – Reference Approach – IEA (RA)	**843.9**	**872.4**	**846.6**	**849.0**	**843.5**	**820.1**	**821.3**	**804.1**	**802.5**	**755.1**
IEA (RA) with respect to UBA (CRF 1.A)	1.9	2.7	1.3	2.0	2.9	2.0	1.6	2.2	2.1	2.9
IEA (RA) with respect to UBA (RA)	1.5	2.1	0.8	0.6	1.9	0.9	0.2	2.2	3.0	3.9
UBA – Reference Approach – UBA (RA)	**831.6**	**854.1**	**839.8**	**844.0**	**828.0**	**812.5**	**819.4**	**786.5**	**779.5**	**727.1**
UBA (RA) with respect to UBA (CRF 1.A)	0.5	0.5	0.5	1.4	1.0	1.0	1.4	-0.1	-0.9	-0.9
UBA – Sectoral Approach – UBA (CRF 1.A)	**827.8**	**849.7**	**835.4**	**832.1**	**819.4**	**804.2**	**808.3**	**787.0**	**786.3**	**733.7**
Results of the Länder (energy)	**863.1**	**887.6**	**864.5**	**859.6**	**847.4**	**835.7**	**841.6**	**818.7**	**818.7**	**NA**
Länder (energy) with respect to UBA (1.A + 1.C.1.a)	1.9	2.2	1.2	1.0	0.8	1.0	1.1	0.8	0.8	NA
UBA (CRF 1.A) + internat. air transports (CRF 1.C.1.a)	**847.4**	**868.8**	**854.4**	**851.5**	**840.6**	**827.3**	**832.6**	**812.2**	**812.2**	**811.8**

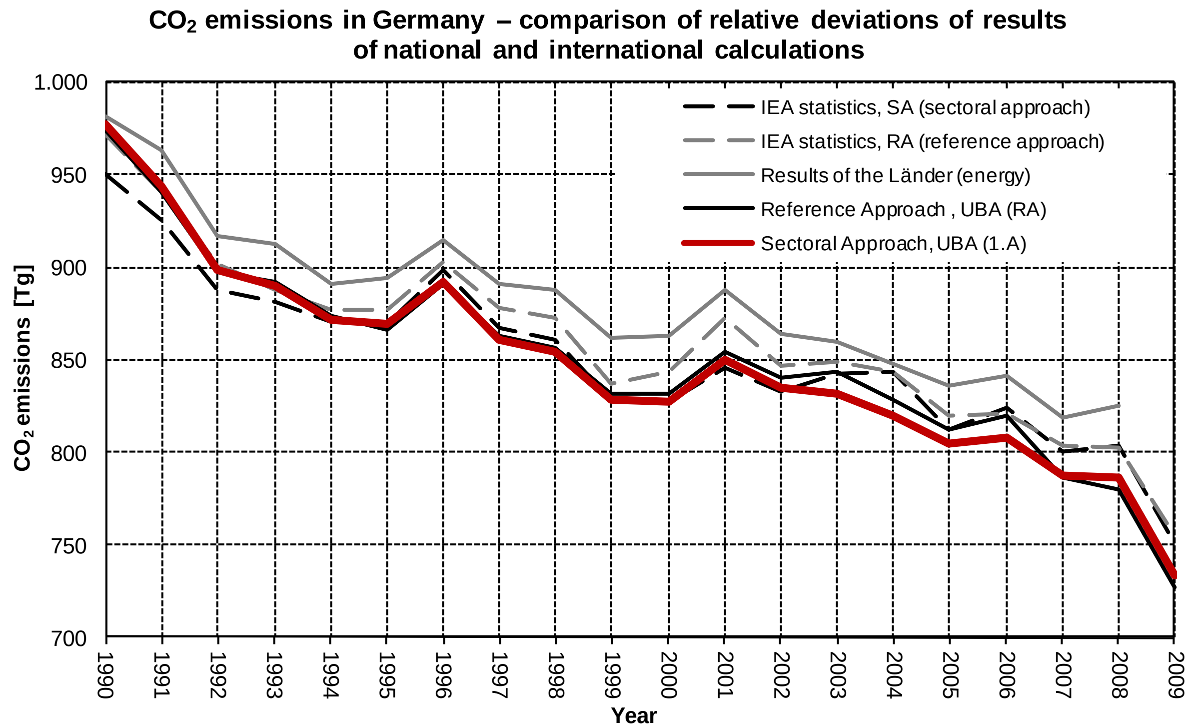


Figure 22: CO_2 emissions in Germany – comparison of results of national and international calculations

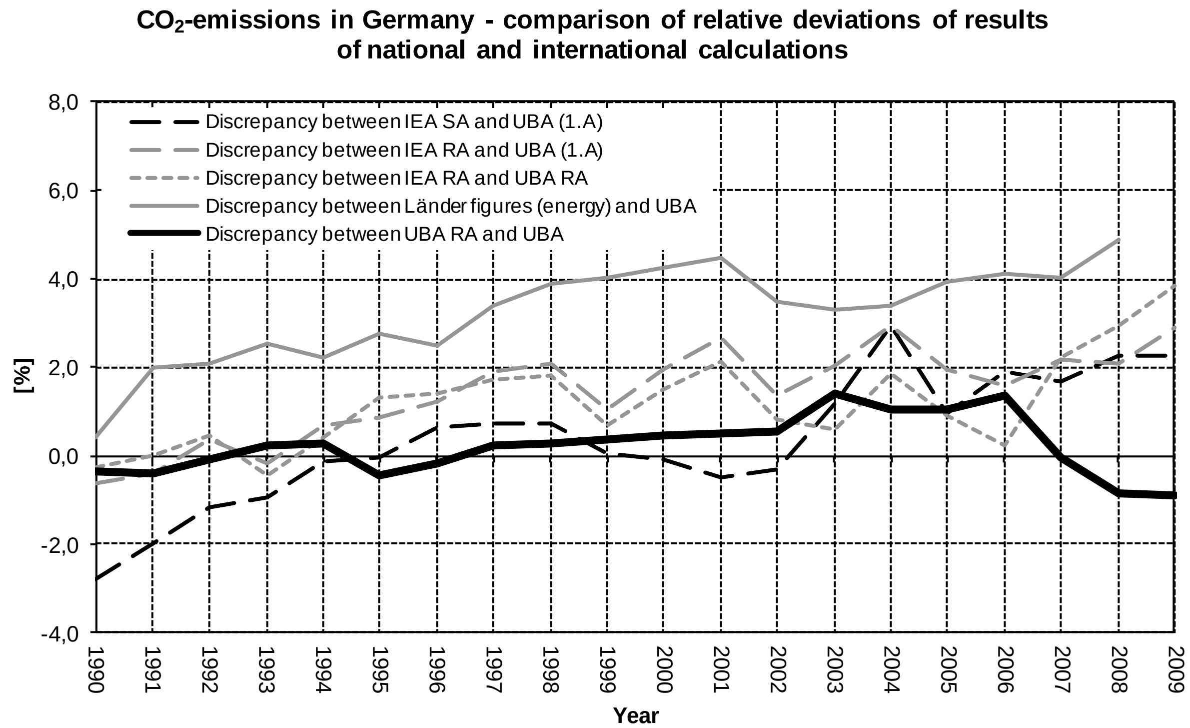


Figure 23: CO_2 emissions in Germany – comparison of relative discrepancies of national and international calculations

3.2.1.2.1 Comparison with the IEA results

The data used are data published annually, in updated form, by the IEA (most recently: OECD/IEA 2011). Since the method for determining, processing and applying the basic data used for this purpose currently is not precisely comparable with the national procedure in Germany at present, and relevant addition methodological information is lacking – particularly information with regard to the detailed data used – this comparison is provided only for reasons of completeness.

However, results of the comparison with the results obtained with IEA's Sectoral Approach confirm the data obtained via the national, detailed method: The average deviation for (currently) 20 years is 0.4 %, while the pertinent individual deviations vary throughout a range of -2.8 to 2.9 %.

The results of the Reference Approach used by the IEA differ from those of the Reference Approach carried out in Germany by 1.2 %, over a 20-year average.

3.2.1.2.2 Comparison with the data obtained for the individual Länder

The German Länder publish data on their own CO_2 emissions (cf.: http://www.lak-energiebilanzen.de/sixcms/detail.php?template=liste_cobilanzen). Regarding the relevant procedures, responsible institutions and methodological descriptions, we call the reader's attention to that Web site and to the pertinent more detailed remarks in the NIR 2009.

The following section presents a comparison, for energy-related CO_2 emissions, of a) available Länder results published to date in the Balance of Emissions Causes (BEU) and b) inventories calculated at the national level. One difficulty hampering the comparison is that pertinent information for the individual Länder is not always available in the form of complete time series. Gaps in the time series were closed via interpolation. Since 2009 data are currently available for only a few German Länder, the comparison is limited to the period 1990 to 2008.

A significant aspect of the comparison is that the methods used in the Energy Balances of the Länder, and for the CO_2-emissions calculations based on those balances, do not correct for the fuels used in international air transports. This is why the Länder results have to be compared with the energy-related (1.A) and reported emissions, for international air transports, as determined for national reporting purposes. This modified comparison, which is being carried out for the first time this year, represents an improvement over previous analyses.

Table 24: Comparison of the results of CO_2 calculations of individual Länder with corresponding figures from the federal inventories

State (Land)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
					[Gg CO_2]					
Baden-Württemberg	74,374	78,590	78,036	78,673	74,535	78,074	81,759	78,570	80,080	77,379
Bavaria	84,544	88,972	87,041	90,335	87,871	88,307	92,265	89,837	92,708	90,590
Berlin	26,941	27,957	25,234	26,643	25,531	24,445	24,726	23,560	22,876	23,693
Brandenburg	81,894	66,751	58,894	57,104	54,011	50,791	50,312	50,762	59,255	57,784
Bremen	13,433	13,586	12,903	12,517	13,341	13,239	14,256	14,170	13,857	12,793
Hamburg	12,743	14,226	13,116	13,813	13,361	13,467	14,572	13,940	*13,651*	*13,362*
Hesse	50,338	53,945	53,267	56,060	56,201	56,126	59,935	57,264	57,156	54,688
Mecklenburg – West Pomerania	15,539	10,757	9,360	9,473	9,510	10,233	11,636	10,654	10,413	10,627
Lower Saxony	77,138	82,276	*80,915*	*79,553*	78,192	*78,334*	78,475	*79,440*	80,405	*77,316*
North Rhine – Westphalia	299,028	309,888	306,287	300,041	295,874	303,349	312,345	307,064	304,784	294,014
Rhineland-Palatinate	27,394	29,448	28,914	30,248	30,274	31,490	31,463	31,646	31,167	30,311
Saarland	23,708	25,767	24,398	23,214	24,313	23,133	23,852	21,825	23,795	22,833
Saxony	91,465	77,105	64,059	66,046	62,988	61,349	56,223	51,036	37,167	35,116
Saxony-Anhalt	50,863	38,085	31,892	27,887	26,307	25,200	25,652	25,294	25,261	26,900
Schleswig-Holstein	24,200	23,826	24,082	24,590	24,191	22,940	23,517	22,654	22,426	21,868
Thuringia	28,098	22,071	18,687	16,334	13,992	13,240	13,641	12,806	12,713	12,438
Total for Länder	**981,699**	**963,249**	**917,084**	**912,531**	**890,493**	**893,716**	**914,629**	**890,521**	**887,713**	**861,712**
Sectoral approach UBA (CRF 1.A)	977,713	944,417	898,318	889,779	871,089	869,890	892,374	861,303	854,542	828,541
International air transports (CRF 1.C.1.a)	12,023	11,937	13,095	14,068	14,688	15,256	15,993	16,530	17,069	18,406
Total, CRF 1.A + CRF 1.C.1.a *)	**989,736**	**956,354**	**911,413**	**903,846**	**885,777**	**885,146**	**908,367**	**877,832**	**871,610**	**846,948**
Deviation (Gg)	**-8,037**	**6,895**	**5,671**	**8,684**	**4,716**	**8,570**	**6,262**	**12,689**	**16,102**	**14,764**
Deviation (%)	**-0.8**	**0.7**	**0.6**	**1.0**	**0.5**	**1.0**	**0.7**	**1.4**	**1.8**	**1.7**

State (Land)	2000	2001	2002	2003	2004 [Gg CO_2]	2005	2006	2007	2008
Baden-Württemberg	74,940	80,108	76,549	75,598	74,768	77,222	78,283	70,952	72,593
Bavaria	88,705	90,377	84,578	83,783	83,190	80,541	81,879	74,972	80,430
Berlin	23,661	24,068	21,281	21,249	20,184	19,998	19,915	17,466	18,604
Brandenburg	60,564	60,928	61,537	57,910	58,882	59,910	58,273	58,173	56,587
Bremen	14,079	14,137	14,031	14,667	13,057	12,222	12,704	13,645	13,056
Hamburg	*13,073*	*12,784*	*12,495*	12,328	11,589	11,343	11,451	10,940	10,891
Hesse	56,011	57,817	54,897	55,528	54,787	54,441	53,170	50,916	52,159
Mecklenburg – West Pomerania	10,256	10,718	10,908	10,451	10,961	10,511	11,080	10,081	10,867
Lower Saxony	74,228	*73,145*	72,061	*71,040*	70,019	*70,158*	70,298	*69,898*	*69,402*
North Rhine – Westphalia	293,987	299,969	295,293	295,885	291,555	282,533	287,140	289,557	286,158
Rhineland-Palatinate	28,853	29,574	27,793	26,787	26,432	26,399	27,110	25,596	27,453
Saarland	23,459	23,260	22,964	23,278	23,917	24,799	23,577	25,714	22,961
Saxony	41,552	48,842	49,038	49,625	48,476	47,019	48,295	46,854	46,927
Saxony-Anhalt	26,301	26,840	27,518	28,171	27,145	27,846	27,821	26,477	26,973
Schleswig-Holstein	21,378	22,737	21,455	21,401	20,592	19,356	19,339	17,032	18,688
Thuringia	12,059	12,339	12,066	11,924	11,812	11,450	11,283	10,422	10,911
Total for Länder	**863,106**	**887,643**	**864,465**	**859,625**	**847,366**	**835,749**	**841,617**	**818,694**	**824,661**
Sectoral approach UBA (CRF 1.A)	827,825	849,669	835,355	832,122	819,398	804,244	808,343	786,995	786,310
International air transports (CRF 1.C.1.a)	19,529	19,101	19,001	19,357	21,170	23,088	24,236	25,207	25,503
Total, CRF 1.A + CRF 1.C.1.a *)	**847,354**	**868,771**	**854,356**	**851,479**	**840,568**	**827,332**	**832,578**	**812,202**	**811,813**
Deviation (Gg)	**15,752**	**18,872**	**10,109**	**8,146**	**6,798**	**8,417**	**9,039**	**6,492**	**12,848**
Deviation (%)	**1.9**	**2.2**	**1.2**	**1.0**	**0.8**	**1.0**	**1.1**	**0.8**	**1.6**

*) A correction is required, since at the Länder level energy consumption is not corrected to taken account of international air transports!

Remark: The figures in italics are not part of consistent time series and were generated via gap-closure procedures (see text).

In terms of trend, the comparison found excellent agreement between the combined Länder results and the Federal inventory. On an average for the 19 years in question, the total CO_2 emissions for the Länder were 1.0 % higher than the Federal result. The extremes of the deviations ranged from -0.8 % in 1990 to 2.2 % in 2001.

3.2.1.2.3 Planned improvements

Following the reporting process, the results of the comparison are discussed, regularly and intensively, and reviewed with regard to potential for improvement, with the representatives of the Länder Working Group on Energy Balances (Länderarbeitskreis Energiebilanzen). At present, no concrete plans for further improvements are in place.

In future, CO_2 verification will have to be improved especially via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). In the process, reference data from detailed emissions calculation (primarily, activity data) are to be compared more closely with aggregated data from emissions trading. Initial pertinent results are presented in the relevant source category chapters.

3.2.2 International bunker fuels

3.2.2.1 Emissions from international transports (1.C.1.a/1.C.1.b)

The area of international transports is divided into international civil air transports (1.C.1.a) and international sea transports (1.C.1.b), the latter of which also includes blue-water fisheries and maritime navigation.

3.2.2.2 Emissions from international air transports (1.C.1.a)

3.2.2.2.1 Source category description (1.C.1.a)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	NS/IS	CS D (lubricants)
CH_4	Tier 3	NS/IS	CS
N_2O	Tier 3	NS/IS	CS
NO_X, CO, NMVOC, SO_2	Tier 3	NS/IS	CS

Source category 1.C.1.a "International civil aviation", which is part of the relevant reported source category, is not included in key-source analysis.

Emissions from fuel consumption for international air transports are included in inventory calculation; however, in agreement with the IPCC Good Practice Guidance (IPCC, 2000: p. 2.57) they are not reported as part of national total inventories.

International air traffic from German airports has been growing continually, in both relative and absolute terms. This trend seems to have been interrupted, however, as a result of the 2009 economic crisis and the impacts of the Eyjafjallajökull eruption in 2010, and thanks to fleet modernisations, efficiency improvements and improved capacity use. The development of the resulting greenhouse-gas emissions is shown in the following figure.

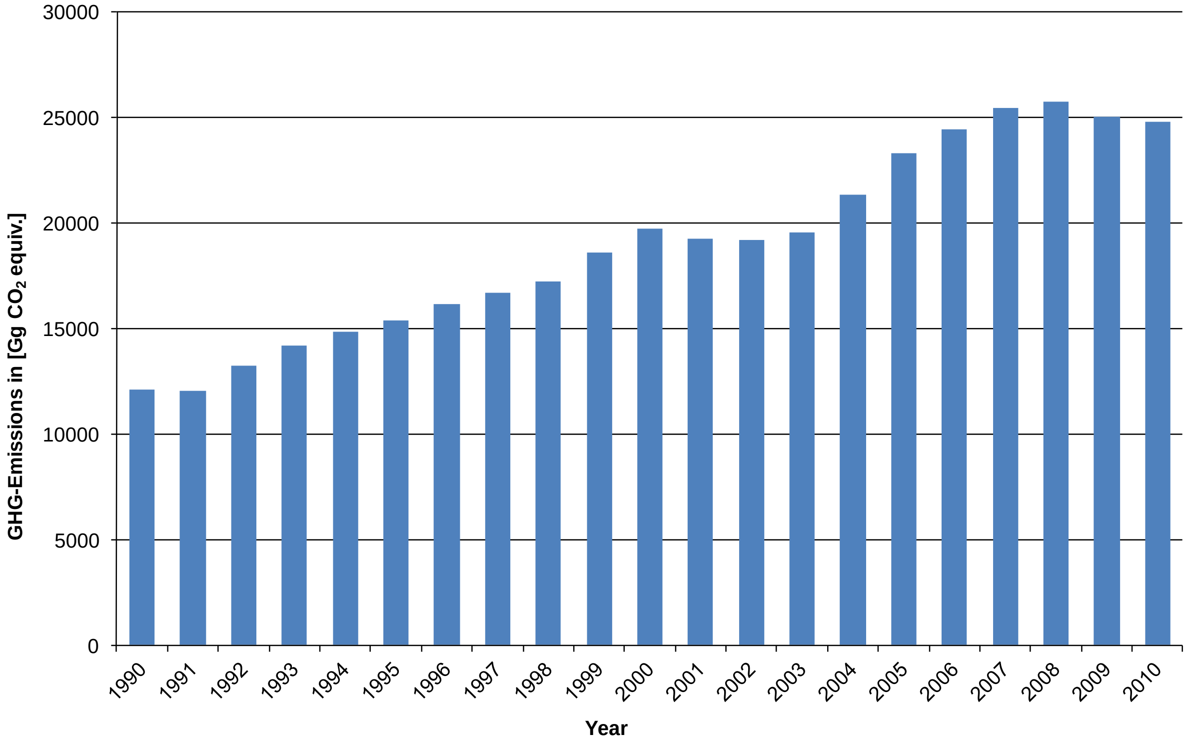


Figure 24: Development of greenhouse-gas emissions of international air traffic departing from Germany, 1990 - 2010

3.2.2.2.2 Methodological issues (1.C.1.a)

German energy statistics do not yet provide an official breakdown of fuel consumption relative to international air-transport emissions. To permit differentiation by national and international consumption nevertheless, these fuel-consumption figures are broken down by domestic and international air transports.

This breakdown is made in accordance with an annual split factor that refers to domestic air transports' share of total kerosene consumption. For 1990, a figure of about 15 %, based on individual movements of aircraft, was obtained via a research project. For years as of 2003, the relevant figure is provided directly by Eurocontrol (which calculates in accordance with Tier 3). For the years 1991 through 2002, interpolation is carried out via a continuous change function that is based on aircraft-movement data.

International air transports' so-determined shares of the kerosene consumption figures listed in the Energy Balance (AGEB) and in the official mineral-oil data (Amtliche Mineralöldaten) of the Federal Office of Economics and Export Control (BAFA) (AGEB, 2011; BAFA, 2011), are as follows:

Table 25: Development of international air transports' share of total kerosene consumption

Year	1990	1995	2000	2005	2006	2007	2008	2009	2010
Share in [%]	84.9	89.2	89.7	91.7	91.6	91.9	92.0	92.3	92.6

Avgas consumption is reported separately, and solely for domestic air transports. It does not enter into calculation of the split factor.

International civil aviation is separately listed as such in the CSE.

Additional information relative to the activity data and emission factors used is presented in Chapter 3.2.10.1 on national civil air transports.

3.2.2.2.3 Uncertainties and time-series consistency (1.C.1.a)

Cf. National air transport, Chapter 3.2.10.1.3.

3.2.2.2.4 Source-specific quality assurance / control (1.C.1.a)

For details, cf. National air transport, Chapter 3.2.10.3.4.

3.2.2.2.5 Source-specific recalculations (1.C.1.a)

On the one hand, recalculations with regard to the 2011 report were carried out especially to take account of a correction of domestic kerosene sales, to civil air transport operations, recorded for the years 2008 and 2009.

Table 26: Revision of domestic kerosene sales to civil air transport operations, 2008 and 2009

	Units	2007	2008	2009
Submission 2012		374,428	378,346	367,234
Submission 2011	[TJ]	374,428	380,114	368,951
Absolute difference		0.0	-1,768	-1,717
Relative difference	[%]	0.00	-0.47	-0.47

At the same time, the key provided by Eurocontrol relative to the split of total kerosene consumption, between domestic and international flights as of 2007, was also revised.

Table 27: Revision of international air transports' share of total kerosene consumption, 2007-2009

	Units	2006	2007	2008	2009
Submission 2012		91.6	91.9	92.0	92.3
Submission 2011	[1]	91.6	91.8	92.1	92.3
Absolute difference		0.00	0.09	-0.09	-0.05
Relative difference	[%]	0.00	0.09	-0.10	-0.06

These changes lead to the following changes in the activity data used in the present context:

Table 28: Recalculation of kerosene consumption in international air transports, 2007-2009

	Units	2006	2007	2008	2009
Submission 2012		330,822	344,088	348,121	338,933
Submission 2011	[TJ]	330,822	343,770	350,086	340,707
Absolute difference		0	318	-1,965	-1,774
Relative difference	[%]	0.00	0.09	-0.56	-0.52

In addition, the quantities of co-combusted lubricants for 2007 and 2008 were slightly revised.

Table 29: Revision of quantities of co-combusted lubricants, 2007-2009

	Units	2006	2007	2008	2009
Submission 2012		10.95	10.37	8.00	6.74
Submission 2011	[TJ]	10.95	10.36	8.01	6.74
Absolute difference		0.00	0.01	-0.01	0.00
Relative difference	[%]	0.00	0.10	-0.12	0.00

The changes in input data as described lead to the following recalculations, with regard to the Submission 2011, in reported greenhouse-gas emissions:

Table 30: Resulting recalculation of GG emissions of international air transports for the years 2007 to 2009

	Units	2006	2007	2008	2009
Submission 2012	[Gg	24,474	25,455	25,753	25,073
Submission 2011	CO_2	24,474	25,432	25,899	25,205
Absolute difference	equiv.]	0	23	-146	-132
Relative difference	[%]	0.00	0.09	-0.56	-0.52

The further impacts on the overall inventory are described in detail in Chapter 3.2.10.1.5.

3.2.2.2.6 Planned improvements (1.C.1. a)

Cf. National air transport, Chapter 3.2.10.1.

3.2.2.3 Emissions from international maritime transport / maritime navigation (1.C.1.b)

3.2.2.3.1 Source category description (1.C.1.b)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	T1	NS	CS D (lubricants)
CH_4	T1	NS	D
N_2O	T1	NS	D
NO_X, CO, NMVOC, SO_2	T1	NS	D

Source category 1.C.1.b "International maritime transport / maritime navigation", which is part of the relevant reported source category, is not included in key-source analysis.

International maritime transports includes both maritime shipping and blue-water fisheries. Fuel consumption and emissions of German blue-water fisheries have been deducted from international maritime transports; in accordance with the IPCC's requirements, those data are reported as part of the national overall inventory under 1.A.4.c iii - Fisheries (cf. the source-category-specific recalculations below, and Chapter 3.2.11).

Emissions from consumption of diesel fuel and heavy fuel oil for international transports of ocean-going ships are included in the inventory calculation although, in keeping with the UNFCCC guidelines, they are not reported as part of total national inventories.

Consumption of heavy oil has been increasing since 1984, as a result of high prices for diesel fuels and of increasing maritime use of diesel engines that can run on heavy fuel oil.

Temporary emissions reductions, especially those that occurred in 1992 and 2009, have been / were caused by trade and oil crises.

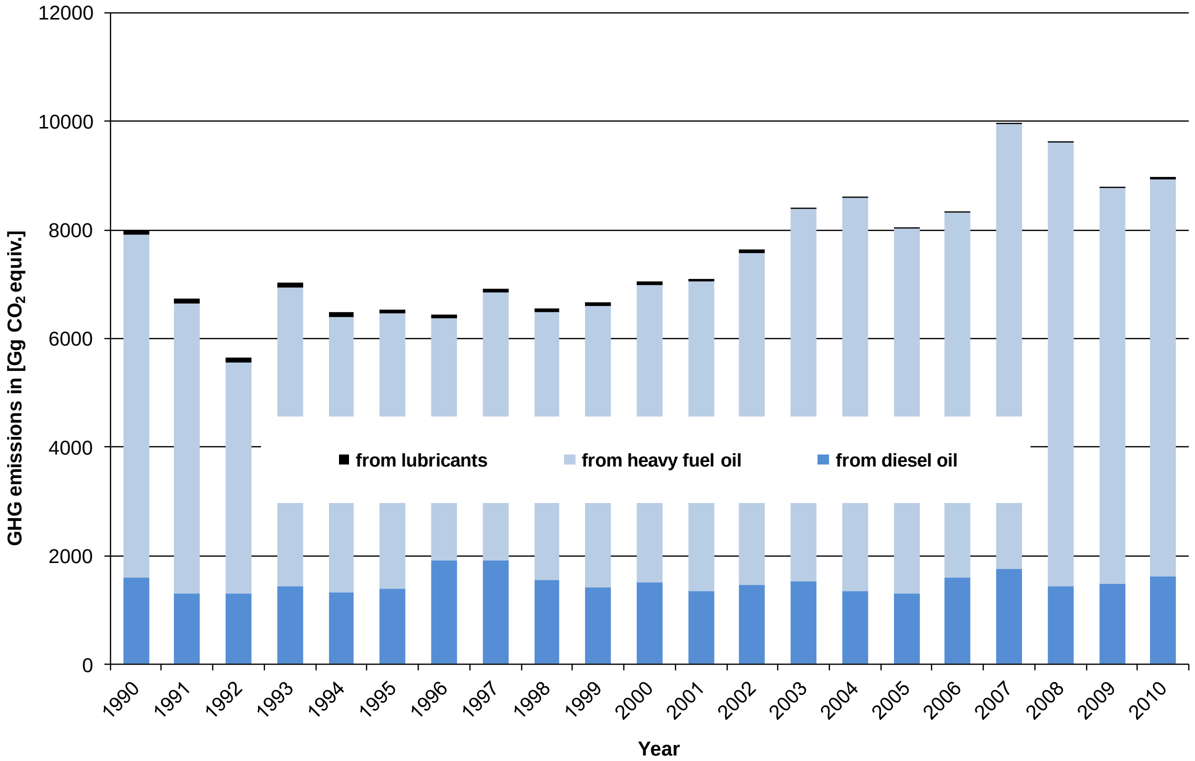


Figure 25: Development of greenhouse-gas emissions in international maritime transports, 1990 – 2010

3.2.2.3.2 Methodological issues (1.C.1.b)

Germany reports in keeping with the Tier 1 method. This means that emissions are calculated as the product of consumed fuels and country-specific emission factors for CO_2 and default emission factors for CH_4 and N_2O.

As a rule, the **activity data** for bunkering in ocean-going ships are taken from the Energy Balances of the Federal Republic of Germany (AGEB, 2011). The reason why these rates are listed separately is that fuel purchased in ports is taxed differently.

Table 31: Activity data used in National Energy Balances

Fuel	Energy Balance line	Relevant years
Diesel fuel Heating oil, heavy / heavy fuel oil	6 – High-seas bunkering	since 1990

For years for which no Energy Balance is yet available, data are obtained from the "Amtliche Mineralöldaten für die Bundesrepublik Deutschland" ("Official mineral-oil data for the Federal Republic of Germany"), which are published by the Federal Office of Economics and Export Control (BAFA) (BAFA, 2001; for the present context: Table 6j, column: "Bunker int. Schifffahrt" ("bunkering, international shipping") and enter into the National Energy Balances.

Beginning with the Resubmission 2010, a conservatively calculated share of these statistically recorded quantities is allotted to German blue-water fisheries and, thus, reported under 1.A.4.c iii – Other sectors: fisheries as part of the national inventory (cf. Chapter 3.2.11).

Table 32: Annual bunkered quantities (in TJ) in international sea transports leaving from Germany

	1990	1995	2000	2005	2006	2007	2008	2009	2010
Heavy fuel oil[1,2]	*80,230*	*64,382*	*69,578*	*85,370*	*85,277*	*104,066*	*103,830*	*92,614*	*93,058*
Diesel fuel [1,3]	23,336	20,426	21,542	18,636	22,376	24,441	20,300	20,748	22,483
of 1.A.4.c iii [4]	*1,928*	*1,928*	*1,509*	*1,098*	*988*	*988*	*988*	*878*	*878*
of 1.C.1.b [5]	*21,408*	*18,498*	*20,033*	*17,538*	*21,388*	*23,453*	*19,312*	*19,870*	*21,605*

1) Annual bunkered quantities pursuant to National Energy Balance, line 6: Bunker fuels
2) Heavy fuel oil: allocated to a degree of 100% to international sea transports
3) Diesel fuel: divided between international sea transports and German high-seas fisheries
4) Share for German high-seas fisheries: conservatively calculated on the basis of fleet sizes (cf. Chapter 3.2.11)
5) Share for international sea transports: Bunkered quantities pursuant to Energy Balance, less the share for 1.A.4.c iii

As of the 2011, pertinent quantities of co-combusted lubricants, along with the resulting CO_2 emissions, are recorded and reported. Figures for annual inputs of lubricants are obtained from the aforementioned "Amtlichen Mineralöldaten für die Bundesrepublik Deutschland" and converted to TJ, via a net calorific value of 40 GJ/t. Domestic deliveries have varied widely over the years, independently of fuel inputs (cf. Table 33).

To date a conservative estimate has been applied whereby 50 % of the input quantities are burned and thus produce CO_2 emissions.

Table 33: Annual quantities of lubricants co-combusted in international sea transports leaving from Germany (in TJ)

	1990	1995	2000	2005	2006	2007	2008	2009	2010
Domestic deliveries [1]	1,832	2,082	1,627	283	238	47	362	712	621
of this, co-combusted[2]	*916*	*1,041*	*814*	*141*	*119*	*24*	*181*	*356*	*310*

1) Annual domestic deliveries pursuant to BAFA
2) Conservative assumption: 50% co-combusted

With regard to the CO_2 **emission factor** for diesel fuel, 74,000 kg/TJ, and to that for heavy heating oil, 78,000 kg/TJ, the reader's attention is called to the documentation in Annex 2, Chapter *CO_2 emission factors*. For co-combustion of lubricants, an IPCC default figure of 80,000 kg CO_2/TJ is currently being used.

For calculation of N_2O, CH_4, CO, NO_X and NMVOC emissions, IPCC default emission factors from the Revised 1996 IPCC Guidelines (Reference Manual, 1996b: p.1.90 Table 1-48) are used.

On the other hand, it is assumed that emissions from co-combustion of lubricants are covered by the emission factors for the fuels used and thus are included in the emissions calculated for the various fuels. Therefore, all emission factors for co-combusted lubricants, with the exception of that for CO_2, are reported as IE (included elsewhere).

3.2.2.3.3 Uncertainties and time-series consistency (1.C.1.b)

Since the emission factor for carbon dioxide is a calculatable value that depends solely on fuel composition, the uncertainty for that emission factor is considered to be very low. It is set here at ±5 %. On the other hand, default uncertainties of the IPCC are used for the emission factors for methane and nitrous oxide.

3.2.2.3.4 Source-specific quality assurance / control and verification (1.C.1.b)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Source-specific verification of the emission factors for CO_2, methane and nitrous oxide was carried out via comparison with the pertinent factors used by other nations.

Due to a lack of relevant additional national and international sources (such as EU-ETS), it was not possible to compare activity data and emissions for this area.

3.2.2.3.5 Source-specific recalculations (1.C.1.b)

With respect to the data provided in the Submission 2011, only marginal recalculations, to take account of corrected activity data for 2009, were carried out.

Table 34: Influence of recalculations on levels of total greenhouse-gas emissions reported for the sector

	Units	1990	1995	2000	2005	2006	2007	2008	2009	2010
Submission 2011	[Gg CO_2 eq.]	7,993	6,538	7,043	8,047	8,326	9,952	9,637	8,823	-
Submission 2012		7,993	6,538	7,043	8,047	8,326	9,952	9,637	8,809	8,970
Δ ***absolute***		*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*-14.1*	-
Δ ***relative***	[%]	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*-0.2*	-

3.2.2.3.6 Planned improvements (1.C.1.b)

In the framework of a study, ship-movement data are currently being determined via the Automatic Identification System (AIS; a radio-based and satellite-based system for transmission of ship data such as size, load, speed, route, etc.). The resulting bunkering-quantities data will then be used, in combination with also-updated specific emission factors, for description of the emissions to be assigned to Germany.

3.2.3 Storage

In a research project carried out in co-operation with the University of Utrecht (UU STS, 2007), emissions from non-energy-related use of industrially used fuels were calculated for the first time for the years between 1990 and 2004 and then compared with the figures used for the CO_2 Reference Approach. The pertinent results are summarised in Annex 2, Chapter 13.9 of the NIR 2007.

3.2.4 CO_2 capture and storage (CCS)

At present, CO_2 capture and storage (CCS) technology is still in the research phase in Deutschland; some pilot systems are in place. Currently, storage via CCS is not included in the German inventory.

3.2.5 Special country-specific aspects

There are no special aspects that would influence reporting.

3.2.6 Public electricity and heat production (1.A.1.a)

3.2.6.1 Source-category description (1.A.1.a)

CRF 1.A.1a	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**339,017.9**	**(27.74%)**	**315,557.5**	**(33.09%)**	**-6.92%**
All fuels	**N_2O**	**L**	**-/T2**	**3,610.0**	**(0.30%)**	**3,498.9**	**(0.37%)**	**-3.08%**
All fuels	**CH_4**	**-**	**T/T2**	**185.8**	**(0.02%)**	**1,684.0**	**(0.18%)**	**806.50%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Public electricity and heat production* is a key category of CO_2 emissions in terms of level and trend. For N_2O emissions, it is a key category only in terms of level, and for CH_4 emissions, it is a key category only in terms of trend.

Under source category 1.A.1.a, "Public electricity and heat production", the CSE includes district heating stations and electricity and heat production of public power stations. Plants that feed electricity produced from biomass into the public grid are also assigned to source category 1.A.1.a.

Some 103 GW of net bottleneck capacity were in place in the public electricity generating sector in 2010. Of this amount, about 70 GW were operated with fossil fuels or with transformation products of fossil fuels. As a group, all fossil-driven plants generated some 300 TWh of electrical work. This corresponds to about 64 % of all public electricity generation (about 469 TWh). About 231 TWh of electricity were generated solely with lignite and hard coal.

In 2010, combined heat and power (CHP) stations contributed net electricity production of about 53 TWh, and net heat production of 101 TWh, to the public energy supply. The district-heat supply is supplemented with heat, amounting to 17 TWh, from heat-only boiler stations that are normally run in peak-load operation. (*STATISTISCHES BUNDESAMT,* 2010a).

The following figure presents an overview of development of CO_2 emissions in source category 1.A.1.a:

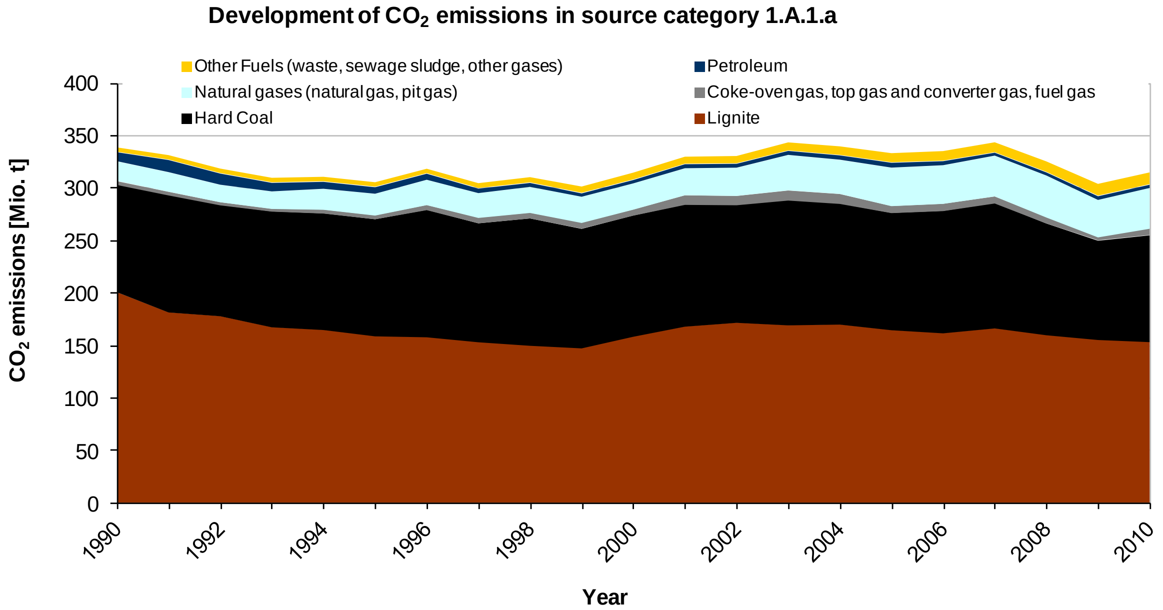


Figure 26: Development of CO_2 emissions in source category 1.A.1.a

Overall, emissions until 1999 show a falling trend, due primarily to closure of four lignite-fired installations in the new German Länder. Thereafter, a number of installations were replaced. As of 2000, then, the newly installed capacities, in the category of lignite-fired power stations, exceeded those of the decommissioned power stations, and thus emissions began increasing again. Nonetheless, overall emissions from lignite-based electricity generation are considerably below the corresponding emissions level in 1990.

In the main, the emissions trend is shaped by the development and structures of the electricity generation installations involved, since those installations account for the majority of the pertinent emissions. From 1990 through 1993, electricity consumption decreased, as a result of the collapse of industry in the new German Länder. From 1994 until 2007, a marked increase in electricity consumption occurred in all sectors, sparking increases in electricity production. As a result, emissions from electricity production also increased. In addition, electricity exports increased. Those exports begin showing up in the overall balance as of 2003. The increasing trend has been tempered by increased use of natural gas, by improvements in power stations' efficiency and by increasing electricity generation via renewable energies.

In 2007, particularly large quantities of coal were used for electricity generation, in keeping with low prices for emissions certificates. Thereafter, beginning as early as 2008, a marked emissions decrease occurred, as a result of increase use of nuclear power, natural gas and renewable energies. In 2009, the financial and economic crisis occurred, also affecting the public energy supply. In particular, hard-coal-fired power stations, which are used in the medium-load range, produced considerably less electricity, thereby also producing considerably lower emissions. With that trend, emissions from hard-coal-fired electricity generation dropped below the 1990 level, for the first time since that year. As seen via the relevant time series, hard-coal-fired power stations show higher fluctuations in fuel inputs than lignite-fired power stations do. The reason is that they, in contrast to lignite-fired power stations, are operated primarily in the medium-load range, where they respond more markedly to fluctuations in demand. What is more, they are dependent on import prices.

Furthermore, as of the mid-1990s sectoral shifting occurred, from industry (1.A.1.c and 1.A.2.f) to the public electricity supply (1.A.1.a), as more and more operators reported their data in the public electricity supply category.

Petroleum plays only a minor role in Germany's electricity supply. It is used primarily for auxiliary and supplementary firing in coal-fired and waste-to-energy CHP power stations, as well as for peak-load generation. Use of petroleum in these roles has dropped by more than half since 1990. In the crisis year 2009, when petroleum became considerably cheaper than natural gas, use of petroleum for peak-load generation increased again somewhat.

Use of natural gas for electricity generation has increased markedly since 1990. That trend has not led to an equivalent emissions increase, however, since the specific CO_2 emissions of natural gas are considerably lower than those of coal. The significant increase in natural gas use seen since 2005 is due especially to the commissioning of a considerable number of major gas and steam turbine power stations and medium-sized gas-turbine power stations. What is more, natural gas is increasingly being used as balancing energy for electricity generation with fluctuating renewable energies. Since 1990, waste inputs in waste-incineration plants and for co-incineration have also been increasing, as a result of changes in relevant laws. While increased use of waste in this area produces additional emissions, it helps prevent methane emissions from landfills. Use of industrial gases for electricity generation depends on production, as the crisis year 2009 showed. In addition, the relevant figures depend on whether operators, in the context of statistical surveys, report their use in the "industry" category or "public electricity supply" category. Overall, changes in sectoral classification repeatedly occur in connection with all fuels.

In 2010, electricity generation with nearly all fossil fuels increased – sharply, in some cases – as a result of economic recovery, and this led to increased CO_2 emissions. Nonetheless, emissions from electricity generation remained below their 2008 level. A cold winter was another reason why CO_2 emissions increased in 2010. The resulting increased demand for heat led to higher fuel inputs in district heating stations.

3.2.6.2 Methodological issues (1.A.1.a)

Activity rates

The calculation method has been selected on the basis of current key-source analysis, and it conforms to the decision tree in the IPCC Good Practice Guidance.

The fuel input for public electricity production is given in line 11 ("Public thermal power stations") of the Energy Balance. The fuel inputs for public heat production are given in lines 15 ("thermal power stations") and 16 ("district heating stations").

In the "Balance of Emissions Causes" model, the energy inputs listed in the Energy Balance are divided among several time series, with the help of statistical data. The aim of the calculations is to produce a database that is adjusted to the special technical characteristics of electricity and heat production. As a result, fuel-specific and technology-specific emission factors can be applied to the relevant activity data.

For the 2006 report, the activity data for the new German Länder for the year 1990 were revised and substantiated in the framework of a research project (FKZ 205 41 115 / sub-project A, "Revision and Documentation of Fuel Inputs for Stationary Combustion System in the new German Länder for the year 1990").

In the case of electricity and heat production in waste-incineration systems of public power stations, and of heat production in waste-incineration systems of public district heating stations, both energy statistics and the Energy Balance have shown considerably smaller relevant waste quantities than have the waste statistics of the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, FS 19 Reihe (series) 1). Although the fuel quantities shown in energy statistics have increased steadily in recent years, the relevant additional data provided by waste statistics are still required.

The quality of the data provided by energy statistics has increased considerably in recent years. Such statistics now differentiate fuel data in a way that makes it possible, via calculation, to separate out figures for solid biomass (especially waste and scrap wood), biogenic gases, sewage sludge and waste heat. Industrial waste appeared as a fuel category in energy statistics for the first time in 2008. As of the NIR 2006, the fossil and biogenic fractions of household / municipal waste are listed separately, in a ratio of 1/1. The pertinent underlying assumption was confirmed via publication of the research project with funding reference number (Förderkennzeichen) 3707 33 303, "Nutzung der Potenziale des biogenen Anteils im Abfall zur Energieerzeugung" ("Use of biogenic waste fractions for energy generation") (UBA, 2011).

The existing assumptions relative to the biogenic fraction of sewage sludge have been retained.

Data relative to industrial waste are taken not from energy statistics but from Fachserie 19 Reihe 1 (of the Federal Statistical Office), because those waste statistics use specific, clearly defined waste keys that permit qualitative analysis. Previously, the fossil fraction of such waste was given as 100 %. That figure is now being reviewed in light of the applicable waste key.

Figure 27 schematically shows all important sources of data on use of waste as fuel for public energy generation.

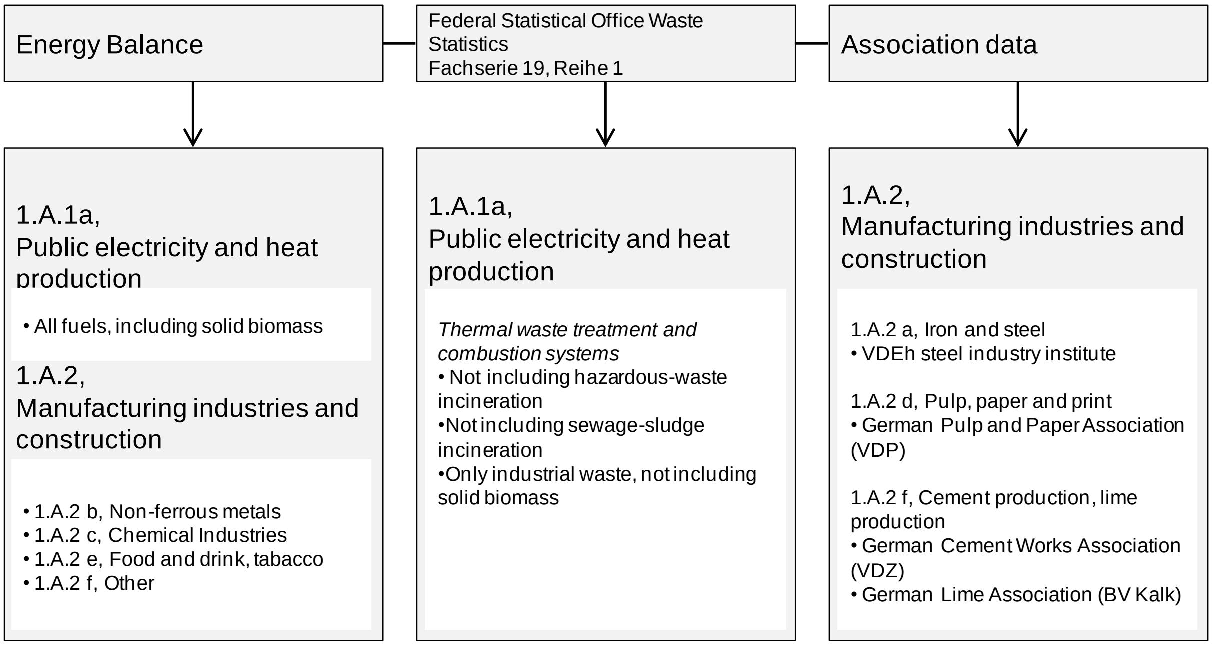


Figure 27: Sources of data on fuel inputs in waste incineration plants and combustion systems of the public energy supply

The activity data for other fuels are taken directly from the Energy Balance. Where pertinent statistical indications or experts' assessments are available, fuel inputs are additionally divided into two size classes (combustion systems smaller and larger than 50 MW). The dividing line between these two categories is based on legal regulations pertaining to licensing of combustion systems in the Federal Republic of Germany.

As of the NIR 2011, CO_2 emissions from top-gas combustion in public power stations are reported in source category 1.A.1.a. The following table provides an overview of relevant emissions from top-gas use, for the entire time series since 1990.

Table 35: CO_2 emissions from top-gas combustion in public power stations

[Millions of t of CO_2]									
1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
3.236	3.283	3.008	2.719	3.744	3.745	4.796	5.282	5.440	5.782
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
5.930	9.243	8.990	9.723	9.597	6.866	7.112	6.578	5.858	3.317
2010									
6.356									

Emission factors (except for that for CO_2)

The underlying data for the emission factors used is provided by the report on the research project "Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010" ("Determination and evaluation of emission factors for combustion plants in Germany for the years 1995, 2000 and 2010"; RENTZ et al, 2002). The values for the intermediate years 1996 - 1999 and 2001 - 2009 are obtained via linear interpolation. That project, along with the linear interpolation for the intermediate years, has also provided the underlying data for the emission factors presented in Chapters 3.2.7, 3.2.8, 3.2.9.6 und 3.2.10.5, where the factors include power stations, gas turbines and boilers for generation of steam and hot/warm water. The research project was carried out by the Franco-German Institute for Environmental Research (Deutsch-Französisches Institut für

Umweltforschung – DFIU) at the University of Karlsruhe, and it was completed at the end of 2002. The project aim was to determine and evaluate representative emission factors for the main air pollutants produced by combustion systems in Germany that are subject to licensing requirements, and to do so for the years 1995, 2000 and 2010. The procedure for achieving that aim consists primarily of analysing and characterising the relevant emitter structures, and the pertinent emission factors, for the year 1995, and then of adequately carrying that data forward for the years 2000 and 2010. The procedure systematically determines emission factors for the substances SO_2, NO_X, CO, NMVOC, particulates and N_2O. Furthermore, it differentiates between 12 coal fuels, 4 liquid fuels, 7 gaseous fuels and firewood. In addition, the available data relative to emission factors of other substances are also compiled; these other substances include PAH, PCDD/F, As and Cd for combustion systems subject to licensing requirements, and CH_4 for gas turbines and combustion systems subject to licensing requirements that fall under the TA Luft. Annex 3 (Chapter 19.1.2) discusses the procedure used in the research project.

In connection with a major research project that began at the end of 2008 and was completed in 2011 (FICHTNER et al. 2011), we have begun updating the described database for emission factors (except for that for CO_2). The reference year for the proposed values is 2004. On that basis, emission factors are being predicted for the years 2010, 2015 and 2020. On the basis of the relevant research results, we have already updated a considerable number of time series – primarily with regard to coal-fired plants – for the emission factors for SO_2, NO_x and mercury. We plan to update additional emission-factor time series, and report the results, in the context of future inventory reports.

For the 2011 reporting round, for the first time ever and in the framework of a research project carried out by the Institute for Future Studies and Technology Assessment (IZT), "Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV" ("Processing of data in emissions declarations pursuant to the 11th Ordinance on the Execution of the Federal Immission Control Act"), special CH_4 emission factors for gas engines were determined. The average value for natural gas as a fuel, 309 kg/TJ, is markedly higher than the previously assumed value, 0.3 kg/TJ, which is approximately the same as the value for steam-turbine power stations. With emissions-monitoring data, it was possible to confirm that significant methane leakage occurs via leakage of unburned natural gas. The pertinent measurements can vary considerably, in keeping with the type of engine and engine-maintenance standards involved. For biogas, sewage gas, landfill gas and mine gas, an average CH_4 emission factor of 185 kg/TJ was determined. For biogas, at least, it was possible to confirm that figure with data from emissions monitoring. In light of the lower methane concentrations of biogenic gases, the corresponding factor must be set lower for them than for natural gas.

In Germany, N_2O is monitored only in exceptional cases; for this reason, no relevant data from regular measurements are available. On the other hand, relevant emissions behaviour in combustion of hard coal and lignite, especially in fluidised-bed combustion, has been specifically studied, especially in the 1990s. For this reason, enough measurement data were available to permit systematic survey of N_2O emission factors in the research project. The relevant technological emission factors for large combustion plants, as determined in the research project, are summarised in Table 36. Those factors were used as a basis for calculating the source-category-specific emission factors for the CSE.

Table 36: Technological emission factors for nitrous oxide from large combustion systems

Fuel / combustion technology	N_2O emission factor (1995 - 2010) [kg/TJ]
Hard coal / fluidised bed	20
Hard coal / other combustion methods	4
Lignite / fluidised bed	8
Lignite / dry-dust combustion, in the new Länder	3.2
Lignite / other combustion methods	3.5
Liquid fuels	1
Gaseous fuels	0.5

The data presented in Table 37, taken from from the research project RENTZ et al (2002), served as the basis for systems < 50 MW furnace thermal output. The relevant median figures are shown in brackets.

Table 37: Technological emission factors for nitrous oxide from systems < 50 MW furnace thermal output

Fuel		Technology	Output	Länder	N_2O emission factor / median [kg/TJ]
Hard coal (Steinkohle)		Grate combustion	< 5 MW	/	2.5 - 5.2 [3.9]
			≥ 5 MW	ABL	2.5 - 5.2 [3.9]
			≥ 5 MW	NBL	2.5 - 5.2 [3.9]
		Furnace-shell combustion	< 5 MW	ABL	2.5 - 5.2 [3.9]
			< 5 MW	NBL	2.5 - 5.2 [3.9]
			≥ 5 MW	/	2.5 - 5.2 [3.9]
		Fluidised-bed combustion	< 5 MW	/	25 - 40 [36]
			≥ 5 MW	/	2 - 170 [47]
Lignite (Braunkohle)	- dust	Dust combustion	≥ 5 MW	NBL	[3.2]
	- briquette	n.i.	< 5 MW	NBL	0.4 - 3.7 [2.1]
	Raw	n.i.	< 5 MW	NBL	0.4 - 3.7 [2.1]
			≥ 5 MW	ABL	0.4 - 3.7 [2.1]
			≥ 5 MW	NBL	0.4 - 3.7 [2.1]
		Fluidised-bed combustion	≥ 5 MW	/	40 - 50 [45]
Heavy heating oil		n.i.	/	ABL	2 - 4 [3]
			/	NBL	2 - 4 [3]
Light heating oil		n.i.	≥ 20 MW	/	0.6 - 1.5 [1.1]
Natural gas		n.i.	≥ 10 MW	/	0.3 - 1.5 [0.9]

n.i. not included
ABL old German Länder
NBL new German Länder

Information on process-related CO_2 emissions from flue-gas scrubbing (flue-gas desulphurisation) in large combustion systems is provided by Annex 3 in Chapter 19.1.2.3.

3.2.6.3 Uncertainties and time-series consistency (1.A.1.a)

Uncertainties for activity data were determined, for the first time ever, for the 2004 report year (research project FKZ 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, Chapter 13.6 of the NIR 2007.

Other aspects relative to time-series consistency of activity data are explained in Chapter 18.4 and Chapter 18.5.

The figures for the uncertainty of the CO_2 emission factor, and for the statistical distribution function for that uncertainty, have been estimated by the Federal Environment Agency. The figures are based on the range covered by the carbon contents of the various individual fuels.

The uncertainty of the determined emission factors has been evaluated in the framework of the DFIU research project described in Chapter 3.2.6.2 and in Annex 3, Chapter 19.1.2.1.

3.2.6.3.1 Methods for determining uncertainties of emission factors

The uncertainties in emissions data result from several different factors. These include *precision*, which is influenced by chance and systematic errors in the framework of emission measurement, as well as by the completeness of the database with regard to available measurements. Another factor consists of *variability* of emissions. In this area, a distinction must be made between variability in emissions of a single plant, within the period in question (*intra-plant variability*) and differences between the emissions behaviours of the various sources considered (*inter-plant variability*).

Other sources of possible uncertainties can affect calculation of emissions with the help of emission factors. In the framework of IPCC-GPG (2000: Chapter 6), methods – adapted, in each case, to data availability – are proposed:

Where *continuous* measurements have been carried out, uncertainties should be characterised via direct determination of statistical indexes such as standard deviation and the 95%-confidence interval.

In determination of *plant-specific emission factors*, any available local measurements should be used. In addition, any special operational states (start-up and shut-down processes) and load changes should be taken account of, and available measurements should be reviewed for representativeness in light of the relevant plant's emissions behaviour.

In use of *emission factors from the literature*, all of the data-quality information provided by the sources in question should also be used. Furthermore, transferability should be reviewed – to what extent is the emission factor in question representative of the situation in the relevant area being studied? If the factor is not representative, an experts' assessment should be carried out.

In general, use of *experts' assessments* is recommended in cases in which available empirical data does not suffice for quantification. A sample explanation is provided in Annex 3, Chapter 14.1.2.2, of the NIR 2007.

3.2.6.3.2 Result for N_2O

Individual evaluations of the uncertainties in N_2O emission factors, carried out in the research project (RENTZ et al, 2002), are included in the Excel tables for transfer of emission factors into the Federal Environment Agency's CSE database; for power stations, the evaluations are also described in the final report. The great majority of values for relative uncertainty lie in the range between 0.6 and 0.9. As part of an experts' assessment carried out by the research customer, pursuant to Tier 1 of the IPCC-GPG (2000: Chapter 6), an upper boundary of +/- 50 % was given for the percentage uncertainty in CRF category 1.A.1.a (as well as for categories 1.A.1.b, 1.A.1.c and 1.A.2.f / all other) (remark: values for +/- ranges must be divided by 2; cf. IPCC-GPG (2000: Chapter 6, p. 6.14); in the process, uniform distribution of uncertainties was assumed – in keeping with the calculation method selected).

3.2.6.3.3 Result for CH_4

Combustion systems in Germany are not subject to monitoring of CH_4 emissions; for this reason, no systematic-measurement data are available in this area. Consequently, relevant individual data items available in Germany and Switzerland have been relied on. As a result of this database limitation, the research project did not attempt any systematic correlation with source categories treated by the project (cf. Chapter 3.2.6.2). The individual CH_4 emission factors, as determined in the research project (RENTZ et al, 2002), are summarised in Annex Chapter 19.1.2.2. Previously, the factors listed there, for hard coal fired in combustion systems < 50 MW (mean value for D: 3.35 kg/TJ), and for light heating oil and natural gas fired in gas turbines, were used in the CSE for the years as of 1995. Review and adoption of the project's remaining proposals are still pending. For these fuels, the existing emission factors in the CSE are used without change (solid fuels: 1.5 kg/TJ; liquid fuels: 3.5 kg/TJ; and gaseous fuels: 0.3 kg/TJ).

As part of an experts' assessment carried out by the research customer, pursuant to Tier 1 of the IPCC-GPG (2000: Chapter 6), an upper limit of +/- 50 % was estimated for the percentage uncertainty in source category 1.A.1.a (as well as in source categories 1.A.1.b, 1.A.1.c and 1.A.2f / all other); in the process, a uniform distribution of uncertainties was assumed – as was the case for N_2O.

3.2.6.3.4 Time-series consistency of emission factors

In the framework of the aforementioned research project (RENTZ et al 2002), the emission factors for N_2O were determined for 1995 (reference year) and then carried forward, on that basis, for 2000 and 2010. With that approach, no changes result for most of these emission factors for the period from 1995 to 2010. The N_2O emission factors were forecast to decrease slightly only in the area of use of gas turbines (natural gas, light heating oil). This is a result of the higher mean gas-turbine-intake temperatures required in modern gas turbines in order to increase efficiency. These changes have no significant effect, however, on levels of total N_2O emissions in the CRF area under consideration.

The time series for N_2O between 1995 and 2010 were reviewed in this light and assessed as consistent overall. The time series of CH_4 emission factors for 1995 to 2010 were also reviewed and assessed as internally consistent.

In the NIR 2009, we reported on the period from 1990 to 1994.

To ensure time-series consistency, the CH_4 emission factors determined for combustion-engine systems were retroactively applied for the period back to 1990. Methane leakage is likely to have been higher in the early 1990s than it is with modern engine systems. Too little relevant measurement data is available for that period, however.

For most biogenic fuels, statistical fuel-input data are available only for the period since 2003. As a result, it is not possible to provide a consistent time series, for the period since 1990, for such fuels. That limitation affects only the trend for CH_4 emissions, which increases sharply as of the year 2003.

3.2.6.4 Source-specific quality assurance / control and verification (1.A.1.a)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the EF and ED of methane and nitrous oxide and for the pertinent AD.

For carbon dioxide, quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

To document its quality-assurance measures in preparation of Energy Balances, the Working Group on Energy Balances (AGEB) submits pertinent quality reports to the Federal Environment Agency (UBA) (cf. Chapter 18.4.2). In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[20].

Quality assurance for official statistics is carried out via an internal quality system. That system's quality reports are available for inspection within the Internet publications of the *Federal Statistical Office*.

In addition to these measures, the AGEB plays a role in the annual review process, and regular exchanges take place with the AGEB in the framework of that body's regular meetings, which are regularly attended by UBA representatives. At such meetings, methodological issues are discussed, and general exchanges take place for the purposes of clarifying data-collection issues and verifying data.

General measures for assuring the quality of emission factors for combustion plants, as used in the framework of a research project (RENTZ et al, 2002), are outlined in the methods description in Annex 3, Chapter 19.1.2.1 (after Figure 80). Their results were reported in the NIR 2005.

3.2.6.5 Source-specific recalculations (1.A.1.a)

For source category 1.A.1.a, recalculations were required for the period as of 2003, as a result of revision of the applicable waste model.

In addition, the provisional figures for the year 2009 have now been replaced with now-available final statistics, leading to the following changes.

Table 38: Source-specific recalculations, CRF 1.A.1.a

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute					Difference, relative
Year	Total	Total	gas	liquid	other	solid	Total	Total
2003	**343,694**	**344,348**	0	0	654	0	**654**	**(0.19%)**
2004	**338,530**	**340,557**	0	0	2,028	0	**2,028**	**(0.60%)**
2005	**331,997**	**334,035**	0	0	2,038	0	**2,038**	**(0.61%)**
2006	**334,038**	**335,958**	0	0	1,920	0	**1,920**	**(0.57%)**
2007	**342,526**	**344,300**	0	0	1,774	0	**1,774**	**(0.52%)**
2008	**324,997**	**326,016**	0	0	1,047	-29	**1,019**	**(0.31%)**
2009	**305,235**	**304,603**	-1,732	-181	774	507	**-632**	**(-0.21%)**

[20] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

3.2.6.6 Planned improvements (source-specific) (1.A.1.a)

Following the completion of the relevant research project begun in 2008 (FICHTNER et al. 2011), the emission factors for NO_X and SO_2 were updated. Updating of the **emission factors** for CH_4 and N_2O is currently in progress.

3.2.7 Petroleum refining (1.A.1.b)

3.2.7.1 Source-category description (1.A.1b)

CRF 1.A.1.b	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**20,005.9**	**(1.64%)**	**19,857.2**	**(2.08%)**	**-0.74%**
All fuels	N_2O	-	-	121.9	(0.01%)	61.1	(0.01%)	-49.86%
All fuels	CH_4	-	-	13.3	(0.00%)	6.8	(0.00%)	-48.78%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Petroleum refining* is a key category of CO_2 emissions in terms of emissions level and trend.

The figures given above apply for refinery power stations (part of source category 1.A.1.b).

The crude oil distillation capacity of German petroleum refineries totalled around 117.6 Mt in 2010. In that period, 95 Mt of crude oil, along with 12 Mt of intermediate products, were input for processing. Production of petroleum products totalled 133 Mt, of which about 60.8 Mt consisted of fuels, about 28.7 Mt consisted of heating oils, about 15.5 Mt consisted of naphtha and about 28.7 Mt consisted of other products. (MWV, 2011, Tab PRE1.1, Tab 4, Tab 5j).

The refineries operate power stations with electrical output of about 1.2 GW. In 2009, these power stations generated 6.5 TWh of electrical work and yielded process heat for production purposes. (*STATISTISCHES BUNDESAMT,* 2010c).

Under source category 1.A.1.b, Petroleum refining, the CSE lists the sub-categories "refinery bottom-heating systems" and "electricity and heat production of refinery power stations".

The following figures provides an overview of emissions trends in source category 1.A.1.b:

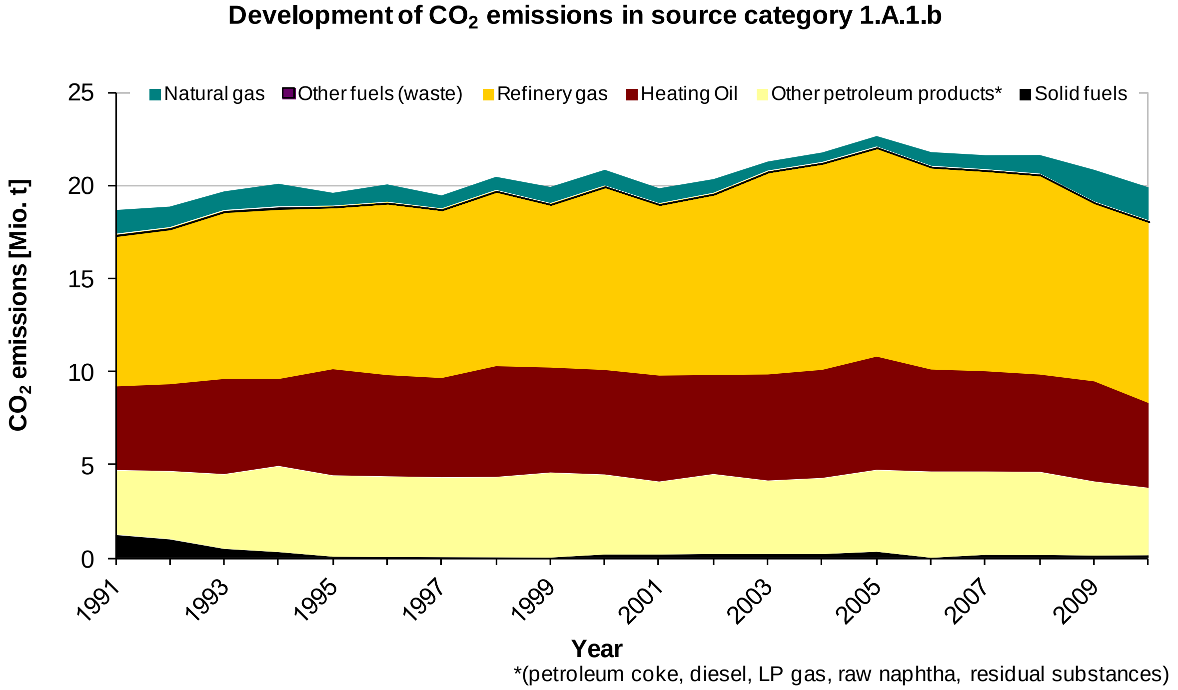


Figure 28: Development of CO_2 emissions in source category 1.A.1.b

Since 1990, emissions have shown a slightly increasing trend overall. While some relevant installations have been decommissioned since 1990 – although such decommissioning has taken place on a smaller scale than that seen in the hard-coal and lignite mining sectors – production increased nevertheless. And while installation efficiencies were improved, increased production of lighter petroleum products, and intensified ultra-hydrodesulphurisation, led to increases in specific fuel consumptions. The emissions fluctuations that have occurred over the years can be explained as the result of differences in production quantities. The maximum production of petroleum products to date, totalling 123.6 million t, occurred in 2005. The pertinent emissions were correspondingly high. Thereafter, production decreased, to a level of 104.9 million t of petroleum products in 2010, and emissions decreased as a result. Petroleum processing is one of the few sectors in Germany that have not profited from economic recovery. This is due to a difficult global market situation resulting from overcapacities. In 2010, one German refinery stopped operating. This led to a further decrease in pertinent emissions in 2010.

3.2.7.2 Methodological issues (1.A.1.b)

Activity data

Fuel inputs for electricity production in refinery power stations are included in Energy Balance line 12 ("Industrial thermal power stations"). Energy Balance lines 38 and 39 show energy consumption (for heat production) of refineries and used-oil-processing facilities. Fuel inputs for heat production in refinery power stations, and for bottom heating in refinery processes, are derived from these figures.

The time-series structure that results from the breakdown of energy inputs from the Energy Balance, in the BEU model, is shown in the Figure "Structural allocation, 1.A.1.b Refineries" .

Activity rates for refineries are determined with the help of figures of the Federal Statistical Office, and of the Federal Office of Economics and Export Control (BAFA), for fuel inputs for electricity and heat production in petroleum refining.

The BAFA statistics include figures for total fuel inputs of refineries (refineries and processing of used oil). For calculation of activity data for electricity production, energy inputs for heat production (EB line 38) are subtracted from those figures. That procedure shows what amount of the energy input in Energy Balance line 12 must be allocated to refinery power stations.

The data of the *Federal Statistical Office* relative to electricity and heat production in refinery power stations cannot be adopted directly, since the data-collection methods of BAFA and the Federal Statistical Office differ. While BAFA's data show only refineries' own consumption, the "Statistik" 067 and 060 published by the *Federal Statistical Office* cover all of the fuels used by refinery power stations. Since refinery power stations also feed electricity into the public grid, the Federal Statistical Office's figures are higher than the corresponding figures of BAFA. Other relevant differences occur in the definitions used for the fuels "heating oil, heavy" and "other petroleum products". In comparison to the BAFA data, the data of the Federal Statistical Office show a larger quantity of other petroleum products overall and a smaller quantity of heavy heating oil. The Energy Balance uses BAFA's mineral-oil statistics for orientation. In the interest of maintaining consistency with the Energy Balance, the ratio between a) the fuel inputs for heat production in refinery power stations and b) the fuel inputs for electricity production in refinery power stations is calculated, on a fuel-specific basis, from the Federal Statistical Office's statistics. That factor, in conjunction with fuel inputs for electricity production in refinery power stations, can then be applied to the fuel consumption given by BAFA in order to calculate fuel inputs in refinery power stations for heat production.

The activity data for refinery-process bottom heating are obtained by subtracting fuel inputs in refinery power stations for heat production from refineries' final energy consumption (EB line 38 Refineries).

Energy inputs in facilities for used-oil processing (EB line 39) are reported under 1.A.1.c "Other transformation sector".

Emission factors (except for that for CO_2)

The emission factors for refinery power stations have been taken from the research project RENTZ et al. (2002). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. The cited project does not provide any emission factors for the bottom-heating systems that supply process heat. To compensate for this gap, for bottom-heating systems the same values for N_2O and CH_4 were chosen that are used for refinery power stations.

3.2.7.3 Uncertainties and time-series consistency (1.A.1.b)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, in the Chapter "Uncertainties in the activity data of stationary combustion systems" (Chapter 13.6 of the NIR 2007).

3.2.7.3.1 Result for N_2O

The values for relative uncertainty are about 0.6. Otherwise, the remarks made in Chapter 3.2.6.3.2 apply mutatis mutandis.

3.2.7.3.2 Result for CH_4

The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

3.2.7.3.3 Time-series consistency of emission factors

The results of Chapter 3.2.6.3.4 apply mutatis mutandis.

3.2.7.4 Source-specific quality assurance / control and verification (1.A.1.a)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the EF and ED of methane and nitrous oxide and for the pertinent AD.

For carbon dioxide, quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

With regard to emission factors, the results of Chapter 3.2.6.3 apply mutatis mutandis.

3.2.7.5 Source-specific recalculations (1.A.1.b)

Recalculations were carried out for the category Other petroleum products, for the period as of 2003, to take account of an adjustment in the model applied. For 2009, replacement of provisional values with values from original statistics leads to the recalculations shown below.

The resulting changes are as follows:

Table 39: Recalculations in CRF 1.A.1.b

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute				Difference, relative
Year	Total	Total	gas	liquid	solid	Total	Total
2003	21,221	21,238	0	17	0	17	(0.08%)
2004	21,667	21,721	0	54	0	54	(0.25%)
2005	22,580	22,599	0	19	0	19	(0.08%)
2006	21,723	21,740	0	17	0	17	(0.08%)
2007	21,574	21,575	0	1	0	1	(0.00%)
2008	21,572	21,585	0	13	0	13	(0.06%)
2009	20,270	20,793	794	-253	-19	523	(2.58%)

3.2.7.6 Planned improvements (source-specific) (1.A.1.b)

No improvements with regard to **activity data** are planned at present.

Following the completion of the relevant research project begun in 2008 (FICHTNER et al. 2011), the emission factors for NO_X and SO_2 were updated. Updating of the **emission factors** for CH_4 and N_2O is currently in progress.

3.2.8 Manufacture of solid fuels and other energy industries (1.A.1.c)

3.2.8.1 Source-category description (1.A.1.c)

CRF 1.A.1.c	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**64,393.8**	**(5.27%)**	**13,645.8**	**(1.43%)**	**-78.81%**
All fuels	N_2O	-	-	684.2	(0.06%)	176.4	(0.02%)	-74.21%
All fuels	CH_4	-	-	85.3	(0.01%)	18.4	(0.00%)	-78.47%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Manufacture of solid fuels and other energy industries* is a key category, in terms of both emissions level and trend, of COCO_2 emissions.

The above figures refer to power stations, and to other boiler furnaces for production of steam and hot/warm water, in source category 1.A.1.c.

Source category 1.A.1.c includes hard-coal and lignite mining, coking and briquetting plants and extraction of crude oil and natural gas. In 2010, the German hard-coal mining sector extracted 12.9 Mt of usable hard coal (13.8 Mt in 2009) (STATISTIK DER KOHLEWIRTSCHAFT 2011: for 2010, Übersicht (overview) 1 and www.kohlenstatistik.de) Coke production in 2010 amounted to 8.1 Mt (STATISTIK DER KOHLEWIRTSCHAFT 2011). Production of hard-coal briquettes was discontinued in 2008.

In 2010, 169.4 Mt of crude lignite was produced in Germany (ibid.). Combined production of lignite briquettes and other lignite products amounted to about 6.0 Mt (ibid.). Steam for drying of raw lignite, for production of refined lignite products, is obtained from lignite-fired power stations with process-steam extraction (CHP plants). From these plants, steam is drawn off for drying crude lignite for production of lignite products.

In 2010, German production of petroleum totalled 2.51 Mt (MWV, 2011), while production of natural gas totalled about 11,411 Nm³ (AGEB, 2011). The fuel inputs required for installations' own operations are reported in source category 1.A.1.c.

In the CSE, source category 1.A.1.c Manufacture of solid fuels and other energy industries includes electricity and heat production in steam-turbine power stations, broken down by hard-coal mining and lignite mining (mine power stations); electricity and heat production in gas turbines, gas engines and diesel engines of all colliery and mine power stations; other heat production in industrial boilers within the transformation sector (not including refineries); and manufacture of hard-coal coke and operation of diesel engines for propulsion purposes in colliery and mine power stations. In reporting, they are broken down into the categories "large combustion systems" and "plants falling under the Technical Instructions on Air Quality Control" (TA Luft).

The following figure provides an overview of emissions trends in source category 1.A.1.c:

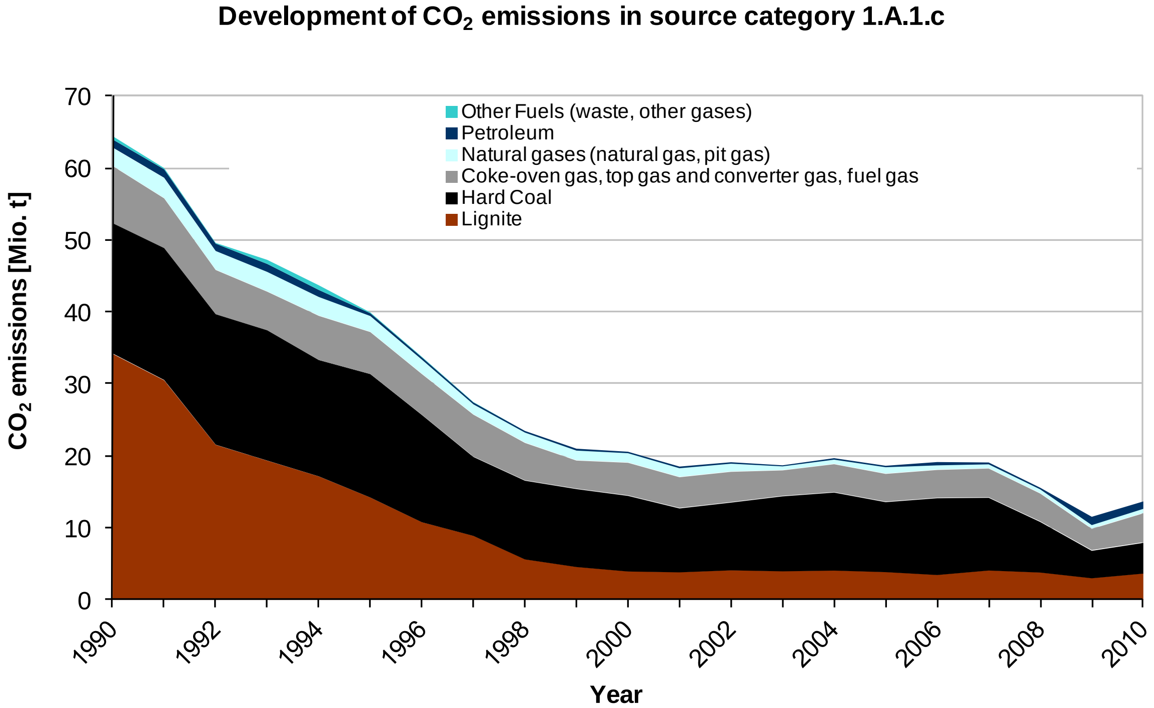


Figure 29: Development of CO_2 emissions in source category 1.A.1.c

The figure clearly shows how sharply emissions in this source category have decreased since 1990. The largest emissions decrease occurred in the area of lignite, use of which decreased strongly in the new German Länder from usage levels of the industry of the former GDR. From raw lignite, a range of refined products used to be produced for industry, households and small commercial operations. A comprehensive transition from lignite to other fuels then took place until the end of the 1990s. In a – then considerably reduced – number of industrial plants and commercial operations, use of hard coal, petroleum and natural gas intensified, while coal-burning stoves in homes were replaced with more modern heating systems fired with heating oil and natural gas. As a result, coal briquette and dust production in the new German Länder decreased from nearly 39 million t in 1990 to about 2.6 million t in 1997. Most lignite-processing plants were closed in that period, and thus emissions decreased sharply. As of 1998, energy for drying lignite products in the new German Länder was provided solely via process steam from public power stations. In the old German Länder, improvements in plants' efficiencies, along with reduced production in that area as well, until 2003, reduced emissions. Thereafter, emissions increased again slightly, as a result of production increases.

Emissions from use of hard coal in sector 1.A.1.c have been decreasing markedly since 1990. That decrease is due, firstly, to a sharp reduction in hard coal mining; while hard coal production still exceeded 70 million t in 1990, by 1997 it amounted to just less than 13 million t. Secondly, the decrease is due to the fact that some installations have shifted, for reporting purposes, from the hard coal mining category to the public electricity supply category, thereby shifting their emissions as well. In addition, the power stations remaining in source category 1.A.1.c feed electricity into the public grid.

In 2010, fuel inputs in the lignite-fired and hard-coal-fired power stations allocated to source category 1.A.1.c. increased, as a result of economic recovery and related increased electricity demand. As a result, emissions increased as well.

Use of industrial gases (coke-oven gas, top gas and converter gas) also decreased until the end of the 1990s. The primary reason for this is that city-gas production was phased out through 1996, in a process involving decommissioning of local gas works. Coke production also decreased markedly. Production of hard coal coke decreased from 19 million t in 1990 to less than half of that figure in 2008. Production in 2009 amounted to only 6.7 million t, as a result of low steel production. In 2010, then, as the economic situation improved, hard-coal-coke production increased to 8.1 million t. Consequently, emissions from combustion of top gas and coke-oven gas rose considerably. While 8 mine coking plants were still in operation in 1990, only one such plant is in operation today, along with a total of four metallurgical coking plants. Overall, plant closures and efficiency increases have decreased emissions markedly in this sector.

3.2.8.2 Methodological issues (1.A.1c)

The calculation method has been selected on the basis of the latest key-source analysis.

Fuel inputs for electricity production in power stations of the hard-coal and lignite mining sector are listed in Energy Balance line 12, "Industrial thermal power stations". Fuel inputs for heat production in the transformation sector are listed in Energy Balance lines 33-39 and in sum line 40 ("Total energy consumption in the transformation sector").

Fuel inputs for electricity production in power stations of the hard-coal mining sector are determined with the help of figures of the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, 2010c). The activity data for heat production in power stations of the hard-coal mining sector correspond to Energy Balance line 34 "Energy input in collieries and briquette plants of the hard-coal mining sector".

The listed fuel input for electricity production in mine power stations is based on association information (personal communication from DEBRIV, the federal German association of all lignite producing companies and their affiliated organisations). Inputs for heat production, especially for lignite drying for production of lignite products, are not shown in the Energy Balance. Those are calculated from figures for production of lignite products (STATISTIK DER KOHLENWIRTSCHAFT n.y.) and from the specific fuel inputs required for drying (personal communication from DEBRIV, February 2007), listed as "non- Energy-Balance inputs" in the CSE, and reported as such.

The quantities of fuel used for production of hard-coal coke are taken directly from the Energy Balance, line 33 (coking plants).

The fuel input for heat production in the other transformation sector is obtained by combining the energy consumption figures in Energy Balance lines 33 to 39 (total energy consumption in the transformation sector). Those figures include mines' own consumption; facilities for petroleum and natural gas production and for processing of waste oil; plants that produce coal products; plants for production and processing of fissile and fertile materials; and wastewater-treatment facilities' own consumption.

As of the 2011 report, CO_2 emissions from top-gas combustion in coking plants are reported in source category 1.A.1.c. The following table provides an overview of CO_2 emissions from top-gas use in coking plants, for the entire time series since 1990.

Table 40: CO_2 emissions from top-gas combustion in coking plants

[Millions of t of CO_2)									
1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
5.328	5.234	4.579	4.220	5.201	4.899	4.686	4.947	4.342	3.131
2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
3.636	3.725	3.668	3.015	3.341	3.308	3.293	3.332	3.230	2.421
2010									
3.390									

Revision of the data for 1990, and for the years 1991-1994, for the new German Länder is described in Annex Chapter 19.1.1.

Emission factors (except for that for CO_2)

The emission factors for power stations and other boiler combustion for production of steam and hot/warm water, in source category 1.A.1.c, have been taken from RENTZ et al (2002). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. In connection with a major research project that began at the end of 2008 and was completed in 2011 (FICHTNER et al. 2011), we have begun updating the described database for emission factors (except for that for CO_2). The reference year for the proposed values is 2004. On that basis, emission factors are being predicted for the years 2010, 2015 and 2020. On the basis of the relevant research results, we have already updated a considerable number of time series – primarily with regard to coal-fired plants – for the emission factors for SO_2, NO_x and mercury. We plan to update additional emission-factor time series, and report the results, in the context of future inventory reports.

Within the sector, the research project differentiates between STEAG power stations, other power stations in the hard-coal mining sector, power stations in the lignite mining sector and other boiler combustion for production of steam and hot/warm water.

The majority of emission factors for coking plants have been obtained from BFI (2012). That data source's emission factors for contained sources have been allocated to source category 1.A.1.c, since those emissions result primarily from bottom-heating of coke ovens. By contrast, the emission factors determined for fugitive sources have been allocated, by definition, to source category 1.B.1.b. In both source categories, calculations cover CO emissions from coking plants, along with other pollutants. With respect to the Resubmission 2010, the methods used for such calculations were changed, because the previously used emission factors did not correctly reflect the actual origin of the emissions and, overall, had overestimated the emissions' levels. For example, until the Resubmission 2010 higher CO emissions were reported in 1.B.1.b than were reported in 1.A.1.c, and yet the CO emissions from bottom-heating, pursuant to BFI (2012), are about 55 times higher than those from fugitive sources. However, via use of the emission factors determined by the BFI, calculations still yield lower emissions, by 3% to 22%, in 1.A.1.c for the years 1990 to 2007 (cf. Chapter 3.2.8.5).

3.2.8.3 Uncertainties and time-series consistency (1.A.1.c)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project FKZ 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, Chapter 13.6 of the NIR 2007.

The procedure for determining uncertainties for the emission factors is described in Chapter 3.2.6.3.1.

3.2.8.3.1 Result for N_2O

Relatively large numbers of fluidised-bed combustion systems are used in plants within the lignite-mining sector – which plants are part of sector 1.A.1.c. Such systems are known to have relatively higher N_2O emissions than systems using other types of coal-combustion technologies. On the other hand, relevant emissions behaviour in combustion of hard coal and lignite, particularly in fluidised-bed combustion, has been specifically studied, especially in the 1990s. For this reason, enough measurement data were available to permit systematic survey of N_2O emission factors in the research project. The values for relative uncertainty are about 0.6. Otherwise, the remarks made in Chapter 3.2.6.3.2 apply mutatis mutandis.

3.2.8.3.2 Result for CH_4

The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

3.2.8.3.3 Time-series consistency of emission factors

The results of Chapter 3.2.6.3.4 apply mutatis mutandis.

3.2.8.4 Source-specific quality assurance / control and verification (1.A.1c)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the EF and ED of methane and nitrous oxide and for the pertinent AD.

For carbon dioxide, quality control (pursuant to Tier 1) and quality assurance have been carried out by the Single National Entity.

The results of Chapter 3.2.6.4 apply mutatis mutandis.

3.2.8.5 Source-specific recalculations (1.A.1.c)

The change in assessment of sewage sludge, which previously had been classified as 100 % of fossil origin, but which in reality consists largely of biomass, led to recalculations in the fuel categories "Other fuels" and "Biomass". In addition, fuel inputs were recalculated for 2009, for which final statistics became available to replace provisional data. The resulting changes are as follows:

Table 41: Recalculations in CRF 1.A.1.c

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute					Difference, relative
Year	Total	Total	gas	liquid	other	solid	Total	Total
2003	**18,481**	**18,664**	0	0	-42	225	**183**	**(0.99%)**
2004	**19,908**	**19,658**	0	0	-434	185	**-250**	**(-1.25%)**
2005	**17,079**	**18,599**	0	0	0	1,520	**1,520**	**(8.90%)**
2006	**17,247**	**19,118**	0	0	-373	2,244	**1,870**	**(10.84%)**
2007	**18,584**	**19,058**	0	0	-42	517	**474**	**(2.55%)**
2008	**15,573**	**15,552**	-17	0	-161	157	**-21**	**(-0.14%)**

2009	**13,030**	**11,514**	20	917	-161	-2,292	**-1,516**	**(-11.63%)**

As a result of the methods change with respect to the Resubmission 2010, as described under 3.2.8.2, the **CO emissions from coking plants** reported in 1.A.1.c were recalculated. Via use of the emission factors determined by the BFI (2012), 3 % to 22 % lower CO emissions result for 1.A.1.c, for the years 1990 to 2007 (cf. the following table).

Table 42: Recalculation of CO emissions (1.A.1.c)

Year	Old calculation:					new:	Change:
	fuel gas (only NGL 1990)	Natural gas	Top gas/ converter gas	Coke-oven/ city gas	1 A 1 c total	(product-related EF)	
1990	458	458	6,054	10,093	17,063	14,556	-2,507
1991		400	5,948	8,420	14,768	13,013	-1,755
1992		395	5,203	8,273	13,871	12,196	-1,675
1993		353	4,796	6,219	11,368	10,001	-1,367
1994		332	5,910	4,199	10,442	9,041	-1,401
1995		52	5,747	5,547	11,346	9,192	-2,153
1996		30	5,452	5,532	11,014	8,828	-2,186
1997		1	5,758	5,000	10,759	8,896	-1,863
1998			5,058	5,149	10,207	8,512	-1,695
1999			3,649	4,894	8,543	7,094	-1,449
2000			4,236	5,213	9,448	7,547	-1,901
2001			4,336	3,423	7,760	6,015	-1,744
2002			4,274	3,416	7,689	5,983	-1,706
2003			3,512	3,191	6,703	6,481	-222
2004			3,893	3,464	7,357	7,007	-351
2005			3,851	3,460	7,311	6,953	-358
2006		0.1	3,836	3,383	7,219	6,930	-289
2007			3,881	3,839	7,720	6,989	-731

3.2.8.6 Planned improvements (source-specific) (1.A.1.c)

Following the completion of the relevant research project started at the end of 2008 (FICHTNER et al. 2011), the emission factors for NO_X and SO_2 were updated. Updating of the **emission factors** for CH_4 and N_2O is currently in progress.

3.2.9 Manufacturing industries and construction (1.A.2)

This source category consists of several sub-source categories defined in close harmony with the IPCC categorisations (CRF). It is described in detail via the relevant sub-chapters.

The calculation algorithms for BEU structural elements in source category 1.A.2 were revised, within the research project "Substantiation of the data quality of activity data" (FKZ 204 41 132), and they are now governed by a consistent system. For the most part, they are based on reliable data of the Federal Statistical Office.

Sectoral differentiation of activity data was carried out solely for process combustion.

As of 2008, classification of economic sectors (Wirtschaftszweige = WZ), in energy statistics, is being changed from the "WZ 2003" standard to the "WZ 2008" standard. As a result, activity data relative to process combustion are now being taken from individual statistics in keeping with the relevant key for the change (STATISTISCHES BUNDESAMT 2008: "Umsteigeschlüssel WZ 2003 auf WZ 2008" (key for the change from WZ 2003 to WZ 2008))

With respect to power and heat production, industrial power stations and boiler systems are aggregated by technologies (gas engines, gas turbines, gas and steam plants and steam turbines), as well as by permit-law provisions (TA-Luft and 13th BImSchV).

The various individual calculation algorithms were substantiated in detail in the aforementioned research project.

In the current report year, an error in the BEU calculation tool, involving the proportions of natural gas and coke-oven gas in the area of primary steel production, was corrected. As a result of the calculation methods involved, this has also led to changes in the area of boilers (1.A.2.f Other).

Following emissions calculation at the structural-element level, sum values for the sub-source categories in 1.A.2 are formed, via maximally IPCC-conformal aggregation of results. Since the NIR 2006, most process combustion has been reported on a sector-specific basis. The available data does not permit fully IPCC-conformal disaggregation. For example, heat and power production of industrial power stations and thermal power stations cannot be oriented to specific sectors; for this reason, it is reported in combined form, under 1.A.2.f Other.

Differentiation of energy-related process combustion for heat and power production in industrial power stations and in boiler systems was carried out via Statistik 067 (Statistics 067; electricity-production systems of the manufacturing sector, and of the mining and quarrying sectors (Stromerzeugungsanlagen des Verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden); *STATISTISCHES BUNDESAMT*, 2010c).

A change in Statistics 067 (op. cit.) of the Federal Statistical Office has led to a jump in the activity data for heat and electricity production. Until 2001, only the fuel inputs for electricity production in electricity production systems were listed. As of 2002, fuel inputs for heat and electricity production are listed. No data are available for inputs for heat production for years prior to 2002.

The ratio between the fossil and biogenic fractions in industrial waste is obtained from the Energy Balance and the relevant industry association figures for substitute fuels.

All of the listed amounts of standard fuels used in all sub-source categories have been taken from the Energy Balance of the Federal Republic of Germany and disaggregated in the Balance of Emission Causes (BEU). In addition to the figures provided from the Energy Balance, in various sub-source categories substitute fuels have now been listed. The relevant amounts were determined in a research project (UBA 2005b, FKZ 204 42 203/02) and are now updated annually with the help of association data (see below). As these figures show, use of substitute fuels has been increasing. This has led to reductions in use of conventional fuels, via de facto fuel substitutions.

In the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; (UBA 2005b, FKZ 204 42 203/02)), the required improvements relative to the topic of "waste fuels" in the energy sector were found to be tied to substitute fuels in four industrial sectors, and the pertinent data were obtained from the relevant industrial associations. As a result, considerably improved, sector-specific data are now available relative to use of substitute fuels in process combustion, and in industrial power stations, in the industrial sectors pig-iron production, pulp and paper production and lime and cement production.

Special aspects of the various sub-source categories are described in the relevant sub-chapters. Special note should be taken of the collective group 1.A.2.f Other.

The uncertainties for the new structural elements created in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; (FKZ 204 41 132) were determined in keeping with the method described in the research project 204 42 203/02. That determination is described in the final report for the research project (FKZ 204 41 132) and in Annex 13.6 of the NIR 2007.

Carbon dioxide emissions predominate in CRF category 1.A.2. Other greenhouse gases account for only very small shares of total emissions.

A sharp reduction in greenhouse-gas emissions occurred in the period 1990 through 1994. It was caused by decommissioning of inefficient manufacturing plants in the new German Länder following the 1990 political transition in Germany.

The emissions fluctuations that occurred in subsequent years reflect production trends in Germany's manufacturing sector, which were tied to overall economic trends.

3.2.9.1 Manufacturing industries and construction – iron and steel (1.A.2.a)

CRF 1.A.2.a	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**34,742.0**	**(2.84%)**	**34,269.1**	**(3.59%)**	**-1.36%**
All fuels	N_2O	-	-	161.4	(0.01%)	126.2	(0.01%)	-21.80%
All fuels	CH_4	-	-	52.5	(0.00%)	59.0	(0.01%)	12.46%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Manufacturing industries and construction – iron and steel* is a key category, in terms of emissions level and trend, of CO_2 emissions.

The iron and steel industry (sub-source category 1.A.2.a) is the second important CO_2-emissions source, along with the cement industry, in the area of process combustion.

3.2.9.1.1 Source-category description (1.A.2a)

The source category comprises the production areas of pig iron (blast furnaces), sinter, rolled steel, iron and steel casting, Siemens-Martin steel, electric steel and the power stations and boilers of the entire steel industry.

Production of Siemens-Martin steel generated emissions only in the new German Länder, and only until shortly after 1990. Thereafter, production was completely discontinued. In the old German Länder, production of Siemens-Martin steel was discontinued before 1990.

In production of pig iron, large amounts of the fuels used in blast furnaces are needed for the reduction processes that take place in the furnaces, while most of the fuel used in other production areas of the iron and steel industry is used for heat production.

The following figure provides an overview of CO_2 emissions in the various sub-source categories in 1.A.2.a.

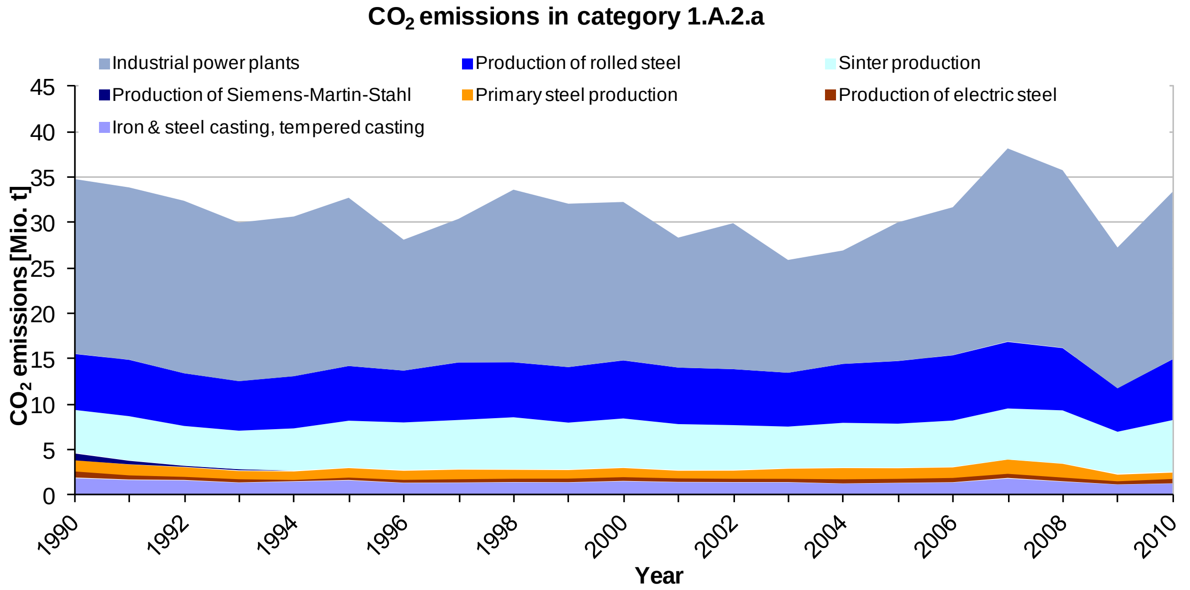


Figure 30: Development of CO_2 emissions in source category 1.A.2.a

As the overview reveals, major fluctuations have occurred over the years. In most cases, those swings were tied to fluctuations in production. In the period 1990 through 1994, emissions reductions occurred primarily as a result of restructuring of the iron and steel sector in the new German Länder following the political transition of 1990.

The drop in CO_2 emissions is particularly pronounced in the crisis year 2009, in which the steel industry registered a sharp production decrease. In 2010, emissions increased again as a result of economic recovery, which had an especially strong impact on the steel industry.

The largest emissions share comes from the areas of rolled-steel and sinter production. In the blast furnace category, only the natural-gas and coking-gas inputs required for furnace operation are reported in source category 1.A.2.a. Process-related emissions are listed in source category 2.C.1.

3.2.9.1.2 Methodological issues (1.A.2a)

This sub-source category comprises process combustion in the various production areas of the iron and steel industry. The relevant fuel-use amounts, including those for secondary fuels, are contained in the Balance of Emission Causes (BEU).

In work to obtain activity data for conventional fuels in this source category, a new data source was developed in the 2011 report year: the so-called "BGS" group (fuel, gas and electricity industries of blast furnaces, steelworks and rolling mills; and forging plants, press works and hammer mills, including the various other plants (without their own coking plants) locally connected to such operations). This improved relevant disaggregation. While the legal basis for surveys relative to the BGS group is no longer available as of the 2012 report year, the pertinent data are currently being provided, in the same structure, on the basis of an agreement with the Wirtschaftsvereinigung Stahl German steel industry association. This change has no impact on relevant calculations.

In addition to providing activity data for sintering plants, blast furnaces, basic oxygen furnaces (converters) and rolling mills, BGS-group data support additional disaggregation of the electric steel sector.

The BGS-group data also permit data-based differentiation of the solid-fuel categories "hard coal and hard coal briquettes"; "coke" and "coke breeze with particle size less than 10 mm". Fuel inputs for coke and coke breeze are summed, and listed under "coke". The "liquid fuels" listed for the BGS group are classified under "heating oil, heavy".

The BGS-group data list fuel inputs in natural units. For the present purpose, those units are converted into energy units, using the relevant net calorific values listed by the Working Group on Energy Balances (AGEB). For gases, the BGS-group data use a norm of 35.16912 MJ/m^3. That figure has been adopted in the methods for calculating activity data for blast-furnace gas, coke-oven gas, natural gas and converter gas.

The method for calculating emissions from secondary fuels has been retained, in keeping with the results of the research project "Einsatz von Sekundärbrennstoffen" ("Inputs of secondary fuels"; UBA 2005b, FKZ 204 42 203/02).

In the area of emissions from the iron and steel industry, a distinction is made, for the entire time series as of 1990, between process-related emissions and energy-related emissions. The method for calculation of process-related emissions is described in Chapter 4.4.1.2 of source category 2.C.1.

3.2.9.1.3 Uncertainties and time-series consistency (1.A.2a)

Uncertainties were determined for all fuels in 2004 (except for substitute fuels), and for substitute reducing agents, with regard to the entire time series. The relevant method is described in a research report (UBA 2005b, FKZ 204 42 203/02). The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) included in the relevant final report.

The statistical data used for calculation until the 2011 report, from the Federal Statistical Office's Fachserie 4 Reihe 8.1, were aggregated in keeping with the BGS-group framework in those statistics. When production of those statistics has been discontinued, the basic BGS-group data will be used directly for calculation.

Direct use of the BGS-group data does not increase the uncertainties. The uncertainties as determined on the basis of the research report were retained, in keeping with the conservative approach applied.

The BGS-group data are available for all reporting years; consequently, the time series is consistent. Legislation is currently being prepared that would ensure the continued availability of the data in the current form. Data provision until a relevant legal provision is in place has been contractually assured via an agreement with the steel-industry assocation.

3.2.9.1.4 Source-specific quality assurance / control and verification (1.A.2.a)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Source category 1.A.2.a, in conjunction with source category 2.C.1, presents extremely complex issues, since there are discrepancies between pertinent methods used in connection with the Energy Balance, with emissions reporting, with emissions trading and with relevant association statistics. In the interest of data quality assurance, regular experts' discussions have to be carried out for the purpose of comparing and evaluating data.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

The aforementioned agreement with the steel-industry association calls for the association to carry out quality assurance for the BGS-group data in keeping with the QSE manual.

3.2.9.1.5 Source-specific recalculations (1.A.2.a)

As a result of error correction, recalculations had to be carried out in the current report year for the categories natural gas and liquefied petroleum gas, for the years 1995 – 2010.

For power stations fired with top gas, the allocation method was modified. That led to a considerable increase in CO_2 emissions from solid fuels. Previously, data for those power stations had been reported in source category 1.A.2.f Other.

Table 43: Recalculations in CRF 1.A.2.a

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute				Difference, relative
Year	Total	Total	gas	liquid	solid	Total	Total
1990	**15,582**	**34,742**	0	0	19,160	**19,160**	**122.96%**
1991	**14,924**	**33,819**	0	0	18,895	**18,895**	**126.61%**
1992	**13,428**	**32,354**	0	0	18,926	**18,926**	**140.94%**
1993	**12,559**	**29,960**	0	0	17,401	**17,401**	**138.55%**
1994	**13,104**	**30,626**	0	0	17,522	**17,522**	**133.72%**
1995	**14,125**	**32,687**	144	-36	18,454	**18,562**	**131.41%**
1996	**13,575**	**28,083**	181	-32	14,360	**14,508**	**106.88%**
1997	**14,359**	**30,370**	272	-3	15,741	**16,010**	**111.50%**
1998	**14,340**	**33,569**	279	27	18,923	**19,229**	**134.09%**
1999	**13,743**	**32,031**	358	10	17,920	**18,288**	**133.08%**
2000	**14,597**	**32,222**	292	-32	17,366	**17,625**	**120.74%**
2001	**13,921**	**28,311**	179	-41	14,252	**14,390**	**103.37%**
2002	**13,659**	**29,893**	300	-74	16,008	**16,234**	**118.85%**
2003	**12,892**	**25,862**	675	-82	12,377	**12,970**	**100.61%**
2004	**13,749**	**26,901**	759	-40	12,433	**13,152**	**95.66%**
2005	**14,128**	**29,986**	681	-21	15,199	**15,858**	**112.25%**
2006	**14,837**	**31,644**	637	-47	16,218	**16,808**	**113.29%**
2007	**15,829**	**38,097**	1,132	-42	21,179	**22,269**	**140.69%**
2008	**15,257**	**35,708**	998	-25	19,479	**20,452**	**134.05%**
2009	**11,564**	**27,230**	341	-100	15,425	**15,666**	**135.47%**

3.2.9.1.6 Planned improvements (source-specific) (1.A.2.a)

No improvements are planned at present.

3.2.9.2 Manufacturing industries and construction – non-ferrous metals (1.A.2b)

CRF 1.A.2.b	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	CO_2	-	-	1,601.2	(0.13%)	1,462.9	(0.15%)	-8.63%
All fuels	N_2O	-	-	17.8	(0.00%)	7.9	(0.00%)	-55.51%
All fuels	CH_4	-	-	1.2	(0.00%)	1.4	(0.00%)	16.04%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category *Non-ferrous metals* is not a key category.

3.2.9.2.1 Source category description (1.A.2.b)

This source category aggregates process combustion of various areas of non-ferrous-metal production. The available data does not support more detailed description.

3.2.9.2.2 Methodological issues (1.A.2.b)

The pertinent fuel inputs are contained in the Balance of Emission Causes (BEU). The source for fuel inputs consists of statistics for the manufacturing sector (Statistik 060 – Energieverwendung des produzierenden Gewerbes (energy use in the manufacturing sector; *STATISTISCHES BUNDESAMT* 2010b) (Melde-Nr. (reporting number) 27.43 (WZ 2003 old; WZ = classification system for economic data) → 24.43 (WZ 2008 new); Erzeugung und erste Bearbeitung von Blei, Zink und Zinn (production and initial processing of lead, zinc and tin) 27.44 (WZ 2003 old) → 24.44 (WZ 2008 new); Erzeugung und erste Bearbeitung von Kupfer (production and initial processing of copper)) and, for differentiations relative to heat and electricity production, Statistik 067 (*STATISTISCHES BUNDESAMT*, 2010c).

Descriptions of calculation algorithms for activity data in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of such revision, production and initial processing of precious metals, aluminium and other non-ferrous metals are now taken into account in determination of activity data.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The 1990 activity data for the new German Länder were revised and substantiated, with the help of new data, in the project "Base year and updating" ("Basisjahr und Aktualisierung" (UBA 2005c: FKZ 205 41 115); see Annex Chapter 19.1.1).

3.2.9.2.3 Uncertainties and time-series consistency (1.A.2.b)

For 2004, the uncertainties for all activity data were determined for the first time. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.2.4 Source-specific quality assurance / control and verification (1.A.2.b)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance for the EF and ED carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the AD.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.2.5 Source-specific recalculations (1.A.2.b)

For this source category, this year recalculations were carried out for the year 2009, because the pertinent final Energy Balance (updated) became available; the last report made use of the provisional Energy Balance. The recalculations have led to the following changes in CO_2 emissions for 2009:

Table 44: Recalculations in CRF 1.A.2.b

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute				Difference, relative
Year	**Total**	**Total**	gas	liquid	solid	**Total**	**Total**
2009	**1,491**	**1,431**	-58	-4	1	**-60**	**-4.01%**

3.2.9.2.6 Planned improvements (source-specific) (1.A.2.b)

No improvements are planned at present.

3.2.9.3 Manufacturing industries and construction – Chemicals (1.A.2.c)

CRF 1.A.2.c	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**IE**	**IE**	**IE**	**IE**	**IE**	**IE**	**IE**	**IE**

The chemical industry's process combustion and own power production are not listed separately; instead, they are summarised in 1.A.2.f Other.

Fuel inputs in calcium-carbide production are process-related and are reported under CRF 2.B.4 (cf. Chapter 4.3.4).

This approach has been confirmed by the research project "Base year and updating" (UBA 2005c, FKZ 205 41 115), for 1990 in the new German Länder (the most important production location): the relevant coke was used as a production material and not as a fuel for energy. Calcium-carbide production is thus not a source of energy-related CO_2 emissions.

The emissions for the entire sub-source category 1.A.2.c are thus included elsewhere (IE). 1.A.2.c has not been listed separately in the key-source analysis.

3.2.9.4 Manufacturing industries and construction – Pulp, paper and print (1.A.2.d)

CRF 1.A.2.d	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	CO_2	-	-	3.6	(0.00%)	9.0	(0.00%)	146.36%
All fuels	N_2O	-	-	2.9	(0.00%)	12.4	(0.00%)	325.22%
All fuels	CH_4	-	-	0.5	(0.00%)	2.3	(0.00%)	325.22%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2		IE	

The source category *Pulp, paper and print* is not a key category.

3.2.9.4.1 Source category description (1.A.2.d)

The energy consumption for production of pulp, paper and printed products – otherwise referred to as the "pulp and paper industry" for short – can be described only for substitute fuels, of which this industry uses large amounts.

Emissions from use of regular fuels in process combustion, and emissions generated by plants in own-power production, have not been listed separately. They are summarised under 1.A.2.f Other.

3.2.9.4.2 Methodological issues (1.A.2.d)

Only some of the substitute fuels used by the paper industry are listed in the Energy Balance. The fuels in question consist of waste from the relevant sectors' own production areas. The data on the types and amounts of substances used were provided by the German Pulp and Paper Association (VDP). The great majority of the substitute fuels used in the sector consist of wood and pulp fibres – and, thus, of biomass. The biogenic and fossil fractions of pertinent fuels were derived in the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen") (UBA 2005b, FKZ 204 42 203/02). In addition, CO_2 emission factors were derived on the basis of data on carbon content, water content and net calorific values.

3.2.9.4.3 Uncertainties and time-series consistency (1.A.2.d)

In the framework of a research project, the uncertainties of the CO_2 emission factors derived for substitute fuels were determined using the Monte Carlo method (UBA 2005b, FKZ 204 42 203/02). In the procedure, figures for C content, water content and net calorific value were taken into account. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO_2 emission factors for secondary fuels, along with the relevant uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

3.2.9.4.4 Source-specific quality assurance / control and verification (1.A.2.d)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance for the EF and ED carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the AD.

The paper industry has long kept records of inputs of secondary fuels (VDP, various years). In spite of small structural breaks in the time series in such records, the records clearly show the paper industry's increasing use of substitute fuels in place of regular fuels.

3.2.9.4.5 Source-specific recalculations (1.A.2.d)

Updating of the relevant fuel data led to the following recalculations:

Units [Gg] Year	NIR 2011 Total	NIR 2012 Total	Difference, absolute Total	Difference, relative Total
2007	19	17	-2	-9.35%
2008	19	18	-2	-9.64%
2009	14	12	-2	-14.33%

3.2.9.4.6 Planned improvements (source-specific) (1.A.2.d)

No improvements are planned at present.

3.2.9.5 Manufacturing industries and construction – Sugar production (1.A.2.e)

CRF 1.A.2.e	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**-**	**T/-**	**1,989.2**	**(0.16%)**	**458.6**	**(0.05%)**	**-76.94%**
All fuels	N_2O	-	-	25.6	(0.00%)	3.8	(0.00%)	-85.18%
All fuels	CH_4	-	-	3.8	(0.00%)	0.4	(0.00%)	-90.05%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The *Sugar production* source category is a key category for CO_2 emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-76.94 %), and thus an extremely low emissions level has been attained (in 2010, emissions amounted to 13.1 % of the contribution of the smallest key category identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

3.2.9.5.1 Source-category description (1.A.2.e)

This source category includes only the sugar industry's process combustion. Plants generating their own power are not listed separately; they are reported under 1.A.2.f Other.

3.2.9.5.2 Methodological issues (1.A.2.e)

Descriptions of calculation algorithms for activity data in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of this revision, it was determined that the statistics publications Statistik 060 (*STATISTISCHES BUNDESAMT*, 2010b) and Statistik 067 (*STATISTISCHES BUNDESAMT*, 2010c) list all of the fuels required for calculation of the pertinent activity data and should be used as data sources.

The relevant calculation algorithms, and special analyses relative to fuel inputs, are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.5.3 Uncertainties and time-series consistency (1.A.2.e)

For 2004, the uncertainties for all activity data were determined for the first time. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.5.4 Source-specific quality assurance / control and verification (1.A.2.e)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance for the EF and ED carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the AD.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.5.5 Source-specific recalculations (1.A.2.e)

For this source category, this year recalculations were carried out for the year 2009, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

The recalculations have led to the following changes in CO_2 emissions:

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute				Difference, relative
Year	Total	Total	gas	liquid	solid	Total	Total
2009	**163**	**450**	212	84	-8	**287**	**176.39%**

3.2.9.5.6 Planned improvements (source-specific) (1.A.2.e)

No improvements are planned at present.

3.2.9.6 Manufacturing industries and construction – Other (1.A.2.f, sum)

CRF 1.A.2.f	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	137,298.8	(11.24%)	77,896.2	(8.17%)	-43.27%
All fuels	N_2O	-	-	1,204.6	(0.10%)	585.5	(0.06%)	-51.39%
All fuels	CH_4	-	-	178.7	(0.01%)	112.3	(0.01%)	-37.15%

The source category *Manufacturing industries and construction – Other*, the sum of all other sub-source categories, is a key source, in terms of emissions level and trend, of CO_2 emissions. Key-source analysis was carried out only for the sum of sub-source categories in 1.A.2.f.

The NIR inventory structure includes the sub-source categories 1.A.2.f Cement (structural element "Production of cement clinkers (process combustion)"), 1.A.2.f Ceramics (structural element "Production of ceramics products (process combustion)"), 1.A.2.f Glass (structural element "Production of glass (process combustion)"), 1.A.2.f Lime (structural element "Production of lime (process combustion)") and 1.A.2.f Other ("other manufacturing" in the CSE, with various structural elements).

Binding key-source analysis has been carried out. In addition, the predominant (in terms of emissions) sub-source categories have been identified. 1.A2.f Cement and 1.A.2.f Other are worthy of special note: 1.A2.f Cement as a significant source of process combustion, and 1.A.2.f Other as a collective group that includes emissions from heat and power production of industrial power stations and industrial boiler systems, as well as (inter alia) energy-related emissions from the chemical industry.

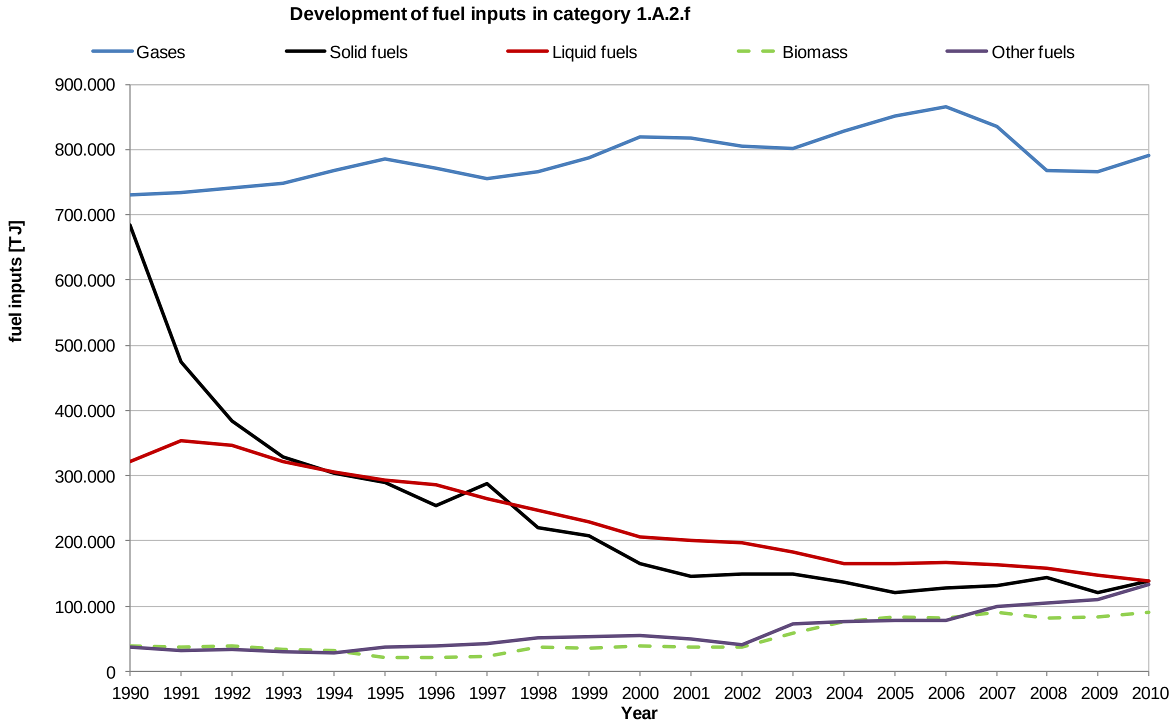


Figure 31: Development of fuel inputs in source category 1.A.2.f

This source category exhibits a marked change in fuel inputs.

A particularly noticeable decrease in use of solid fuels has occurred, primarily via reduced use of lignite and intensified use of gas, biomass and substitute fuels (waste).

A statistical discontinuity is seen in the area of biomass. Prior to the entry into force of the Act on Energy Statistics (Energiestatistikgesetz), biomass inputs for energy generation were either not recorded statistically or were recorded only in part. Biomass's share of energy generation has been increasing.

In 2009, inputs of nearly all fossil fuels decreased markedly, as a result of the economic slowdown. In 2010, those inputs then increased considerably, as a result of economic recovery.

3.2.9.7 Manufacturing industries and construction – Cement production (1.A.2.f, Cement)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS/IE	NS/IE	CS/IE

Outside of the framework of binding key-source analysis, this sub-source category must be considered particularly important.

3.2.9.7.1 Source-category description (1.A.2.f, Cement)

In this source category, only process combustion from burning of clinkers can be listed. The final step in cement production, i.e. grinding and mixing, is not included. As a power-intensive process, it is included in power production (1.A.1). Some plants within this category also generate power for their own use; such generation is not listed separately, but is included under 1.A.2.f Other.

In addition to substitutions of raw materials (smelter slag instead of cement clinkers, a subject not treated here in its own right), cement production involves considerable fuel substitutions in burning of clinkers. In the process, both conventional fuels, such as lignite, hard coal, oil and gas, and "secondary fuels" (waste from other economic sectors) are used. This reduces consumption of regular fuels.

3.2.9.7.2 Methodological issues (1.A.2.f, Cement)

The pertinent inputs of conventional fuels are contained in the Balance of Emission Sources (BEU). The source for fuel inputs for energy-related process combustion is Statistik des produzierenden Gewerbes (manufacturing-sector statistics; Melde-Nr. (reporting number) 26.51 (WZ 2003 old; WZ = classification system for economic data) → 23.51 (WZ 2008 new), Cement production). The source for pertinent differentiation from heat and electricity production is Statistik 067 (*STATISTISCHES BUNDESAMT*, 2010c).

As of 2002, the data for Statistik 067 (op. cit.) are found only among three-digit reporting numbers. This means that only data for reporting number 26.5 (WZ 2003 old) → 23.5 (WZ 2008 new) (production of cement, lime and burnt plaster) can be used as a basis.

To permit relevant separation, the individual data available for the period through 2001 for production of cement (reporting number 26.51 (WZ 2003 old) → 23.51 (WZ 2008 new)), production of lime (reporting number 26.52 (WZ 2003 old) → 23.52 (WZ 2008 new) and production of plaster (reporting number 26.53 (WZ 2003 old) → 23.53 (WZ 2008 new)) were analysed. The various types of production involved (cement, lime, plaster) were differentiated via allocation of individual fuels.

In the process, it was seen that relevant fuel inputs in electricity-generating plants were listed only for production of cement and plaster. In addition, in all years only light heating oil was listed for the cement industry, while for the plaster industry coal dust and dry coal, and natural gas and heavy heating oil, were also listed. For this reason, fuel inputs for light heating oil (Meldenummer (reporting number) 26.5 (WZ 2003 old) → 26.5 (WZ 2008 new)) have been allocated to the cement industry, in the relevant proportions.

It is assumed that the fuel “Other petroleum products”, which was reported for the first time in Statistik 067 (*STATISTISCHES BUNDESAMT*, 2010c) as of 2003, must also be allocated to the plaster industry, since technologies used to date in the cement industry (for use of light heating oil) are not suited for use of other petroleum products.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The fuel inputs for the new German Länder in 1990 were calculated on the basis of specific fuel consumption in 1989 and production in 1990.

The cement industry uses significant amounts of substitute fuels that do not appear in national statistics and in the Energy Balance. Relevant production figures and fuel-use amounts have been taken from statistics of the VDZ cement-industry association. The procedure used to compile activity data oriented to the old and new German Länder as of

1990, and to all of Germany as of 1995, is described in the final report of the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; UBA 2005b, FKZ 204 42 203/02). Data on the relevant types, amounts and energy contributions of the substitute fuels used were provided by the VDZ.

In a first step, fuel inputs were allocated to the groups "Biomass" or "Other fuels (waste)", in keeping with IPCC procedures. In the research project "Inputs of secondary fuels", the biogenic fractions of relevant fuels were derived and then entered into the calculations, with the help of split factors. In the same project, CO_2 emission factors were derived for substitute fuels, on the basis of data on carbon content, water content and net calorific value (UBA 2005b, FKZ 204 42 203/02).

3.2.9.7.3 Uncertainties and time-series consistency (1.A.2.f, Cement)

In the framework of the research project "Inputs of secondary fuels", the uncertainties of the CO_2 emission factors derived for substitute fuels were determined using the Monte Carlo method (UBA 2005b, FKZ 204 42 203/02). In the procedure, figures for C content, water content and net calorific value were taken into account. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO_2 emission factors for secondary fuels, along with the relevant uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

Uncertainties were determined for all fuels in 2004 and for the aforementioned substitute fuels with regard to the entire time series. The relevant methods are explained in Annex Chapter 13.6 of the NIR 2007 and in the final report of the research project (UBA 2005b, FKZ 204 42 203/02).

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) included in the relevant final report.

The activity data for the new German Länder, for base year 1990 and the following years, 1991-1994, were adjusted in keeping with findings from the pertinent research project (FKZ 205 41 115 / Sub-project A "Revison and substantiation of fuel inputs for stationary combustion plants in the new German Länder for the year 1990"). The relevant recalculation method is described in the Annex, 19.1.2.1.

3.2.9.7.4 Source-specific quality assurance / control and verification (1.A.2.f, Cement)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

In the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"), the data series for inputs of substitute fuels in the cement industry were subjected to intensive quality checks (UBA 2005b, FKZ 204 42 203/02). In addition, figures of the Verein der Zementindustrie (VDZ) cement-industry association were checked for validity and integrated within their proper sectoral context.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.7.5 *Source-specific recalculations (1.A.2.f, Cement)*

The change in assessment of sewage sludge, which previously had been classified as 100 % of fossil origin, but which in reality consists largely of biomass, led to recalculations in the fuel categories "Other fuels" and "Biomass".

Recalculations also had to be carried out for 2009, since the relevant final Energy Balance became available (the last report used the relevant provisional Energy Balance) and showed that all values for the year 2009 had to be corrected. The resulting changes are as follows:

Table 45: Recalculations in CRF 1.A.2.f Cement

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute					Difference, relative
Year	Total	Total	gas	liquid	other	solid	Total	Total
2003	**6,450**	**6,446**	0	0	-4	0	**-4**	**-0.06%**
2004	**7,167**	**7,149**	0	0	-18	0	**-18**	**-0.25%**
2005	**6,090**	**6,045**	0	0	-45	0	**-45**	**-0.74%**
2006	**6,166**	**6,075**	0	0	-91	0	**-91**	**-1.47%**
2007	**7,163**	**7,067**	0	0	-97	0	**-97**	**-1.35%**
2008	**7,181**	**7,080**	0	0	-102	0	**-102**	**-1.41%**
2009	**6,413**	**6,475**	-8	375	-100	-204	**62**	**0.97%**

3.2.9.7.6 *Planned improvements (source-specific) (1.A.2.f, Cement)*

No improvements are planned at present.

3.2.9.8 Manufacturing industries and construction – Ceramics (1.A.2.f, Ceramics)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS/IE	NS/IE	CS/IE

3.2.9.8.1 *Source-category description (1.A.2.f, Ceramics)*

Source category Ceramics, 1.A.2.f, includes process combustion in the brick industry, including other construction ceramics. Some plants within this category also generate power for their own use; such generation is not listed separately, but is included under 1.A.2.f Other.

3.2.9.8.2 *Methodological issues (1.A.2.f, Ceramics)*

The fuel inputs for process combustion are calculated in the Balance of Emission Sources (BEU). The fuel-input data have been taken from manufacturing industry statistics (Statistik des produzierenden Gewerbes; Melde-Nr. (reporting no.) 26.40 (WZ 2003 old) → 23.32 (WZ 2008 new), Ziegelei (brickworks), production of other construction ceramics), and, for differentiation from heat and electricity production, Statistik 067 (*STATISTISCHES BUNDESAMT*, 2010c).

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.8.3 Uncertainties and time-series consistency (1.A.2.f, Ceramics)

Uncertainties for all fuels were determined, for the first time, for 2004 (research project "Substantiation of the data quality of activity data, FKZ 204 41 132)". The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.8.4 Source-specific quality assurance / control and verification (1.A.2.f, Ceramics)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.8.5 Source-specific recalculations (1.A.2.f, Ceramics)

For this source category, this year recalculations were carried out for the year 2009, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

3.2.9.8.6 Planned improvements (source-specific) (1.A.2.f, Ceramics)

No improvements are planned at present.

3.2.9.9 Manufacturing industries and construction – Glass (1.A.2.f, Glass production)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS/IE	NS/IE	CS/IE

3.2.9.9.1 Source-category description (1.A.2.f, Glass production)

This sub-source category includes process combustion for the areas of flat-glass production; concave-glass production; production of glass fibre; finishing and processing of flat glass; and production and finishing of other glass and technical glass products.

Some plants within this category also generate power for their own use; such generation is not listed separately, but is included under 1.A.2.f Other.

3.2.9.9.2 Methodological issues (1.A.2.f, Glass production)

The source for fuel inputs for energy-related process combustion is Statistik des produzierenden Gewerbes (manufacturing-sector statistics; Melde-Nr. (reporting number) 26.1 (WZ 2003 old; WZ = classification system for economic data) → 23.1 (WZ 2008 new), Production of glass and glassware). The source for pertinent differentiation from heat and electricity production is Statistik 067 (*STATISTISCHES BUNDESAMT*, 2010c).

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.9.3 Uncertainties and time-series consistency (1.A.2.f, Glass production)

Since 1995, when official statistics were converted to the economic-sector classification system (Klassifikation der Wirtschaftszweige; *STATISTISCHES BUNDESAMT*, 2002c), only one set of statistics has been used for Germany as a whole. This has considerably improved time-series consistency in comparison to that for the period 1990 to 1994.

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) included in the relevant final report.

Uncertainties were determined for all activity data, for the first time, for the year 2004. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

3.2.9.9.4 Source-specific quality assurance / control and verification (1.A.2.f, Glass production)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.9.5 Source-specific recalculations (1.A.2.f, Glass production)

For this source category, this year recalculations were carried out for the year 2009, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

3.2.9.9.6 Planned improvements (source-specific) (1.A.2.f, Glass production)

No improvements are planned at present.

3.2.9.10 Manufacturing industries and construction – Lime (1.A.2.f, Lime production)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS/IE	NS/IE	CS/IE

3.2.9.10.1 Source-category description (1.A.2.f, Lime production)

With regard to conventional fuels, the process-combustion figures refer to production of lime.

The reported figures for inputs of substitute fuels refer to all process combustion in German lime works.

3.2.9.10.2 Methodological issues (1.A.2.f, Lime production)

The relevant inputs of regular fuels are contained in the Balance of Emission Sources (BEU). The fuel-input data has been taken from manufacturing industry statistics (Statistik des produzierenden Gewerbes; Melde-Nr. (reporting no.) 26.52/lime (WZ 2003 old) → 23.52 (WZ 2008 new)).

Pursuant to Statistik 067 (*STATISTISCHES BUNDESAMT*, 2010c), in the years 1995 – 2001 the lime industry used no fuels for electricity production. It is assumed that this industry will continue to produce no electricity. For calculations, therefore, only Statistik 060 (*STATISTISCHES BUNDESAMT*, 2010b) is used.

Additional review is expected to show whether the shifting seen in relevant coal use has resulted from allocation to the sugar industry.

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The fuel inputs for the new German Länder in 1990 were calculated on the basis of specific fuel consumption in 1989 and production in 1990.

Since 2003, the lime industry has used minor amounts of substitute fuels that do not appear in national statistics and in the Energy Balance. The fuel-input data was provided by the Bundesverband der Deutschen Kalkindustrie national lime-industry association. The procedure used to compile activity data oriented to the territory of Germany, for the period as of 2003, is described in the final report of the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; UBA 2005b, FKZ 204 42 203/02). The data on the types and amounts of substitute fuels used were also provided by the Bundesverband der Deutschen Kalkindustrie national lime-industry association. In the research project "Inputs of secondary fuels", the biogenic fractions of relevant fuels were derived and then entered into the calculations, with the help of split factors. In the same project, CO_2 emission factors were derived for substitute fuels, on the basis of data on carbon content, water content and net calorific value (ibid.).

3.2.9.10.3 Uncertainties and time-series consistency (1.A.2.f, Lime)

Since 1995, when official statistics were converted to the economic-sector classification system (Klassifikation der Wirtschaftszweige; *STATISTISCHES BUNDESAMT*, 2002c), only one set of conventional-fuel statistics has been used for Germany as a whole. This has considerably improved time-series consistency in comparison to that for the period 1990 to 1994.

Uncertainties were determined for all regular fuels, for the first time, for the year 2004. The relevant method is described in Annex 13.6 of the NIR 2007.

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) included in the relevant final report.

In the framework of the research project "Inputs of secondary fuels" (UBA 2005b, FKZ 204 42 203/02), the uncertainties of the CO_2 emission factors derived for substitute fuels were determined using the Monte Carlo method. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO_2 emission factors for secondary fuels, along with the relevant uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

The activity data for the new German Länder, for base year 1990 and the following years, 1991-1994, were adjusted in keeping with findings from the pertinent research project (FKZ 205 41 115 / Sub-project A "Revison and substantiation of fuel inputs for stationary combustion systems in the new German Länder for the year 1990"). The relevant recalculation method is described in the Annex, 19.1.2.1.

3.2.9.10.4 Source-specific quality assurance / control and verification (1.A.2.f, Lime)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

In the research project "Inputs of secondary fuels" (UBA 2005b, FKZ 204 42 203/02), the time series for data on substitute-fuel inputs in the lime industry were also intensively checked for consistency and plausibility. To those ends, the industry's entire energy and emissions situation was considered – i.e. the same procedure was used that has been applied to other economic sectors with substitute-fuel inputs. Such quality assurance is subject to the constraint that the relevant data provided by the Bundesverband Kalk lime-industry association begin with the year 2003, however.

The data obtained fit with the overall picture for the sector, in light of relevant other fuel consumption and the pertinent CO_2 emissions.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

3.2.9.10.5 Source-specific recalculations (1.A.2.f, Lime production)

For this source category, this year recalculations were carried out for the year 2009, because the pertinent final Energy Balance became available; the last report made use of the provisional Energy Balance.

3.2.9.10.6 Planned improvements (source-specific) (1.A.2.f, Lime production)

No improvements are planned at present.

3.2.9.11 Manufacturing industries and construction – Other energy production (1.A.2.f, Other)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	CS	NS	CS
N_2O	CS	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

As a result of its function as a collective category for fuel inputs that cannot be disaggregated to the individual-sector level, this sub-source category is particularly significant; it contributes substantially to the entire energy sector's CO_2 emissions.

3.2.9.11.1 Source-category description (1.A.2.f Other)

In this sub-source category, all those emissions are reported for which the relevant energy inputs cannot be disaggregated in keeping with the categories in 1.A.2. This sub- source category is responsible for about ¾ of all CO_2 emissions of source category 1.A.2. When emissions from use of biomass in process combustion are not included, its share becomes even larger.

All heat and power generation in industrial power stations and boiler systems is listed in this sub-source category. All energy-related emissions from the chemical industry are also reported in it. No specific data are assigned to the structural element "Other process combustion". A large part of the energy inputs listed in 1.A.2.f Other should really be allocated to the various corresponding sectors, but the available data do not permit such allocation. Since no delivery data are available for the gases in source category 1.A.2, these gases cannot be assigned to the various individual processes. They are thus reported here in sum form.

3.2.9.11.2 Methodological issues (1.A.2.f Other)

The fuel inputs for electricity generation in industrial power stations are shown in Energy Balance line 12. The difference resulting after deduction of the fuel inputs for refinery power stations, mine power stations, power stations in the hard-coal-mining sector and, for the period until 1999, for the power stations of Deutsche Bahn (German Railways) consists of the activity data for other industrial power stations. These data cannot be further differentiated at present.

Additional data from the Federal Statistical Office are needed for allocation of fuel inputs to heat production in industrial power stations and boiler systems. Fuel inputs for heat production in CHP systems can be determined from relevant statistics. The activity data for boiler systems are calculated as the pertinent difference.

For both electricity production and heat production, gas turbines, gas and steam systems and gas engines are differentiated.

A detailed description of the relevant calculation algorithms, which were extensively revised for the 2008 reporting year, is provided in the final report for the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132).

With the new data source "BGS-Bogen" ("BGS form; see above), it has become possible to list, separately, use of top gas for energy production in live-steam boilers in the iron and steel industry.

The total energy quantity listed in Energy Balance line 54 (metal production), for use of top gas, is lower than the total top-gas input as shown by the BGS data (see above). The thusly underestimated input quantity is assigned, by definition, to part of the relevant flaring and line losses.

Emission factors (except for that for CO_2)

The emission factors for power stations and other boiler combustion for production of steam and hot/warm water, in source category 1.A.2f / all other, have been taken from RENTZ et al (2002). A detailed description of the procedure is presented in Chapter 3.2.6.2 and in Chapter 19.1.2.1 in Annex 3. The research project breaks down the relevant sector into power stations of Deutsche Bahn AG, other industrial power stations and other boiler combustion systems for production of steam and hot/warm water. In connection with a major research project that began at the end of 2008 and was completed in 2011 (FICHTNER et al.

2011), we have begun updating the described database for emission factors (except for that for CO_2). The reference year for the proposed values is 2004. On that basis, emission factors are being predicted for the years 2010, 2015 and 2020. On the basis of the relevant research results, we have already updated a considerable number of time series – primarily with regard to coal-fired plants – for the emission factors for SO_2, NO_x and mercury. We plan to update additional emission-factor time series, and report the results, in the context of future inventory reports.

3.2.9.11.3 Uncertainties and time-series consistency (1.A.2.f, Other)

Activity data

The uncertainties were determined, for the first time, for 2004. The relevant method is described in Annex Chapter 13.6 of the NIR 2007.

The uncertainties for the activity data were updated in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) included in the relevant final report.

Emission factors

The procedure for determining uncertainties is described in Chapter 3.2.6.3.1.

Result for N_2O: The results of Chapter 3.2.6.3.2 apply mutatis mutandis.

Result for CH_4: The results of Chapter 3.2.6.3.3 apply mutatis mutandis.

The results obtained in Chapter 3.2.6.3.4 in determination of time-series consistency apply mutatis mutandis.

3.2.9.11.4 Source-specific quality assurance / control and verification (1.A.2.f, Other)

Quality control and quality assurance (for the AD, pursuant to Tier 1; for the EF & ED, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

Activity data

The quality of the data was reviewed in the research project "Substantiation of the data quality of activity data" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132) and improved via use of statistics of the Federal Statistical Office as a database. No other data sources with long-term availability have been identified.

Emission factors

The results obtained in Chapter 3.2.6.4, in the general procedure for source-specific quality assurance / control and verification, apply mutatis mutandis.

3.2.9.11.5 Source-specific recalculations (1.A.2.f, Other)

Activity data

Recalculations for the period as of 1990 were carried out to take account of the calculation methods used and of the recalculations for the iron and steel industry. The following table provides an overview of the recalculations carried out for the period as of 1990:

Table 46: Recalculations for CO_2 in CRF 1.A.2.f Other

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute					Difference, relative
Year	Total	Total	gas	liquid	other	solid	Total	Total
1990	**137,992**	**118,832**	0	0	0	-19,160	**-19,160**	**-13.88%**
1991	**120,504**	**101,608**	0	0	0	-18,895	**-18,895**	**-15.68%**
1992	**110,504**	**91,578**	0	0	0	-18,926	**-18,926**	**-17.13%**
1993	**101,565**	**84,164**	0	0	0	-17,401	**-17,401**	**-17.13%**
1994	**97,720**	**80,197**	0	0	0	-17,522	**-17,522**	**-17.93%**
1995	**97,620**	**79,058**	-144	36	0	-18,454	**-18,562**	**-19.01%**
1996	**89,930**	**75,422**	-181	32	0	-14,360	**-14,508**	**-16.13%**
1997	**92,250**	**76,239**	-272	3	0	-15,741	**-16,010**	**-17.36%**
1998	**88,416**	**69,188**	-279	-27	0	-18,923	**-19,229**	**-21.75%**
1999	**86,623**	**68,334**	-358	-10	0	-17,920	**-18,288**	**-21.11%**
2000	**82,311**	**64,685**	-292	32	0	-17,366	**-17,625**	**-21.41%**
2001	**78,377**	**63,987**	-179	41	0	-14,252	**-14,390**	**-18.36%**
2002	**79,751**	**63,517**	-300	74	0	-16,008	**-16,234**	**-20.36%**
2003	**74,929**	**63,791**	-675	65	2,073	-12,601	**-11,138**	**-14.86%**
2004	**76,856**	**63,254**	-759	-14	-212	-12,618	**-13,603**	**-17.70%**
2005	**82,738**	**64,743**	-681	3	-601	-16,717	**-17,995**	**-21.75%**
2006	**86,207**	**65,742**	-637	30	-1,397	-18,462	**-20,466**	**-23.74%**
2007	**88,254**	**65,085**	-1,132	41	-383	-21,695	**-23,169**	**-26.25%**
2008	**85,869**	**62,419**	-981	13	-2,846	-19,636	**-23,449**	**-27.31%**
2009	**75,537**	**61,082**	2,951	255	-2,056	-15,604	**-14,455**	**-19.14%**

Elimination of an error in the pertinent calculation tool led to recalculations relative to industrial power stations' inputs of liquefied petroleum gas and natural gas, throughout the entire time series as of 1995.

In addition, shifting of the steel industry's power stations and boilers into source category 1.A.2.a, throughout the entire time series, has necessitated considerable recalculations in the area of solid fuels.

Emission factors:

The results of Chapter 3.2.6.5 apply mutatis mutandis.

3.2.9.11.6 Planned improvements (source-specific) (1.A.2.f, Other)

Activity rates:

No improvements are planned at present.

Emission factors:

Following the completion of the relevant research project started at the end of 2008 (FICHTNER et al. 2011), the emission factors for NO_X and SO_2 were updated. Updating of the emission factors for CH_4 and N_2O is currently in progress.

3.2.10 Transport (1.A.3)

3.2.10.1 Transport – Civil aviation (1.A.3.a)

3.2.10.1.1 Source category description (1.A.3.a)

CRF 1.A	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Aviation gas	CO_2	-	-	2,309.6	(0.19%)	1,989.6	(0.21%)	-13.86%
Aviation gas	N_2O	-	-	24.0	(0.00%)	20.8	(0.00%)	-13.24%
Aviation gas	CH_4	-	-	2.0	(0.00%)	1.7	(0.00%)	-13.06%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 1, Tier 2	NS/IS	CS D (lubricants)
CH_4	Tier 1, Tier 2	NS/IS	D
N_2O	Tier 1, Tier 2	NS/IS	D
NO_X, CO	Tier 3	NS/IS	CS
NMVOC	Tier 1, Tier 3	NS/IS	CS/D
SO_2	Tier 1	NS/IS	CS

The source category *Civil aviation* is not a key category.

In terms of emissions origins, air transports differ considerably from land and water transports, since aircraft burn most of their fuel under atmospheric conditions that differ from those on the ground and that are not constant. The main factors that influence the combustion process in this sector include atmospheric pressure, environmental temperature and humidity – all of which are factors that vary considerably with flight altitude.

In addition to considering carbon dioxide, the debate on the climate effects and airborne-emissions-related environmental impacts of air transports focuses mainly on water vapour and nitrogen oxides and, secondarily, on hydrocarbons, particulates, carbon monoxide and sulphur dioxide. In the framework of national emissions reporting, figures for other emissions are also required, however. The following remarks thus refer to emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O, laughing gas), nitrogen oxides (NO_X, i.e. NO and NO_2), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), sulphur dioxide (SO_2), particulates (total suspended particulates; TSP) and ammonia (NH_3).

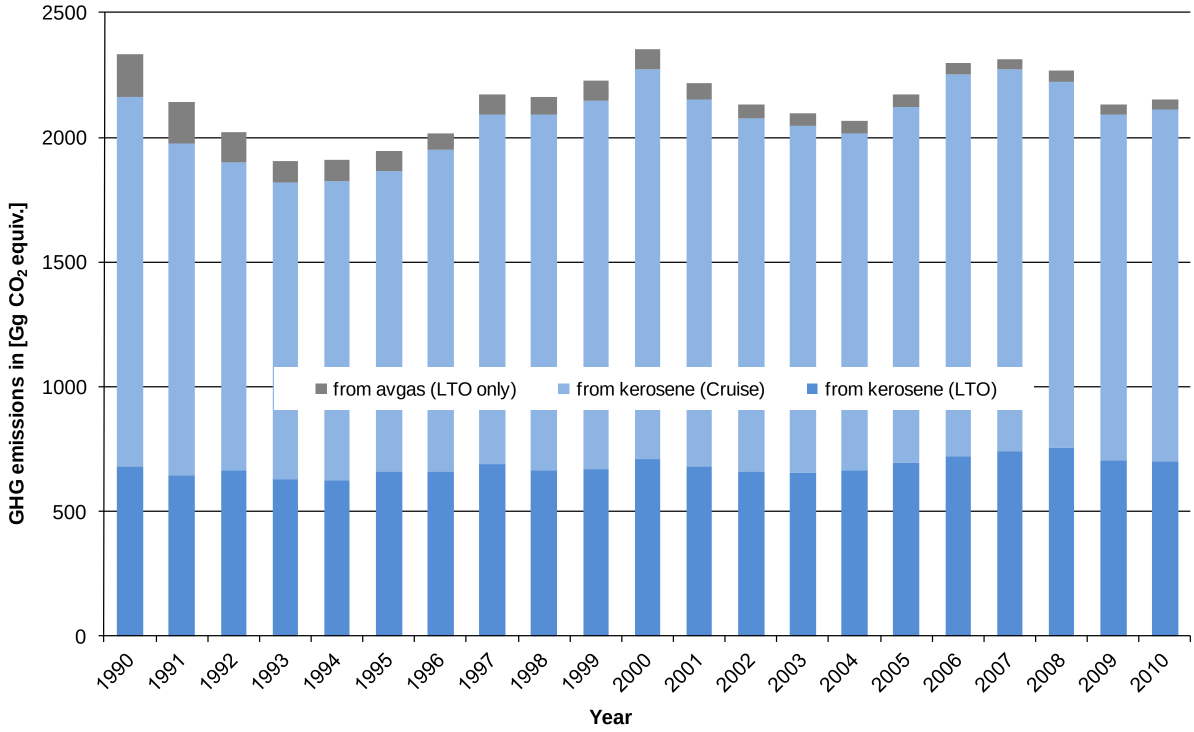


Figure 32: Development of greenhouse-gas emissions in national air transports, 1990 – 2010

3.2.10.1.2 Methodological issues (1.A.3.a)

This year, air-transport emissions are being calculated for the first time in accordance with Tier 3a, i.e. taking account of the annual flight mileages logged by the relevant individual aircraft types, broken down by national and international flights, and taking account of the operational states LTO cycle (landing/take-off cycle, i.e. aircraft movements to an elevation of 3,000 feet / about 915 m) and cruise.

In general, emissions are determined on the basis of the Energy Balance data for consumption of kerosene and aviation gasoline (AGEB, 2011). For years for which no data are yet available, data of the Federal Office of Economics and Export Control (BAFA, 2011) are used. The manner in which national (domestic, i.e. within Germany) and international air transports are differentiated plays a decisive role in reporting. The differentiation is achieved via a "split factor" that describes national kerosene consumption as a share of total kerosene consumption. For all years as of 2003, pertinent figures provided by Eurocontrol, the European Organisation for the Safety of Air Navigation, are used. Using the ANCAT model, Eurocontrol calculates fuel consumption on the basis of individual aircraft movements. It does not cross-check fuel consumption against national Energy Balances, however. The split factor for the years 1990 through 2002 has been determined in a different manner – with the help of a research project's findings relative to the mileage, expressed in terms of great-circle distances, flown by the various different types of aircraft (FKZ 360 16 029 – "Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV)" ("Development of an independent model for calculations oriented to air transports (TREMOD-AV)"; (IFEU & ÖKO-INSTITUT 2010). The relevant data are collected by the Federal Statistical Office. For breakdown of kerosene consumption by the phases LTO (landing/take-off) and cruise, the results of calculations made in TREMOD-AV (TREMOD Aviation), on the basis of data of the Federal Statistical Office, are used.

For reporting purposes, emissions are determined, in each case, by multiplying fuel consumption for the relevant flight phase by the pertinent specific emission factor. CO_2 and SO_2 emissions figures do not depend on what Tier method is used; they depend solely on quantities and characteristics of consumed fuel. Emissions of NMVOC, CH_4, CO, NO_X and N_2O, on the other hand, depend on engines, flight altitudes, flight phases, etc., and thus they are described more precisely by higher-Tier methods. The emission factors for NO_X, CO and HC are thus taken from the results of the TREMOD calculations.

Since 2007, figures for the relevant aviation gasoline consumed are no longer reported together with figures for consumed jet kerosene; they are reported separately. As proposed in IPCC 2006a, emissions from consumption of aviation gasoline are calculated separately, with adapted emission factors and net calorific values, pursuant to the Tier 1 method. In such calculation, there is no need for any breakdown into national and international transports; aviation gasoline is used only in smaller aircraft that fly mostly domestic routes. That understanding functions as a conservative assumption; it leads to slight overestimation of national emissions.

Activity data:

Aviation turbine fuel / jet kerosene

The relevant consumption data accord with the figures for aviation fuel sold in Germany, pursuant to the national Energy Balance (the latest version, covering the period until 2010) and to the official mineral-oil data provided by the Federal Office of Economics and Export Control (AGEB, 2011; BAFA, 2011).

For the present purposes, jet-kerosene-consumption figures from the Energy Balance and from BAFA statistics have to be broken down by national and international flights, in the manner described above. The calculations within TREMOD-AV take account of the numbers of flights, for the various aircraft types and great-circle distances involved, for national and international air transports. In the process, the commercial flights recorded by the Federal Statistical Office, for certain airports, are included. The Federal Statistical Office differentiates the other types of flights concerned (at other airports, and non-commercial flights) only by weight classes or aircraft classes, however; it does not differentiate them by destination. The great majority of the relevant commercial flights at other airports are flights by small aircraft fuelled with aviation gasoline. The relevant share of such aircraft types is higher in the non-commercial category, which also includes balloons and motorised gliders. Rough calculations pursuant to IFEU & ÖKO-INSTITUT (2010) indicate that it is appropriate to allocate all such flights to (solely national) avgas consumption.

For reasons of international comparability, the data available from Eurocontrol, for the period as of the year 2003, are still being used.

Table 47: Development of national air transports' share since 1990

Year		1990	1995	2000	2005	2006	2007	2008	2009	2010
national share(1	[%]	15.1	10.8	10.3	8.3	8.4	8.1	8.0	7.7	7.4

Source: IFEU & ÖKO-INSTITUT 2010: 1990-2002: calculated within TREMOD-AV on the basis of flight data of the Federal Statistical Office; as of 2003: Eurocontrol (ANCAT)

Jet-kerosene consumption is broken down, in accordance with the two flight phases *LTO* and *cruise*, with the help of the results of TREMOD-AV calculations. Those results make it possible to extract kerosene consumption figures for the LTO flight phase (cf. IFEU & ÖKO-INSTITUT, 2010), for both national and international air traffic. Consumption in the cruise flight phase then results, in each case, as the difference between kerosene consumption pursuant to the Energy Balance and consumption in the LTO phase.

Avgas

The relevant consumption data accord with the figures for aviation fuel sold in Germany, pursuant to the national Energy Balance and to the official mineral-oil data provided by the Federal Office of Economics and Export Control (AGEB, 2011; BAFA, 2011). In a conservative approach, all relevant consumption is assumed to occur in national flight operations. Pursuant to IPCC 2006a, breakdown by LTO and cruising flight phases is not required.

Lubricants

The figures for annual inputs of lubricants in air transports are taken from the official mineral-oil statistics (Amtliche Mineralölstatistik) of BAFA, and the co-combusted fraction is determined via expert assessment.

Emission factors:

Aviation turbine fuel / jet kerosene

The emission factor for *carbon dioxide* was derived from the carbon content of jet kerosene. The so-determined *implied emission factor for carbon dioxide from kerosene*, 3,150 g/kg, has been confirmed in numerous publications (including IPCC, 1999: p. 3.64), and it is used, without any changes, for all flight operations (national/international; LTO/cruise).

Nitrous oxide (laughing gas) is a product of nitrogen oxidation in the combustion chamber, and it can occur in traces. The available data for this substance are poor. Since the emission factors have to be broken down in accordance with the two flight phases, the emission factors for both nitrous oxide and *methane* have been taken from the IPCC emission factor database (cf. Table 318).

Emissions are calculated separately by flight phases, on the basis of the relevant emission factors. In the process, different sources are used.

The data for emissions of NO_X, CO and NMVOC are based on aircraft-type-specific emission factors listed in TREMOD-AV. Those emission factors are used to generate the average (implied) emission factors that are used for reporting within the Central System of Emissions (CSE). For reporting purposes, and in the manner described above, annual average (implied) emission factors are also derived for the entire fleet.

The emissions per LTO cycle are recalculated using standard values for jet-kerosene consumption per LTO cycle: For national flight operations, the relevant figure is 850 kg jet kerosene / LTO, while for international flight operations an average value of 1,675 kg kerosene / LTO cycle is assumed (IPCC 2006b). Figures relative to the air pollutants additionally considered are presented in Chapter 19.1.3.1 in the Annex.

For the relevant years until 2003, emission factors were converted from [kg emissions / kg of burned fuel] to [kg emissions / TJ converted energy] via a net calorific value of 43,000 kJ/kg. As of 2004, a net calorific value of 42,800 kJ/kg (AGEB, 2011a) is used for conversion.

Avgas

Pursuant to IPCC 2006a, no differentiation by LTO cycle and cruise phase is required for avgas. For this reason, no corresponding differentiation of emission factors was carried out.

For purposes of calculation of *CO_2 emissions*, the standard value pursuant to the *IPCC Guidelines* (2006a) is used. In those guidelines (page 3-64), the emission factors for *methane* and *nitrous oxide* are explicitly defined as equal to the relevant values given for jet-kerosene use. That assumption has been adopted here.

In a procedure similar to that used for jet kerosene, the emission factors for NO_X and CO were obtained from the results of TREMOD calculations carried out with aircraft-type-specific emission factors from the EMEP-EEA database. Those factors were then divided by the relevant avgas consumption, to obtain annual, average emission factors for reporting purposes. All pertinent emission factors are listed in Table 48.

Table 48: Emission factors for avgas (1990-2010)

Greenhouse gas (GG; Treibhausgas)	Emission factor [g/kg]	Remarks regarding the source or calculation
CO_2	3,018.00	from IPCC Guidelines 2006, Table 3.6.4
CH_4	0.36	same as EF kerosene, LTO/national
N_2O	0.10	same as EF kerosene, cruise/national

Source: Öko-Institut (2011)

The relevant emission factors were converted from [kg emissions / kg of burned avgas] to [kg emissions / TJ converted energy]; the conversion factor used for this was the pertinent net calorific value, 44,300 kJ/kg.

Lubricants

The CO_2 emissions from co-combustion of lubricants were calculated via an IPCC default-EF of 80,000 kg/TJ. The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

3.2.10.1.3 Uncertainties and time-series consistency (1.A.3.a)

For determination of uncertainties, the individual components that enter into emissions calculation are identified, and their uncertainties (U_1 to U_x) are quantified. Pursuant to to IPCC GPG (2000), the total uncertainty U_{total} is obtained via additive linking of squared partial uncertainties, in accordance with the following formula:

$$U_{ges} = \sqrt{U_1^2 + U_2^2 + ... + U_n^2}$$

For all time series and flight phases, uncertainties were estimated as mean values. The total uncertainties were calculated as is shown in Annex Chapter 19.1.3.1.2. The left column contains the components that enter into the uncertainty calculation; the relevant partial uncertainties are listed in the neighbouring columns to the right. The columns that then follow to the right contain the values for the required total uncertainties. Some of these, in turn, are individual components of the uncertainties calculation for other values. For example, the uncertainty for national jet-kerosene consumption in the two relevant flight phases, LTO and cruise, is calculated from the partial uncertainties for total national jet-kerosene consumption and from the partial uncertainty for the LTO/cruise differentiation. The latter of these partial uncertainties is based on the number of relevant flights, pursuant to the *Federal Statistical Office*, as well as on assumptions pertaining to the manner in which the fleet is divided (in national flight operations, an average consumption of 850 kg jet kerosene per LTO cycle is applied, in keeping with the IPCC's assumptions). The total uncertainty for jet-kerosene consumption during the LTO and cruise flight phases, in turn, serves as a partial uncertainty in determination of the uncertainties for emissions data.

Some partial uncertainties are based on assumptions. For example, one uncertainty for the entire time series for the split factor for dividing national and international flights is given as an average throughout the time series. For the years 1990 through 2002, the data are based on TREMOD calculations that, in turn, are based on the relevant data of the Federal Statistical Office, on the emission factors in the EMEP-EEA database and on calculations of our own. For the years 2003 to 2010, the pertinent Eurocontrol data are used, data which were calculated with the ANCAT model. Comparisons of random samples of a) results obtained with the ANCAT model and b) actual consumption data show deviations of ±12 %. Eurocontrol data obtained with the AEM 3 model had an uncertainty of only 3 to 5 % (EUROCONTROL 2006).

3.2.10.1.4 Source-specific quality assurance / control and verification (1.A.3.a)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The current calculation procedures have been verified on the basis of more-current data and findings. This applies to the various emission factors used and the energy-content figures required for conversion into energy-related emission factors.

Basically, calculation of greenhouse-gas emissions is based on data of the Energy Balance and on emission factors pursuant to the IPCC-Guidelines. Air transports are divided into national and international air transports, via the split factor, in keeping with TREMOD-AV (for the years 1990-2002) and with the relevant figures of Eurocontrol (as of 2003). In addition, the breakdown into the two flight phases, and the emission factors for NO_X, HC and CO, also result from the TREMOD calculations. Those calculations are based on data of the Federal Statistical Office, as well as on aircraft-type-specific data taken from the EMEP-EEA database. For a growing share of aircraft types for which no specific data are available, emission factors have to be obtained via regressions carried out on the basis of take-off weight. Use of more current, and more complete, aircraft-type-specific data would further improve the quality of the calculations. Furthermore, expansion of the TREMOD calculations, to include differentiation in accordance with the different engines used, would also improve the quality of the calculations.

Except for the emission factors for sulphur dioxide, international standard values were used, taken from the IPCC emission-factors database, the EMEP-EEA database or the CORINAIR

Guidebook (2006). Discussions of the various individual values are presented in the "Methodological Aspects" chapters of the presentations of the various emission factors.

In October 2011, for the first time, Eurocontrol provided country-specific consumption and emissions data from the PAGODA model. For the time being, those data are being used only to verify our own surveys.

3.2.10.1.5 Source-specific recalculations (1.A.3.a)

On the one hand, recalculations with regard to the data provided in the 2011 report were carried out especially to take account of a correction of domestic kerosene sales, to civil air transport operations, recorded for the years 2008 and 2009.

Table 49: Revision of domestic kerosene sales to civil air transport operations, 2008 and 2009

	Units	2007	2008	2009
Submission 2012	[TJ]	374,428	378,346	367,234
Submission 2011		374,428	380,114	368,951
Absolute difference		0	-1,768	-1,717
Relative difference	[%]	0.00	-0.47	-0.47

At the same time, the key provided by Eurocontrol relative to the split of total kerosene consumption, between domestic and international flights as of 2007, was also revised.

Table 50: Revision of national (domestic, within Germany) air transports' share of domestic kerosene sales, 2007-2009

	Units	2006	2007	2008	2009
Submission 2012	[1]	8.42	8.10	7.99	7.71
Submission 2011		8.42	8.19	7.90	7.66
Absolute difference		0.00	-0.09	0.09	0.05
Relative difference	[%]	0.00	-1.04	1.13	0.67

These changes lead to the following changes in the activity data used in the present context:

Table 51: Recalculation of kerosene consumption in national air transports, 2007-2009

	Units	2006	2007	2008	2009
Submission 2012	[TJ]	30,411	30,340	30,225	28,301
Submission 2011		30,411	30,658	30,028	28,244
Absolute difference		0	-318	197	57
Relative difference	[%]	0.00	-1.04	0.66	0.20

In addition, the quantities of co-combusted lubricants for specific years were slightly revised.

Table 52: Revision of quantities of co-combusted lubricants, 2007-2009

	Units	2006	2007	2008	2009
Submission 2012	[TJ]	1.01	0.91	0.70	0.56
Submission 2011		1.01	0.92	0.69	0.56
Absolute difference		0.00	-0.01	0.01	0.00
Relative difference	[%]	0.00	-1.09	1.45	0.00

For national (domestic, within Germany) air transports only, the sold quantities of avgas were also corrected for the years 2008 and 2009.

Table 53: Revision of sales of avgas in 2008 and 2009, pursuant to AGEB and BAFA

	Units	2007	2008	2009
Submission 2012		611.00	638.00	594.00
Submission 2011	[TJ]	611.00	638.17	594.62
Absolute difference		0.00	-0.17	-0.62
Relative difference	[%]	0.00	-0.03	-0.10

The changes in input data as described lead to the following recalculations, with regard to the Submission 2011, in greenhouse-gas emissions reported for the years 2007 through 2009:

Table 54: Impacts of the described revisions of the inventory on reported greenhouse-gas emissions

	Units	2006	2007	2008	2009
Submission 2012	[Gg CO_2 equiv.]	2,299	2,290	2,284	2,138
Submission 2011		2,299	2,314	2,270	2,134
Absolute difference		0	-24	16	4
Relative difference	[%]	0.00	-1.02	0.64	0.20

3.2.10.1.6 Source-specific planned improvements (1.A.3.a)

As soon as Eurocontrol provides data from the AEM 3 model, such data can be used in reporting. With such data, the applicable share for national air transports, the breakdown of kerosene consumption by the two relevant flight phases and NO_X, HC and CO emissions data would all be based on calculations pursuant to Tier 3b.

The data collected by Eurocontrol within the framework of its PAGODA model need to be reviewed carefully for suitability as a basis for inventories of air-transport emissions. If the results of such review are positive, and if long-term and on-time availability of such data are assured, the possibility of using the data for purposes in addition to verification will be considered.

3.2.10.2 Transport – Road transport (1.A.3.b)

3.2.10.2.1 Source category description (1.A.3.b)

CRF 1.A.3.b	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T/T2**	**150,358.3**	**(12.30%)**	**145,437.9**	**(15.25%)**	**-3.27%**
All fuels	N_2O			1,164.5	(0.10%)	1,250.2	(0.13%)	7.35%
All fuels	CH_4			1,094.4	(0.09%)	155.6	(0.02%)	-85.78%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	NS	CS D (biodiesel, lubricants)
CH_4	Tier 3	NS	CS/M/D
N_2O	Tier 3	NS	CS/M
NO_X, CO, NMVOC, SO_2	Tier 3	NS	CS/M

The source category *Road transport* is a key category of CO_2 emissions in terms of emissions level and trend.

Emissions from motorised road traffic in Germany are reported under this category. It includes traffic on public roads within Germany, except for agricultural and forestry transports and military transports. Calculations are made for the vehicle categories of passenger cars, motorcycles, light duty vehicles, heavy duty vehicles and buses. For calculation purposes, the vehicle categories are broken down into so-called *vehicle layers* with the same emissions behaviour. To that end, vehicle categories are also broken down by type of fuel used, vehicle size (trucks and buses by weight class; automobiles and motorcycles by engine displacement) and pollution control equipment used, as defined by EU directives for emissions control ("EURO norms"), and by regional traffic distribution (outside of cities, in cities and on autobahns).

3.2.10.2.2 Methodological issues (1.A.3.b)

Since 1990, emissions of CH_4, NO_X, CO, NMVOC and SO_2 from road transports have decreased sharply, due to catalytic-converter use and engine improvements resulting from continual tightening of emissions laws, and due to improved fuel quality.

Between 1990 and 1993, the methane emission factor for petrol dropped sharply, producing a corresponding sharp reduction in methane emissions. This was due especially to a massive reduction in the numbers of vehicles with two-stroke engines in the new German Länder. Further EF decreases have resulted via the aforementioned tightening of emissions standards.

For buses and heavy duty vehicles (over 3.5 t total permissible vehicle weight), maximum permissible levels of hydrocarbon (HC) emissions were lowered considerably (-40 %) via the introduction of the EURO3 standard in 2000. Since EURO3 vehicles were very quick to reach the market as of 2000, the emission factor for hydrocarbon emissions from diesel fuel – and the relevant emissions themselves – decreased considerably after 2000. A similar trend occurred for methane, emissions of which are calculated as a fixed share of total HC emissions.

N_2O emissions result primarily from incomplete reduction of NO to N_2 in 3-way catalytic converters. They are not limited by law. Initially, growth in numbers of cars with catalytic converters caused increases in N_2O emissions in comparison to the 1990 level. Newer catalytic converters are optimised to produce only small amounts of N_2O, however. As a result, N_2O decreased during the period 2000-2006. Since then, such emissions have been increasing again. Those increases are due to increasing use of selective catalytic reduction (SCR) equipment in heavy utility vehicles; under certain conditions, such equipment can produce N_2O as an undesired by-product.

CO_2 emissions depend directly on fuel consumption. From 1990-1999, these emissions increased, since growth in mileage travelled outweighed improvements in vehicle fuel consumption. Prior to the year 2000, CO_2 emissions showed only an increasing trend in the transport sector. Since that year, a first marked trend reversal has been seen, however. In 2010, fossil-fuel emissions were 25.8 million t lower than they were in 2000. The likely reasons for this trend include reductions in specific fuel consumption, the marked shift toward diesel vehicles in new registrations, continual increases in fuel prices, use of biofuels – and consumers' growing tendency to travel to other countries in order to make their fuel purchases (see the following paragraphs).

Table 55: Emissions from road transports

[Gg]	CO_2 fossil	CO_2 *bio**	CH_4	N_2O	NO_X	CO	NMVOC**	SO_2
1990	150,358.34	0.00	52.12	3.76	1,350.94	6,624.59	1,165.01	90.20
1995	165,104.07	106.47	32.91	5.43	1,164.77	3,829.17	543.56	69.31
2000	171,229.50	869.15	20.60	5.07	1,054.68	2,367.71	311.70	19.67
2005	151,603.50	5,573.71	12.21	3.26	756.19	1,484.89	190.93	0.81
2006	147,747.29	10,179.95	11.01	3.18	739.56	1,343.78	173.98	0.82
2007	145,034.69	11,023.55	9.78	3.31	679.96	1,220.91	156.75	0.81
2008	144,831.48	8,940.25	8.49	3.51	604.62	1,104.48	139.61	0.81
2009	144,134.18	8,030.56	7.84	3.70	557.05	1,038.60	131.01	0.81
2010	145,437.91	8,608.69	7.41	4.03	537.61	976.75	122.69	0.83

*) CO_2 emissions from biofuels are listed here solely for informational purposes.

**) includes evaporation-related emissions

CO_2 emissions from motorised road transports in Germany are calculated via a "*bottom-up*" approach (Tier 2 approach pursuant to IPCC GPG, 2000: p. 2.46): In the pertinent process, the fuels sold in Germany (petrol, (bio-) ethanol fuel, diesel fuel, biodiesel, LP and natural gas, petroleum (until 2002)) are allocated, within the TREMOD ("Transport Emission Model") model, to the various relevant vehicle layers (cf. Chapter 19.1.3.2). The consumption data that enter into the model, for each type of fuel, are obtained from the *Energy Balances*. CO_2 emissions are calculated – following import of the layer-specific fuel consumption figures – using country-specific emission factors from the CSE.

Non-CO_2 emissions are calculated with the aid of the TREMOD model (IFEU, 2011)[21]. That model incorporates a Tier-3 approach whereby mileage of the individual vehicle layers is multiplied by specific emission factors. For passenger cars and light duty vehicles, a "*cold start surplus*" is also added. The total consumption determined for each fuel type is cross-checked against consumption pursuant to the Energy Balance. Then, the relevant emissions are corrected with the help of factors obtained via such cross-checking. For petrol-powered vehicles, the evaporation emissions of VOC are calculated in keeping with the pollution-control technology used.

From the emissions and fuel-consumption figures for the various vehicle layers, aggregated, fuel-based emission factors (kg of emissions per TJ of fuel consumption) are derived and then forwarded to the CSE database. In keeping with the CORINAIR report structure, these factors are differentiated only by type of fuel, type of road (autobahn, rural road, city road) and, within the vehicle categories, by "without/with emissions-control equipment". The following emissions-control categories are differentiated:

21 To make it possible to derive and assess reduction measures, energy consumption and CO_2 emissions for the various vehicle categories are also calculated with TREMOD. The resulting values are subsequently checked against total consumption and total CO_2 emissions.

Table 56: Differentiation of emissions-control categories in road transports

Vehicle classes considered	Emissions-control system Without	With
Passenger cars / light commercial vehicles with petrol-burning engines	Without catalytic converter	With catalytic converter
Passenger cars / light duty vehicles with diesel engines, busses, heavy duty vehicles, motorcycles	Prior to the EURO 1 standard	As of the EURO 1 standard

For calculation with TREMOD, extensive basic data from generally accessible statistics and special surveys have been used, co-ordinated, and supplemented. An overview of the principal sources and key assumptions is given below. Detailed descriptions of the databases, including information on the sources used, and the calculation methods used in TREMOD, are provided in the aforementioned IFEU report.

<u>Motor-vehicle-fleet data:</u>

For western Germany from 1990 through 1993, and for Germany as a whole as of 1994, car ownership was calculated on the basis of the officially published ownership and new registration statistics of the Federal Motor Transport Authority (KBA). The car ownership analysis for East Germany in 1990 was based on a detailed analysis of the Adlershof car-emissions-testing agency in 1992 and the time series in the statistical annuals of the GDR. For the period between 1991 and 1993, it was necessary to estimate the figures with the aid of numerous assumptions.

Fleet data for the TREMOD model, as of reference years as of 2001, is the result of cross-checking with the database of the Federal Motor Transport Authority (KBA). The supplied data include vehicle fleets for each reference year, broken down as required for emissions calculation, i.e. in accordance with the following characteristics: type of engine (petrol, diesel, other), size class, vehicle age and emissions standard. For each reference year, the mid-year fleet is assumed to be representative of the fleet's composition for the year.

<u>Emission factors:</u>

All emission factors are listed in the "Emission-factor manual for road transports 3.1" ("Handbuch für Emissionsfaktoren des Straßenverkehrs 3.1" (HBEFA) (INFRAS, 2010), a reference work prepared via co-operation, between Germany, Switzerland, Austria and the Netherlands, in derivation of emission factors for road traffic. The emission factors in the manual originate predominantly from the measurement programmes of TÜV Rheinland (TÜV = Technical Control Association) and RWTÜV. Those programmes include foundational studies relative to the reference years 1989/1990. In those studies, a new method was used, for both passenger cars and heavy duty vehicles, whereby emission factors were derived on the basis of driving habits and traffic situations. Emission factors for automobiles until the 1994 (automobile-)model year were updated with the help of field-monitoring data. Version 3.1 of the "Emission-factor manual for road transports", which is used for the current emissions calculations, draws on findings of the EU working group COST 346 and the ARTEMIS research programme.

The emission factors are derived from the development of the various vehicle layers and from the data provided by the "Emission-factor manual for road transports 3.1". The emissions reduction achieved via the introduction of sulphur-free fuels was estimated by the Federal Environment Agency.

For the country-specific emission factors for CO_2, the reader's attention is called to the documentation in Annex 2, the Chapter "CO_2 emission factors". For bioethanol, the value used for gasoline, 72,000 kg/TJ, is used, while an IPCC default value of 70,800 kg/TJ is used for biodiesel.

Country-specific values are also used for liquefied petroleum gas and natural gas – 65,000 kg/TJ and 56,000 kg/TJ, respectively. We also refer to the information in the relevant Annex chapter.

An IPCC default value is also used for CO_2 from co-combusted lubricants: 80,000 kg/TJ. The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

Mileage data:

Mileage data were updated on the basis of the "2002 mileage survey" ("Fahrleistungserhebung 2002"; Institute of Applied Transport and Tourism Research (IVT) 2004), the "2005 road-transport census" ("Straßenverkehrszählungen 2005"; Federal Highway Research Institute (BASt), 2007) and data on growth of transports on federal highways (BASt, 2008).

Shifting of fuel purchases to other countries

Because fuel prices in Germany are higher – significantly, in some cases – than in almost all of Germany's neighbours, for some time the fuels used in Germany have included fuels purchased in other countries and brought into the country as "grey" imports.

At present, no precise data are available on this phenomenon, which is significant for truck and automobile traffic in Germany's border regions and which is referred to as "refuelling tourism" ("Tanktourismus"). Although several detailed studies have been carried out, no reliable overall picture of the situation is available (cf. LENK et al., 2005).

The sources that have documented shifting of consumers' fuel purchases to other countries (along with the resulting negative impacts on neighbouring countries' own emissions inventories) have included a study published by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW, 2005). The relevant neighbouring countries profit, to a not-inconsiderable degree, from additional revenue from energy taxation of such fuels. Such revenue is likely to be significantly higher than the certificate costs for the pertinent CO_2 emissions would be.

3.2.10.2.3 Uncertainties and time-series consistency (1.A.3.b)

In the framework of a study (IFEU & INFRAS 2009), uncertainties were calculated for the activity data entered into TREMOD, for the emission factors generated in TREMOD and for the emissions calculated in the Central System of Emissions (CSE).

3.2.10.2.4 Source-specific quality assurance / control and verification (1.A.3.b)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[22].

The emission factors used were compared with those of other countries. A number of countries were selected for this purpose; the emission factors included in the comparison were those of the Netherlands, Denmark, Switzerland, France, the UK, Norway and the European Union. The ranges covered by the various relevant groups of emission factors varied from greenhouse gas to greenhouse gas. All of the emission factors used by Germany are either right in the middle of the ranges for their groups in this context (this is the case for the emission factor for CO_2) or in the lower middle parts of those ranges (this is the case for the emission factors for CH_4 and N_2O).

3.2.10.2.5 Source-specific recalculations (1.A.3.b)

The presented emissions data were calculated with TREMOD version 5.11 (IFEU, 2011). The activity data (fuel consumption data) were adjusted with respect to the 2011 report year: The 2009 consumption data for all fuels were brought into line with the currently available data of the Energy Balances, the official mineral-oil data (Amtliche Mineralöldaten) of BAFA and the data of the Association of the German Petroleum Industry (MWV). Minor changes were made with regard to diesel fuel and petrol for 2008, while the figures for biodiesel and bio-ethanol for the period as of 2004 were updated.

[22] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

Table 57: Updated fuel inputs in road transports

	Fuel	Units	2004	2005	2006	2007	2008	2009
Subm. 2012	Diesel fuel	[TJ]	1,110,931	1,077,173	1,081,161	1,078,362	1,107,062	1,114,253
	Gasoline		1,072,720	992,377	930,834	892,982	854,002	829,227
	Biodiesel		38,806	71,792	130,139	143,431	109,612	89,327
	Bioethanol		1,144	6,817	13,418	12,065	16,385	23,697
	Natural gas		0	2,843	5,211	4,089	4,882	5,300
	Liquid gas		1,887	2,357	4,605	8,942	15,652	23,842
Subm. 2011	Diesel fuel	[TJ]	1,110,931	1,077,173	1,081,161	1,078,362	1,107,102	1,126,100
	Gasoline		1,072,720	992,377	930,834	892,982	854,145	827,898
	Biodiesel		38,795	71,725	130,006	143,461	109,595	90,128
	Bioethanol		1,155	6,884	13,548	12,182	16,547	23,889
	Natural gas		0	2,843	5,211	4,089	4,882	5,546
	Liquid gas		1,887	2,357	4,605	8,942	15,652	19,020
Absolute difference	Diesel fuel	[TJ]	*0*	*0*	*0*	*0*	-40	-11,847
	Gasoline		*0*	*0*	*0*	*0*	-143	1,329
	Biodiesel		11	67	133	-30	17	-800
	Bioethanol		-11	-66	-130	-117	-162	-192
	Natural gas		*0*	*0*	*0*	*0*	*0*	-246
	Liquid gas		*0*	*0*	*0*	*0*	*0*	4,822
Relative difference	Diesel fuel	[%]	*0.000*	*0.000*	*0.000*	*0.000*	-0.004	-1.052
	Gasoline		*0.000*	*0.000*	*0.000*	*0.000*	-0.017	0.161
	Biodiesel		0.029	0.094	0.102	-0.021	0.016	-0.888
	Bioethanol		-0.962	-0.962	-0.962	-0.962	-0.979	-0.803
	Natural gas		*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	-4.436
	Liquid gas		*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	25.352

Much larger changes in the CH_4 and N_2O emissions reported since 1990 result from adjustment of the emission factors used in TREMOD to HBEFA 3.1 (see above). For all years, corrections – considerable, in some cases – were made in the emission factors used for individual vehicle layers. In particular, emission factors from COPERT 4 were adopted in HBEFA 3.1, in keeping with COPERT 4's more current database for N_2O. The impacts of this TREMOD update on the reported methane and nitrous oxide emissions are shown in the following tables.

Table 58: Recalculation of methane emissions as of 1990, almost completely as a result of corrections of EF

	Units	1990	1995	2000	2005	2006	2007	2008	2009
Subm. 2012		52.12	32.91	20.60	12.21	11.01	9.78	8.49	7.84
Subm. 2012	[Gg]	60.53	30.34	15.68	8.76	8.14	7.29	6.64	6.27
Absolute diff.		-8.41	2.57	4.91	3.45	2.87	2.49	1.85	1.57
Relative diff.	[%]	-13.90	8.47	31.33	39.36	35.22	34.14	27.93	25.13

Table 59: Recalculation of nitrous oxide emissions as of 1990, almost completely as a result of corrections of EF

	Units	1990	1995	2000	2005	2006	2007	2008	2009
Subm. 2012		3.76	5.43	5.07	3.26	3.18	3.31	3.51	3.70
Subm. 2011	[Gg]	1.96	4.63	4.82	3.76	3.56	3.37	3.13	3.03
Absolute diff.		1.79	0.79	0.25	-0.50	-0.37	-0.06	0.38	0.67
Relative diff.	[%]	91.43	17.15	5.18	-13.41	-10.49	-1.82	12.21	22.04

The above-described changes in the TREMOD data on which the calculations are based led to the following changes in reported greenhouse-gas emissions:

Table 60: Recalculated total greenhouse-gas emissions for the source category, since 1990, and not including CO_2 emissions from biodiesel

	Units	1990	1995	2000	2005	2006	2007	2008	2009
Subm. 2012	[Gg	152,617	167,478	173,233	152,870	148,966	146,266	146,098	145,445
Subm. 2011	CO_2	152,238	167,178	173,053	152,954	149,021	146,232	145,954	145,686
Absolute diff.	eq.]	380	300	181	-84	-55	33	144	-241
Relative diff.	[%]	0.25	0.18	0.10	-0.05	-0.04	0.02	0.10	-0.17

Table 34: Recalculated CO_2 emissions from biofuels

	Units	1990	1995	2000	2005	2006	2007	2008	2009
Subm. 2012	[Gg	0	106	869	5,574	10,180	11,024	8,940	8,031
Subm. 2011	CO_2	0	106	869	5,574	10,180	11,034	8,951	8,101
Absolute diff.	eq.]	0.00	0.01	0.00	0.01	0.01	-10.61	-10.46	-70.48
Relative diff.	[%]	0.00	0.01	0.00	0.00	0.00	-0.10	-0.12	-0.87

3.2.10.2.6 Source-specific planned improvements (1.A.3.b)

No improvements are planned at present.

3.2.10.3 Transport – Railways (1.A.3.c)

3.2.10.3.1 Source-category description (1.A.3.c)

CRF 1.A.3.c	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**		**T**	**2,880.8**	**(0.24%)**	**945.4**	**(0.10%)**	**-67.18%**
All fuels	N_2O	-	-	12.6	(0.00%)	4.2	(0.00%)	-66.59%
All fuels	CH_4	-	-	2.3	(0.00%)	0.4	(0.00%)	-83.92%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	NS	CS D (biodiesel, lubricants)
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	Tier 2	NS	CS

The source category *Transports – Railways* is a key category of CO_2 emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-67.18 %), and thus an extremely low emissions level has been attained (in 2010, emissions amounted to 27 % of the contribution of the smallest key category identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

Germany's railway sector is undergoing a long-term modernisation process, aimed at making electricity the main energy source for rail transports. Use of electricity, instead of diesel fuel, to power locomotives has been continually increased, and electricity now provides 80 % of all railway traction power[23]. Railways' power stations for generation of required traction current are allocated to the stationary component of the energy sector (1.A.1.a) and are not included in the following section.

In energy input for trains operating in Germany, diesel fuel is the only energy source that plays a significant role apart from electric power. Since 2004, biodiesel has also been used, as an additive. Reliable figures for that fuel have been available since 2009.

In historic vehicles – primarily, steam-powered locomotives operated for exhibition purposes – small quantities of solid fuels are also used. The official Energy Balances provide pertinent evaluatable consumption data for lignite, for the period until 2002, and for hard coal, for the period until 2000. Since no other evaluatable statistics are available, emissions from consumption of solid fuels cannot be calculated for later years.

[23] from Energiewirtschaftliche Tagesfragen, 54th year (Jahrgang; 2004), issue 3, p. 185

Use of other fuels – such as vegetable oils or gas – in private narrow-gauge railway vehicles has not been included to date and may still be considered negligible.

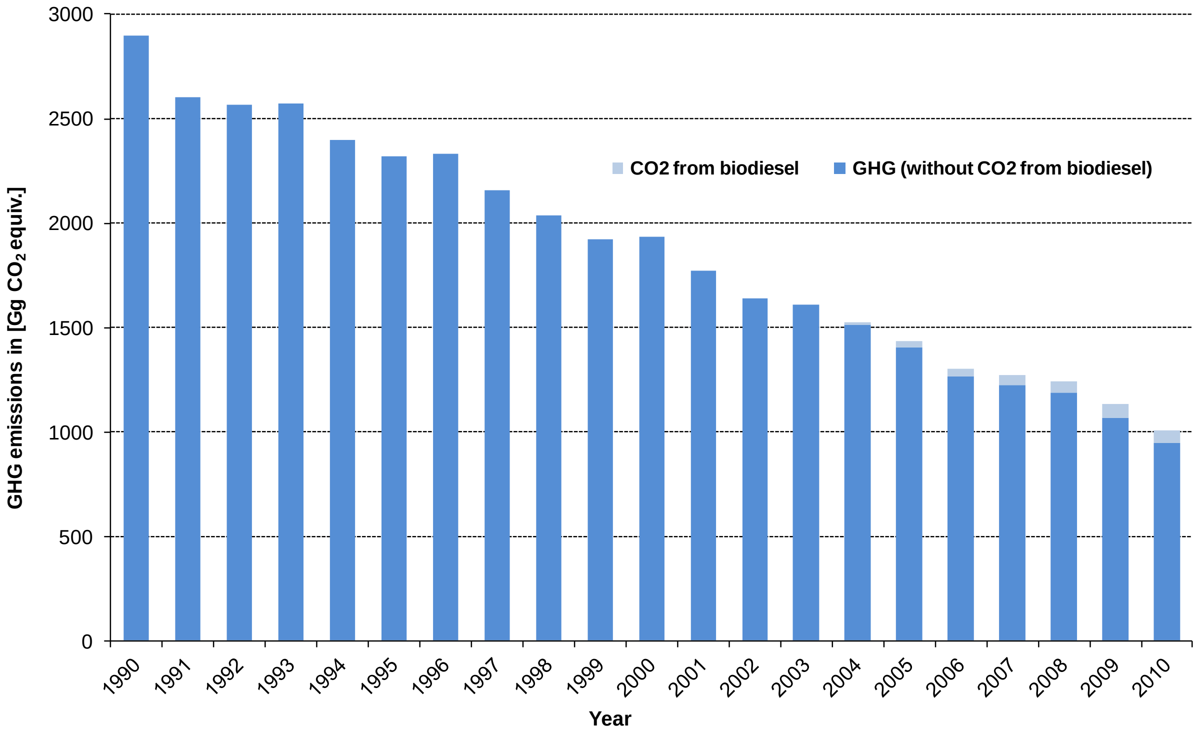


Figure 33: Development of greenhouse-gas emissions from railway transports, 1990-2010 (not including emissions from generation of electric power for railways)

3.2.10.3.2 Methodological issues (1.A.3.c)

No specific information relative to this source category is found in the IPCC Good Practice Guidance (2000: Chapter 2). The relevant emissions are thus calculated as the product of fuel consumption and the relevant country-specific emission factors. This procedure conforms to the general Tier 2 method and the basic calculation rule pursuant to equation 2.6 of the IPCC Good Practice Guidance (2000, p. 2.46).

Activity data:

As a rule, energy consumption data (currently, for the period from 1990 to 2009) are taken from the official Energy Balances of the Federal Republic of Germany (AGEB, 2011). In particular, the fuel data have been taken from the following Energy Balance lines, for the following periods:

Table 61: Sources for AD in 1.A.3.c

Fuel type	Energy Balance line	Relevant years
Diesel fuel	74	through 1994
	61	since 1995
Lignite briquettes	61	since 1996
Raw lignite	61	since 1996
Hard coal (Steinkohle)	74	through 1994
	61	since 1995
Hard-coal coke	61	since 1995

For years for which no Energy Balance is yet available, or only a provisional Energy Balance is available, sales data of the Association of the German Petroleum Industry (MWV) are used. Those data are published in the annual report "Petroleum Data" ("Mineralöl-Zahlen"; in the present instance: page 52, Table "Sectoral consumption of diesel fuel" ("Sektoraler Verbrauch von Dieselkraftstoff") (MWV, 2011)).

As of the 2010 report, use of biogenic fuels (biodiesel) is also covered. Because the relevant data in the Energy Balances of 2004 and 2005 were incomplete, for the present report the annual consumption figures for those years were calculated on the basis of the official mixing quotas. As of the year 2006, the figures from the relevant Energy Balance lines are used.

As of the last report, pertinent quantities of co-combusted lubricants, along with the resulting CO_2 emissions, are also recorded and reported. Due to a lack of pertinent figures on annual inputs of lubricants, i.e. figures such as those listed by the official mineral-oil statistics (Amtliche Mineralölstatistik) for road transports and inland-waterway transports, the quantities of lubricants used are derived from the quantities of diesel fuel used. The co-combusted quantities of lubricants are then calculated on the basis of those lubricant figures.

Emission factors:

The emission factors are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- With regard to CO_2, the reader's attention is called to the documentation in Annex 2, the Chapter "CO_2 emission factors". For co-combustion of lubricants, an IPCC default figure of 80,000 kg CO_2/TJ is currently being used.
- The CH_4 EF for solid fuels are based on the UBA study "Air quality control '88" ("Luftreinhaltung '88") (UBA, 1989b). A comparison of the resulting country-specific emission factors with the corresponding IPCC default values shows that the EF used for coal are higher than the pertinent figures in the IPCC Reference Manual (1996b, Table 1-7). Specific emission factors, for diesel fuel and biodiesel, have been derived for all diesel locomotives in service in Germany. In emissions calculations, such locomotive-model-specific emission factors are linked with relevant operational mileage (kilometres travelled) for the relevant year (TREMOD; IFEU, 2011). The default value in the IPCC Reference Manual (1996b, Table 1-7) is higher than the country-specific emission factors used by Germany, which take account, chronologically, of engine-based measures to improve the emissions behaviour of railway vehicles (1995: 2.45 kg/TJ; 2010: 1.29 kg/TJ).

- As to the solid-fuel emission factor for N_2O, the Federal Environment Agency's experts agree with the Federal Environment Agency study "Luftreinhaltung '88" (UBA, 1989b). The country-specific EF are considerably higher than the corresponding values in the IPCC Reference Manual (1996b, Table 1-8). With regard to diesel fuel and biodiesel, a value is obtained by analogy to heavy duty vehicles without emissions-control equipment. The country-specific emission factor, at 1.0 kg/TJ, is higher than the value of 0.6 kg/TJ given by the Reference Manual (IPCC, 1997, Table 1-8).
- The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

Table 62: Comparison of EF used and default EF

GG	Fuel	Emission factor used [kg/TJ]	Default EF [kg/TJ]	
CH_4	Diesel & biodiesel	1.3 - 2.5		
	Hard coal (Steinkohle)	15.0	**Oil:**	**5.0**
	Lignite briquettes	15.0	**Coal:**	**10.0**
	Raw lignite	15.0		
	Hard-coal coke	0.5		
N_2O	Diesel & biodiesel	1.0		
	Hard coal (Steinkohle)	4.0	**Oil:**	**0.6**
	Lignite briquettes	3.5	**Coal:**	**1.4**
	Raw lignite	3.5		
	Hard-coal coke	4.0		

Source: Luftreinhaltung `88 (UBA, 1989b); IFEU (2009)

3.2.10.3.3 Uncertainties and time-series consistency (1.A.3.c)

In the framework of a study (IFEU & INFRAS 2009), uncertainties were calculated for the activity data entered into TREMOD, for the emission factors generated in TREMOD and for the emissions calculated in the Central System of Emissions (CSE).

The activity-rate time series for lignite briquettes, hard coal and hard-coal coke exhibit inconsistencies resulting from statistical conversion as of 1994/1995; these inconsistencies cannot be eliminated at present.

3.2.10.3.4 Source-specific quality assurance / control and verification (1.A.3.c)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[24].

[24] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

The emission factors used were compared with those of other countries. A number of countries were selected for this purpose; the emission factors included in the comparison were those of the Netherlands, Denmark, Switzerland, France, the UK, Norway and the European Union. The ranges covered by the various relevant groups of emission factors varied from greenhouse gas to greenhouse gas. All of the emission factors used by Germany are either right in the middle of the ranges for their groups in this context (this is the case for the emission factor for CO_2) or in the lower middle parts of those ranges (this is the case for the emission factors for CH_4 and N_2O).

Since no other sources of data for Germany are known, it is currently not possible to verify the emissions reported here via comparison.

3.2.10.3.5 Source-specific recalculations (1.A.3.c)

Recalculations were carried out to take account of the use of updated figures (only for 2009), from the Energy Balances and of the Association of the German Petroleum Industry (MWV), for inputs of diesel and biodiesel, and to take account of the use of updated emission factors for methane (for the period as of 2001).

Table 55: Changes in underlying consumption data, 2009

	Units	Diesel fuel	Biodiesel	Lubricants
Submission 2012	[TJ]	14,329	983	7.7
Submission 2011		15,217	727	8.0
Absolute difference		-888	256	-0.3
Relative difference	[%]	-5.84	35.21	-3.89

Table 55: Adjustment of EF(CH_4) for period as of 2001

	Units	2001	2002	2003	2004	2005	2006	2007	2008	2009
Submission 2012	[kg/TJ]	1.993	1.804	1.765	1.748	1.583	1.514	1.417	1.379	1.312
Submission 2011		1.994	1.806	1.768	1.755	1.594	1.569	1.498	1.492	1.382
Absolute difference		-0.001	-0.002	-0.003	-0.007	-0.011	-0.055	-0.081	-0.113	-0.070
Relative difference	[%]	-0.02	-0.10	-0.18	-0.39	-0.69	-3.51	-5.43	-7.58	-5.08

Table 63: Impacts of the described recalculations on the source category's total greenhouse-gas emissions (except for CO_2 emissions) from biodiesel, as of 2001

	Units	2001	…	2005	2006	2007	2008	2009
Subm. 2012	[Gg CO_2 equiv.]	1,772.278	…	1,404.291	1,265.72	1,222.78	1,185.30	1,066.13
Subm. 2011		1,772.278	…	1,404.295	1,265.74	1,222.81	1,185.34	1,132.10
Absolute difference		-0.0002	…	-0.004	-0.02	-0.03	-0.04	-65.97
Relative difference	[%]	-0.00001	…	-0.0003	-0.002	-0.002	-0.003	-5.83

Table 57: Effects of recalculations on CO_2 emissions from biodiesel

	Units	2009
Submission 2012	[Gg CO_2]	70
Submission 2011		51
Absolute difference		18
Relative difference	[%]	35.21

3.2.10.3.6 Source-specific planned improvements (1.A.3.c)

A project is determining the quantities of coal and coke, and of all other fuels in addition to diesel fuel and biodiesel, used since 1990.

3.2.10.4 Transport – Navigation (1.A.3.d)

3.2.10.4.1 Source-category description (1.A.3.d)

CRF 1.A.3.d	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	CO_2	-	-	2,065.7	(0.17%)	758.2	(0.08%)	-63.29%
All fuels	N_2O	-	-	8.6	(0.00%)	3.4	(0.00%)	-60.69%
All fuels	CH_4	-	-	1.7	(0.00%)	0.5	(0.00%)	-67.56%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 1	NS	CS D (biodiesel, lubricants)
CH_4	Tier 1	NS	CS
N_2O	Tier 1	NS	CS
NO_X, CO, NMVOC, SO_2	Tier 1	NS	CS

The source category *Navigation* is not a key category.

Navigation is broken down into the categories "coastal and inland navigation" (domestic) and "international maritime transport". All domestic navigation is diesel-powered (and uses diesel fuel with added biodiesel), while heavy fuel oil (heavy oil) is also used in the international shipping sector. Emissions from international navigation are listed in the emissions inventories, as a memo item, but they are not included in total emissions.

Under source category 1.A.3d Navigation, the CSE includes coastal and inland fishing and coastal and inland shipping.

The following figure shows the development of greenhouse-gas emissions in inland shipping since 1990, which development parallels that for fuel inputs in this source category.

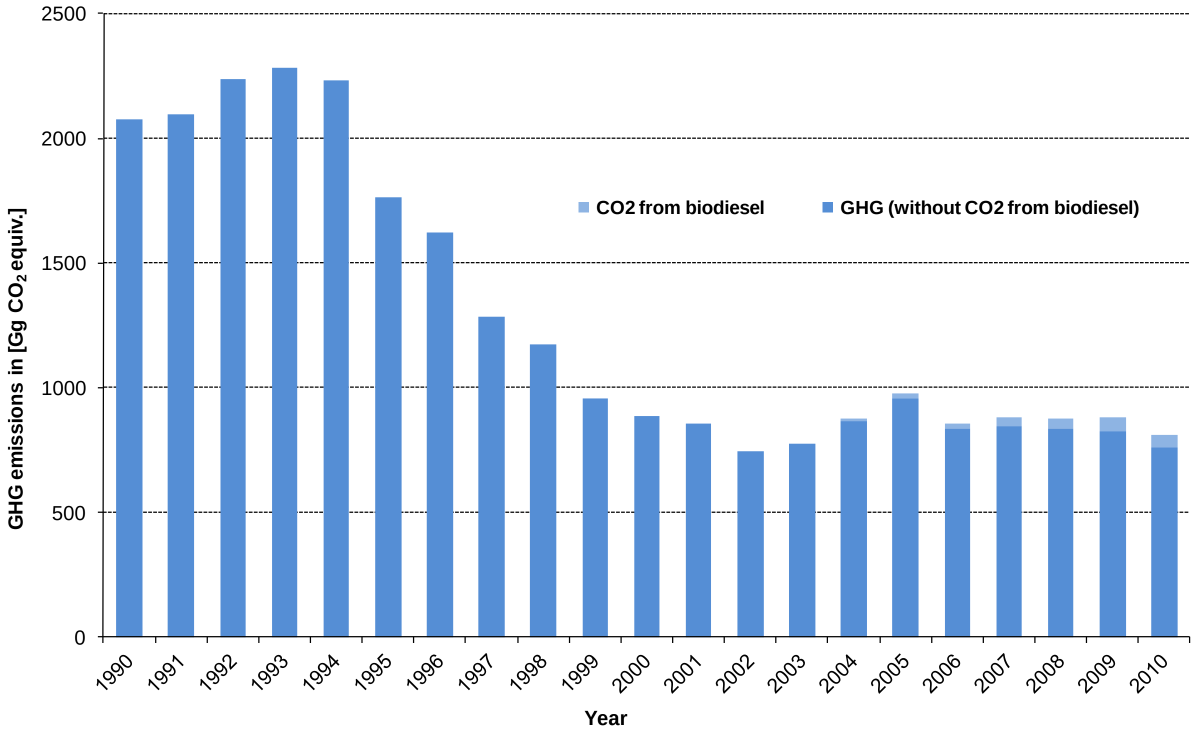


Figure 34: Development of greenhouse-gas emissions in inland shipping, 1990 – 2010

3.2.10.4.2 Methodological issues (1.A.3.d)

For Germany, emissions from this source category are calculated as the product of consumed fuels and country-specific emission factors for CO_2, CH_4 and N_2O. This procedure is in keeping with the general Tier 1 method and the basic calculation rule using the equation "emission factor times fuel consumption" pursuant to the IPCC Good Practice Guidance (2000: Chapter 2.4.1.1, p. 2.51). Refuelling in other countries is also a significant factor in the navigation sector, although no data are available on the relevant quantities involved (cf. Chapter 3.2.10.2.2).

Activity data:

In general, energy-consumption figures are taken from the official Energy Balances of the Federal Republic of Germany (AGEB, 2011).

For years for which no final Energy Balance is yet available, data of the Federal Office of Economics and Export Control (BAFA) are used as a basis. Those data are published as "Amtliche Mineralöldaten für die Bundesrepublik Deutschland" ("Official mineral-oil data for the Federal Republic of Germany"; for the present context: Table 7j): "Inlandsablieferungen nach ausgewählten Verwendungssektoren" ("Domestic deliveries, by selected sectors") (BAFA, 2011).

On the other hand, data on the annual quantities of lubricants sold to this sector are always taken from the "Amtliche Mineralöldaten" of BAFA.

Table 64: Sources for the activity data used

Material	Source statistics	location within the source	
Diesel fuel	Energy Balance	line 77 (for period until 1994) line 64 (for period as of 1995)	Coastal and inland navigation
Biodiesel	Energy Balance	line 64 (for period as of 2004)	
Lubricants	Amtliche Mineralöldaten	Table 7j, column [4]	Domestic sales to the inland-navigation sector

Both official balances divide activity data in shipping into the categories *domestic* (AGEB: "Coastal and inland navigation" = BAFA: "an die Binnenschifffahrt" ("for inland shipping")) and *international* (AGEB: "high-seas bunkering" = BAFA: "Bunker int. Schifffahrt" ("bunkering for international shipping"), in accordance with the various differently taxed quantities of ship fuel sold. The manner in which emissions for domestic ship transports and international ship transports are separately calculated and listed (cf. Chapter 3.2.2.3) is in accordance with that breakdown. The criteria for breakdown of domestic and international emissions that are presented in the IPCC-GPG (2000: Table 2.8), on the other hand, cannot be used due to a lack of suitable movement data.

Fuel consumption in coastal and inland-waterway navigation varies in keeping with waterway navigability. Since the mid-1990s, the overall trend for such consumption has been a decreasing one, as many ships have been refuelling abroad in order to take advantage of lower fuel prices. The abrupt decrease that occurred in 1994/1995 was due solely to a conversion in the Energy Balance, however.

As of the 2010 report, use of biogenic fuels (biodiesel) is also covered. Because the relevant data in the Energy Balances for 2004 and 2005 were incomplete, for the present report the annual consumption figures for those years were calculated on the basis of the official mixing quotas.

As of the 2011 report, pertinent quantities of co-combusted lubricants, along with the resulting CO_2 emissions, are also being recorded and reported. The relevant co-combusted quantities are obtained from the figures in the official mineral-oil data (Amtliche Mineralöldaten) of the Federal Office of Economics and Export Control (BAFA) relative to annual domestic deliveries.

For the years 2007 and 2008, reliable official consumption figures for diesel – and, thus, for added biodiesel – are lacking. The reason for this is that the manner in which one, important, refinery operator reports to the Association of the German Petroleum Industry (MWV) differs from the reporting practices of other operators; this leads to erroneous figures in the official mineral-oil statistics. Therefore, the applicable quantities of fuel and co-combusted lubricants were extrapolated from the corresponding consumption data of past years, on the basis of the applicable mileage travelled. As soon as the described statistical problems have been eliminated, this section will present suitable corrections. In the meantime, the relevant Energy Balance has been corrected for the year 2009. In that correction, the extrapolated data were replaced with original values from the Energy Balance (cf. the recalculations below).

Data on use of diesel fuel and heavy fuel oil in international maritime transports are provided in the Chapter International maritime transports (1.C.1.b, Chapter 3.2.2.3).

Emission factors:

The diesel emission factors (which currently are adapted for biodiesel) for domestic navigation are based, for each specific gas in question, on the results of various research projects and experts' reviews conducted by the Federal Environment Agency:

- With regard to the CO_2 emission factor, the reader's attention is called to the documentation in Annex 2, Chapter 18.6 – "CO_2 emission factors". For diesel fuel, a country-specific value of 74,000 kg/TJ is used, while for biodiesel an IPCC default value of 70,800 kg/TJ is used. For co-combustion of lubricants, an IPCC default figure of 80,000 kg/TJ is currently being used.
- The CH_4 emission factors used have been derived from the value used for heavy duty vehicles without emissions control systems. A 15% reduction of specific CH_4 emissions in the period 1990 to 2005, resulting from engine improvements, has been assumed, in keeping with experts' estimates. The country-specific EF, at 2.37 to 2.65 kg/TJ, are also lower than the IPCC default value for diesel fuel, 5.0 kg/TJ, as listed in the Reference Manual (IPCC et al, 1996b, p. 1.35, Table 1-7).
- The emission factors for N_2O are in keeping with Federal Environment Agency (UBA) experts' assessments based on the UBA study "Air Quality Control '88" ("Luftreinhaltung '88") and on analogies to heavy duty vehicles without emissions-control equipment. The country-specific EF for diesel fuel and biodiesel, at 1.0 kg/TJ, is higher than the value of 0.6 kg N_2O/TJ given by the Reference Manual (IPCC, 1996b: Table 1-8).
- The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for diesel fuel. The emissions themselves are thus included in quantities calculated for diesel fuel, and they are reported here as "IE" (included elsewhere).

Data on emission factors for use of diesel fuel and heavy fuel oil in international maritime transports are provided in Chapter 3.2.2.3 International maritime transports (1.C.1.b).

3.2.10.4.3 Uncertainties and time-series consistency (1.A.3.d)

In 2009, the uncertainties of the relevant activity data, emission factors and emissions were studied for the first time, in the framework of a research project (IFEU & INFRAS 2009).

The emission factors for CO_2 and N_2O are constant throughout the entire time series and, thus, are consistent.

The activity-data time series for coastal and inland shipping exhibit inconsistencies resulting from the Energy-Balances transition between 1994 and 1995; these inconsistencies cannot be eliminated at present.

3.2.10.4.4 Source-specific quality assurance / control and verification (1.A.3.d)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances.

In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[25].

The emission factors used were compared with those of other countries. A number of countries were selected for this purpose; the emission factors included in the comparison were those of the Netherlands, Denmark, Switzerland, France, the UK, Norway and the European Union. The ranges covered by the various relevant groups of emission factors varied from greenhouse gas to greenhouse gas. All of the emission factors used by Germany are either right in the middle of the ranges for their groups in this context (this is the case for the emission factor for CO_2) or in the lower middle parts of those ranges (this is the case for the emission factors for CH_4 and N_2O).

Since no other sources of data for Germany are known, it is currently not possible to verify the emissions reported here via comparison.

3.2.10.4.5 Source-specific recalculations (1.A.3.d)

Only slight recalculations have been carried out with respect to the data provided in the Resubmission 2011. As described above, the activity data for diesel fuel and biodiesel, which previously had been extrapolated from data for earlier years, were adjusted to the corrected Energy Balance for 2009. (Data for domestic deliveries of lubricants to the inland-shipping sector, pursuant to the official mineral-oil data (Amtliche Mineralöldaten) of the Federal Office of Economics and Export Control (BAFA), were not affected, however.)

Table 65: Adjustment of the activity data for 2009 to figures in the corrected Energy Balance

	Units	Diesel fuel	Biodiesel
Submission 2012		11,091	761
Submission 2011	[TJ]	9,740	488
Absolute difference		1,351	273
Relative difference	[%]	13.87	55.91

The effects on the reported greenhouse-gas emissions for the source category are shown in the following tables.

Table 66: Resulting changes in total greenhouse-gas emissions (not including CO_2) from biodiesel, for 2009

	Units	GG emissions
Submission 2012		827
Submission 2011	[Gg CO_2 equiv.]	727
Absolute difference		101
Relative difference	[%]	13.84

Table 67: Resulting changes in CO_2 emissions from combustion of biodiesel, for 2009

	Units	CO_2 emissions
Submission 2012		54
Submission 2011	[Gg CO_2]	35
Absolute difference		19
Relative difference	[%]	55.91

[25] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

3.2.10.4.6 Source-specific planned improvements (1.A.3.d)

Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.3.d.

In a project, the basic data used in the TREMOD module for inland shipping are being extensively revised.

3.2.10.5 Transport – Other transport (1.A.3.e)

3.2.10.5.1 Source category description (1.A.3.e)

CRF 1.A.3.e	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**-/T2**	4,751.7	(0.39%)	4,140.5	(0.43%)	-12.86%
All fuels	N_2O	-	-	32.7	(0.00%)	19.1	(0.00%)	-41.64%
All fuels	CH_4	-	-	7.1	(0.00%)	2.9	(0.00%)	-59.74%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 1	NS	CS
CH_4	Tier 1	NS	CS
N_2O	Tier 1	NS	CS

The source category *Other transport* is a key category of CO_2 emissions in terms of level.

Reporting in source category 1.A.3.e – Other transport includes emissions from construction-related transports and from gas turbines in natural-gas compressor stations. Construction-related transports are included in the Energy Balance category "Commercial and institutional and other consumers". Gas turbines in natural-gas compressor stations, on the other hand, are a clearly defined plant type.

3.2.10.5.2 Methodological issues (1.A.3.e)

The emissions for the aforementioned areas are calculated as the product of fuel consumption and the relevant country-specific emission factors. The IPCC Good Practice Guidance (2000) provides no specific provisions for "good practice" in connection with Other transport. The selected procedure is in keeping with the general Tier 1 method as set forth, for example, in equation 2.3 of the IPCC Good Practice Guidance (2000: p. 2.37).

Activity data:

The area **construction-sector transports** accounts for the majority of energy inputs in this source category. The diesel-fuel and petrol consumption data are taken from Energy Balance lines 79 and 67 (through 1994 and as of 1995) (cf. Chapter 18.2), following deduction of energy inputs for military and agricultural transports. Since construction-sector transports are significant with regard to this category's status as a key category, the calculation procedure used for this category should be as detailed as possible. At present, due to a lack of detailed data, only the above-described Tier 1 method can be used, however.

The area of **natural gas compressor stations** accounts for the smaller share of energy inputs. Calculation of fuel inputs for natural gas compressors has been completely revised for the NIR 2012. As of 2005, the fuel inputs reported for purposes of emissions trading, and aggregated by the emissions-trading authority, are being used directly, as a new data source. From that data set, only data for those natural gas compressors are being used that are allocated to the transport network. Natural gas compressors of pumping stations are identified via energy statistics and are thus already included in source category 1.A.1.c. This allocation approach prevents double-counting in the inventory.

In light of the new data situation, it seemed likely that the fuel inputs used were too low, throughout the entire time series. Only the value shown in the 2002 Energy Balance seemed plausible. While fuel inputs for natural gas compressors in the period 1995-2002 were reported in the context of statistics, it may be assumed that the recorded levels were too low. To establish consistency in the relevant time series, therefore, recalculations back to 1990 were carried out. Since the relevant fuel inputs fluctuate annually, in keeping with primary energy consumption, simple interpolation would not have led to the desired consistency. For that reason, a mean for the pertinent relationship (fuel inputs / primary energy consumption) was calculated for the period 2005-2009, and then that mean was used for the calculations back to 1990. This procedure has produced a plausible time series.

Emission factors:

The emission factors for emissions of **construction-sector transports** are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- With regard to CO_2, the reader's attention is called to the documentation in Annex 2, the Chapter "CO_2 emission factors". For diesel fuel, a country-specific value of 74,000 kg/TJ is used, while for petrol an IPCC default value of 72,000 kg/TJ is used.
- The country-specific EF (CH_4) are based on a Federal Environment Agency study of the emissions of mobile machinery (IFEU, 2009). These factors reflect the emissions standards that have been phased in gradually, since the mid-1990s, for construction-sector machinery. For 2010, the relevant value for diesel fuel is 1.5 kg/TJ (1995: 4.1 kg/TJ), while for petrol it is 20.5 kg/TJ (1995: 22.8 kg/TJ).
- The country-specific N_2O emission factors for petrol (for the old German Länder for 1990-1994, and for all of Germany as 1995: 3.7 kg/TJ; for the new German Länder for 1990-1994: 2.1 kg/TJ) were also obtained from the Federal Environment Agency study "Air Quality Control '88" ("Luftreinhaltung '88" (UBA, 1989b)). The N_2O emission factor for diesel fuel, 1.0 kg/TJ, was derived, by analogy, from the value for heavy duty vehicles without emissions-control equipment.

The emission factors for natural-gas use in **natural gas compressor stations** are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- With regard to CO_2, the reader's attention is called to the documentation in Annex 2, the Chapter "CO_2 emission factors".
- The CH_4 and N_2O EF have been taken from Chapter 4.9.5 and Annex E, Table 5 of the Federal Environment Agency study on stationary combustion systems (RENTZ et al, 2002); the procedure used in the study is described in Chapter 3.2.6.2.

3.2.10.5.3 Uncertainties and time-series consistency (1.A.3.e)

Uncertainties for the activity data were determined for the first time in the 2004 report year (research project 204 41 132, UBA). The method for determining the uncertainties is described in Annex 2, in the Chapter "Uncertainties in the activity data of stationary combustion plants", of the NIR 2007.

The EF time series for N_2O for petrol (construction industry) exhibits inconsistencies resulting from statistical conversion as of 1994/1995; these inconsistencies cannot be eliminated at present. Since 1995, relevant activities in the new German Länder have not been listed separately. As a result, emissions cannot be calculated using new-Länder EF that diverge from those for the old German Länder. Since it cannot be assumed that specific emissions – and, thus, EF – were comparable in the old and new German Länder until 1994, the different EF for those years have been retained. As a result, the time series contains a methodological change, manifested as a jump in the overall EF (IEF).

The procedure for determining uncertainties for the EF of natural gas compressor stations is described in Chapter 3.2.6.2. Results for N_2O are presented in Chapter 3.2.6.3.2, while those for CH_4 are presented in Chapter 3.2.6.3.3.

3.2.10.5.4 Source-specific quality assurance / control and verification (1.A.3.e)

Quality control (pursuant to Tiers 1+2) and quality assurance for the activity data have been carried out by the Single National Entity.

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the EF and ED, and they have also been carried out for the AD relative to "all-terrain transport vehicles".

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out, by source-category experts, for the category "Pipeline transport". Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Quality reports of the Working Group on Energy Balances (AGEB) have been submitted to the Federal Environment Agency, for purposes of quality assurance of the Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[26].

For purposes of further verification of calculated fuel inputs in natural gas compressor stations, plans call for data from emissions trading to be allocated to the relevant economic sectors and then compared with the pertinent data from emissions reporting. To rule out any possibility of double-counting, such comparisons will have to be carried out extremely carefully.

In addition, implied emission factors (IEF) for the area of construction-sector transports were compared with those of other countries. Due to this source category's highly heterogeneous

[26] AG Energiebilanzen (Working Group on Energy Balances): explanations relative to revision of the Energy Balances 2003 – 2006; URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 (last checked on 30 October 2009)

composition, however, such comparisons are extremely difficult to carry out for methane and nitrous oxide.

Natural gas compressor stations: the results of Chapter 3.2.6.4 apply mutatis mutandis.

3.2.10.5.5 Source-specific recalculations (1.A.3.e)

Construction-sector transports:

Changes with respect to last year's report were made to take account of a correction of the Energy Balance; these changes solely affected the year 2009.

Table 68: Adjustment of the activity data to the corrected Energy Balance for 2009

	Units	Diesel fuel	Petrol
Submission 2012	[TJ]	37,632	1,809
Submission 2011		34,793	2,924
Absolute difference		2,838	-1,116
Relative difference	[%]	8.16	-38.14

As a result of correction of the consumption data used, as described, the greenhouse-gas emissions for 2009 have been recalculated as follows:

Table 69: Recalculated total greenhouse-gas emissions for 2009

	Units	2009
Submission 2012	[Gg CO_2 equiv.]	2,931
Submission 2011		2,802
Absolute difference		129
Relative difference	[%]	4.60

Natural-gas-compressor stations: Recalculations for the period as of 1990 have been carried out to take account of new fuel data obtained from the ETS and of methodolgical adjustment of the time series.

Table 70: Recalculations in CRF 1.A.3.e, Natural gas compressor stations

Units [Gg]	NIR 2011	NIR 2012	Difference, absolute			Difference, relative
Year	Total	Total	gas	liquid	Total	Total
1990	**4,302**	**4,752**	449	0	**449**	**10.45%**
1991	**4,405**	**4,876**	470	0	**470**	**10.68%**
1992	**3,843**	**4,309**	466	0	**466**	**12.12%**
1993	**3,973**	**4,463**	490	0	**490**	**12.34%**
1994	**3,962**	**4,463**	501	0	**501**	**12.65%**
1995	**3,996**	**4,595**	599	0	**599**	**14.98%**
1996	**4,071**	**4,693**	622	0	**622**	**15.27%**
1997	**4,019**	**4,645**	626	0	**626**	**15.58%**
1998	**3,987**	**4,621**	635	0	**635**	**15.92%**
1999	**4,211**	**4,697**	486	0	**486**	**11.55%**
2000	**3,998**	**4,597**	599	0	**599**	**14.98%**
2001	**3,981**	**4,561**	580	0	**580**	**14.58%**
2002	**4,623**	**4,623**	0	0	**0**	**0.00%**
2003	**3,869**	**4,489**	621	0	**621**	**16.04%**
2004	**3,787**	**4,410**	624	0	**624**	**16.47%**
2005	**3,666**	**4,262**	596	0	**596**	**16.24%**
2006	**3,722**	**4,514**	792	0	**792**	**21.29%**
2007	**3,660**	**4,162**	502	0	**502**	**13.73%**
2008	**3,692**	**4,304**	612	0	**612**	**16.57%**
2009	**3,608**	**4,286**	549	130	**679**	**18.81%**

3.2.10.5.6 Source-specific planned improvements (1.A.3.e)

Natural-gas-compressor stations: Following the completion of the relevant research project begun in 2008 (FICHTNER et al. 2011), the emission factors for NO_X and SO_2 were updated. Updating of the emission factors for CH_4 and N_2O is currently in progress.

Construction-sector transports: No improvements are planned at present.

3.2.11 Other: Residential, commercial/institutional, agriculture, forestry and fisheries (1.A.4)

3.2.11.1 Source category description (1.A.4)

CRF 1.A.4	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
CRF 1.A.4.a (commerce, trade, services)								
All fuels	**CO_2**	**L**	**T/T2**	**63,949.6**	**(5.23%)**	**36,399.3**	**(3.82%)**	**-43.08%**
All fuels	**CH_4**	**-**	**T/-**	**1,216.1**	**(0.10%)**	**61.5**	**(0.01%)**	**-94.94%**
All fuels	N_2O	-	-	144.2	(0.01%)	92.3	(0.01%)	-35.97%
CRF 1.A.4.b (Residential)								
All fuels	**CO_2**	**L**	**T/T2**	**129,474.0**	**(10.59%)**	**101,946.5**	**(10.69%)**	**-21.26%**
All fuels	CH_4	-	-	1,200.4	(0.10%)	745.7	(0.08%)	-37.88%
All fuels	N_2O	-	-	801.9	(0.07%)	417.5	(0.04%)	-47.94%
CRF 1.A.4.c (Agriculture, forestry and fisheries)								
All fuels	**CO_2**	**L**	**T/T2**	**11,059.8**	**(0.91%)**	**6,211.5**	**(0.65%)**	**-43.84%**
All fuels	CH_4	-	-	178.5	(0.01%)	22.7	(0.00%)	-87.30%
All fuels	N_2O	-	-	41.7	(0.00%)	31.4	(0.00%)	-24.83%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
CH_4	Tier 2	NS	CS
N_2O	Tier 2	NS	CS
NO_X, CO, NMVOC, SO_2	CS	NS	CS

The source category 1.A.4 *Other* is a key category of CO_2 emissions, in terms of both emissions level and trend, in all of its sub - source categories. The sub-source category *Commercial and institutional* is also a key category of CH_4 emissions, in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-94.94%), and thus an extremely low emissions level has been attained (in 2010, emissions amounted to 1.76 % of the contribution of the smallest key category identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods required for key categories to CH_4 emissions in 1.A.4.a.

Source category 1.A.4 comprises combustion systems in the areas *Residential*, *Commercial and Institutional* and *Agriculture*, along with various mobile sources.

Heat-generation systems in small combustion systems of small commercial and institutional users are reported in sub-source category 1.A.4.a. Commercial and institutional.

1.A.4.b comprises energy inputs in households (the Residential sector). This refers primarily to combustion systems. In addition, source category 1.A.4.b includes residential mobile sources (not including road transports).

Sub-source category 1.A.4.c comprises the areas of agriculture, forestry and fisheries. Reporting under this category includes emissions from heat generation in small and medium-sized combustion systems and emissions from agricultural transports. Pursuant to the IPCC structure, 1.A.4.c also includes emissions from mobile sources in fisheries and in forestry.

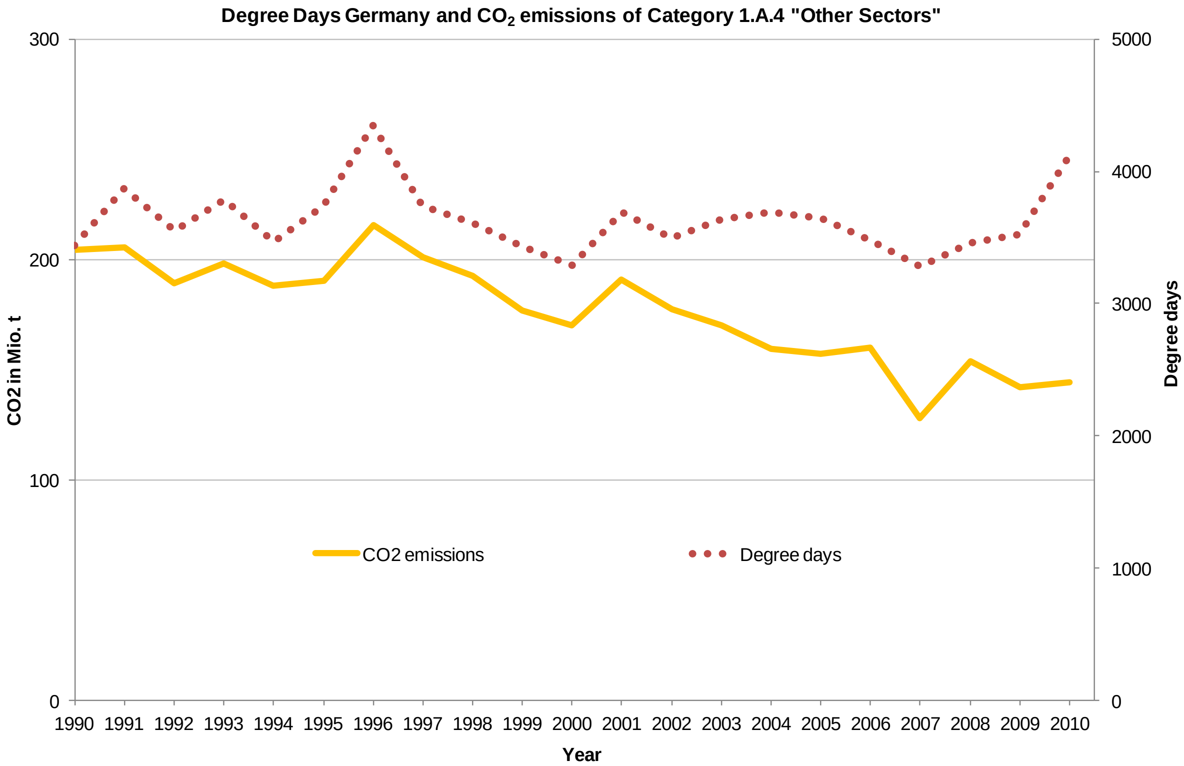


Figure 35: Change in total emissions of 1.A.4, as a function of temperature

The main driver of CO_2 emissions in 1.A.4 is energy consumption for purposes of space heating. Consequently, fluctuations in consumption can plausibly be attributed to differences in periods of winter cold. The trend toward lower CO_2 emissions is a result of higher standards for new buildings and of successful execution of energy-efficiency-oriented modernisations of existing buildings. The trend has also been boosted by shifting to fuels with lower CO_2 emissions. On the other hand, CO_2 emissions from heat pumps, which are being used more and more frequently in new buildings, are not reported here.

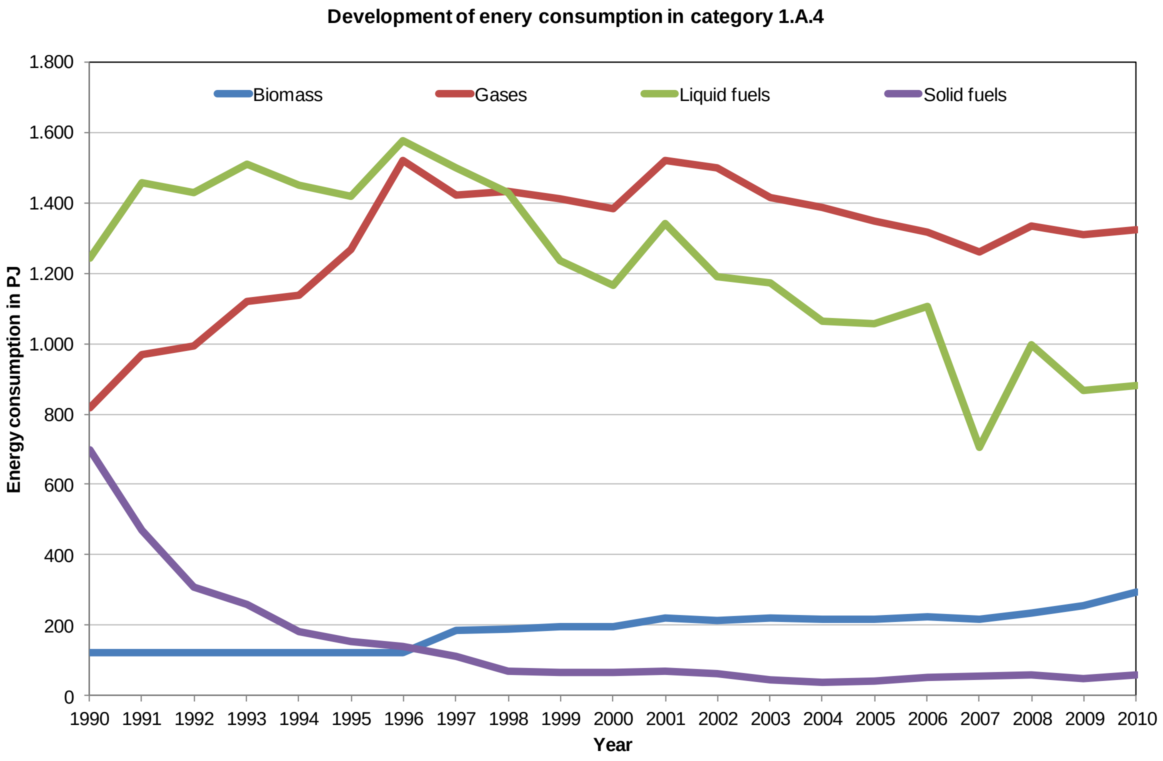


Figure 36: Trends in energy consumption in 1.A.4, for 4 fuel categories

Shifting from liquid fuels (almost exclusively heating oil) and solid fuels (mainly coal) to gaseous fuels (natural gas) and biomass has brought about considerable CO_2-emissions reductions. In 2006 and 2007, a special phenomenon occurred whereby energy consumption was first above-average and then below-average, respectively, as a result of an increase in the value-added-tax (VAT) rate from 16 % to 19 %. Very high heating-oil sales in 2006 brought about increasing CO_2 emissions, since emissions data relative to heating oil are determined on the basis of sales, rather than consumption.

The group of combustion systems in the Residential and Commercial/Institutional sectors is very diverse with regard to installation design and size. It covers a spectrum that includes individual room furnaces for solid fuels with a rated thermal output of approximately 4 kW (e.g. fireplaces, ovens), oil and gas furnaces used to generate room heat and hot water (e.g. central heating boilers), hand-fed and automatically fed wood-burning furnaces in the commercial sector and commercial/institutional users' licensable combustion systems with a rated thermal output of several megawatts, to name but a few examples. In total in 2005, more than 36.5 million combustion systems were installed in Germany in the Residential and Commercial and Institutional sectors (STRUSCHKA, 2008: p. 12). Gas-fired combustion systems accounted for a majority of these systems, or some 14.5 million, while combustion systems using solid fuels accounted for some 14.4 million systems and oil-fired furnaces accounted for some 7.9 million systems. The great majority of these systems (about 95 %) are in place in private households (STRUSCHKA, 2008).

Of the wood fuels used in households and in commerce and trade, large quantities are purchased privately or obtained from system owners' own forest parcels. For this reason, in the Energy Balance, the relevant data from the Federal Statistical Office are supplemented with data from a survey of firewood consumption in private households. Data relative to use of firewood in the source categories commercial and institutional are based on a study from the year 2000 (UBA 2000a). The consumption-level figures determined in that study have been adopted for subsequent years since then. A research project entitled "determination of consumption of biogenic solid fuels in the commercial and institutional sector" ("Ermittlung des Verbrauchs biogener Festbrennstoffe im GHD-Sektor") was carried out to determine wood-fuel activity data in the commercial and institutional sector more precisely. Since the results of that project are not yet directly usable (the project first developed methods, and provided sample calculations, for individual sectors), plans now call for a follow-on project, applying the experience gained in the first project, aimed at completing the results for other relevant sectors. The Energy Balance fuel category "Waste and other biomass" is specified in greater detail in the Satellite Balance. The information in that Balance indicates that only firewood is used in the residential sector, while only gas from wastewater treatment / biogas are used in the sector "Commercial, institutional (commerce/trade/services) and other consumers".

3.2.11.2 Methodological issues (1.A.4)

Activity data

The activity data in source category 1.A.4 are based on the Energy Balances for the Federal Republic of Germany, as prepared by the Working Group on Energy Balances (AGEB). For years prior to 1995 separate Energy Balances are used for the a) old German Länder and b) new German Länder. For years as of 1995, lines 66 (residential) and 67 (commercial and institutional and other consumers) are the standard.

The quantities of gasoline fuels listed in line 66 are all allocated to *Mobile sources in the residential sector* (sub-category *1.A.4.b (ii)*).

Since the data in Energy Balance line 67 – commercial and institutional and other consumers – also include military consumption (offices, and vehicles and aircraft), such military consumption must be deducted from the relevant positions in line 67 (cf. Chapter 3.2.12 with regard to stationary and mobile sources in the military sector).

For energy inputs in *Agricultural combustion systems (1.A.4.c (i)*), which are also included in line 67 of the Energy Balance, relevant data are available, in an existing study (UBA, 2000a), for 1995. That study provides an estimate of agricultural combustion systems' share of total energy inputs in line 67. That share is assumed to have remained constant since then.

Consumed quantities of diesel fuel and gasoline, which are also included in line 67, are allocated completely to mobile consumers (construction-sector, agricultural and military transports). The relevant share for *Agricultural transports (sub-category 1.A.4.c (ii)*) is obtained by deducting pertinent military consumption, as obtained from BAFA data (cf. Chapter 3.2.12), and by deducting construction-sector transports (cf. Chapter 3.2.10.5).

The activity data for high-seas fisheries, which are recorded under *1.A.4.c (iii) – Fisheries*, are conservatively calculated on the basis of the engine types/performance used on active German fishing vessels (EC, 2011) and a fixed consumption level of 200g of diesel fuel per kWh.

Emission factors

The basic data for the emission factors used for N_2O und CH_4, for stationary combustion systems, is provided by the research report "Efficient provision of current emissions data for purposes of air quality control" ("Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung"; STRUSCHKA 2008). Within the context of that project, device-related and source-category-specific emission factors for combustion systems in the residential and commercial/institutional sectors were calculated, with a high level of detail, for all important emissions components for the reference year 2005.

Determination of emission factors is based on a source-category-specific "bottom-up" approach that, in addition, to differentiating (sub-) source categories and fuels, also differentiates system technologies in detail. In the process, several system-specific emission factors are aggregated in order to obtain mean emission factors for all systems within the source categories in question. Use of system-specific / category-specific emission factors ensures that all significant combustion-related characteristics of typical systems for the various categories are taken into account. The procedure is in keeping with the Tier 2/3 method described in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006).

The emission factors are structured in accordance with the relevant fuels involved in final energy consumption in Germany:

- Fuel oil EL
- Natural gas,
- Lignite (briquettes from the Rhine (Rheinisch) and Lusatian (Lausitz) coal fields; imported briquettes),
- Hard coal (coke, briquettes, anthracite) and
- Wood (unprocessed wood, wood pellets, residual wood).

In addition, emission factors for combustion systems are determined in accordance with device design, age level, output category and typical mode of operation. The emissions behaviour of the combustion systems in question was determined via a comprehensive review of the literature, in an approach that distinguished between results from test-bench studies and field measurements. Transfer factors were used to take account of the fact that emissions in a test-bench environment tend to be lower than those of corresponding installed systems.

The description of the structure for installed combustion systems was prepared using statistics from the chimney-sweeping trade, as well as with the help of surveys conducted by the researchers themselves in selected chimney-sweep districts of Baden-Wuerttemberg, North-Rhine Westphalia and Saxony. Those data were used to estimate the energy inputs for various system types, to make it possible to determine sectoral emission factors weighted by energy inputs. Table 71 shows the sectoral emission factors determined.

Table 71: Sectoral emission factors for combustion systems in the residential and commercial/institutional sectors for reference year 2005

1.A.4.b (i) - Residential	**CH_4** [kg/TJ]	**N_2O**
Hard coal	129	11
Briquettes	368	9.7
Hard-coal coke	13	0.82
Lignite briquettes	55	5.2
Unprocessed wood	100	1.5
Heating oil EL	0.046	0.55
Natural gas	2.3	0.25
1.A.4.a (i) & c(i) - Commercial and Institutional		
Hard coal	100	10
Briquettes	-	-
Hard-coal coke	-	-
Lignite briquettes	-	-
Wood fuels	56	1.1
Heating oil EL	0.026	0.56
Natural gas	0.16	0.33

The emission factors for 2005 were used, without change, for subsequent years.

Table 72: Sectoral emission factors for mobile sources of the residential, agricultural-transports and fisheries sectors

1.A.4.b (ii) - Mobile sources of the residential sector	**CH_4** [kg/TJ]	**N_2O**
Petrol	37.0	3.7
1.A.4.c (ii) – Agricultural transports		
Diesel fuel	1990: 7.61 1995: 7.17 2010: 4.25	1.0
Petrol	37.0	3.7
1.A.4.c (iii) – Fisheries (here: high-seas fisheries)		
Diesel fuel	7.0	2.0

At present, constant emission factors are being used for mobile sources, for nearly all years under consideration. Country-specific EF that reflect gradually introduced emissions standards are being used solely for methane from consumption of diesel fuel in agricultural machinery and vehicles.

3.2.11.3 Uncertainties and time-series consistency (1.A.4)

Annex 2, Chapter 13.6 in the NIR 2007 describes the method used to determine the uncertainties for the **activity data**.

To date, default uncertainties pursuant to IPCC have been used for *mobile residential sources* and *agricultural transports*.

A complex procedure is required to calculate reliable emission factors in this installation sector. Apart from emission figures, it is also necessary to obtain other information; for example, one must make allowance for the relevant mode of operation (loads), installation structure and device-specific final energy consumption. In data surveys during the aforementioned research and development project, this approach was for the most part followed; nevertheless, given the sheer number of facilities concerned and the wide range of combustion systems and fuels used, the data must be assumed to have a fairly large "basic uncertainty".

For some installation types, moreover, only inadequate data or no data at all were available on emissions behaviour in connection with certain fuels. It is important to remember that the law does not require the greenhouse-gas emissions of combustion systems of residential and commercial/institutional users to be measured. When calculating the emission factors, therefore, in most cases (with the exception of CO_2, which is largely independent from furnace design) the researchers only had recourse to a few results from individual measurements on selected installations. Gaps in the data were closed via adoption of emission factors of comparable combustion systems.

The uncertainties listed for the emission factors for CH_4 and N_2O, for stationary combustion systems, were determined via expert estimation pursuant to IPCC-GPG (2000: Chapter 6). That assessment, which is based on the emissions data obtained for the aforementioned research project, was carried out in the framework of that project by experts of the University of Stuttgart's Institute of Process Engineering and Power Facility Technology (Institut für Verfahrenstechnik und Dampfkesselwesen). Uncertainties were estimated separately for all combustion technologies and fuels. The following sources of error entered into the estimates for N_2O and CH_2:

- Measuring errors in determination of pollutant concentrations;
- Uncertainties in estimating transfer factors (systematic differences between test-bench and field measurements);
- Uncertainties resulting from having too little emissions data;
- Uncertainties resulting from use of different measuring procedures;
- Uncertainties in the installation data used (overall group structure in terms of type, age and performance and fuel consumption)

In gas-fired systems, another error occurs in determination of start-up/shutdown emissions. During start-up/shutdown procedures, some partly unburned CH_4 is emitted from natural gas. Those emissions, which occur upstream and downstream from the actual combustion process, cf. Chapter 3.3.2.4 (natural gas), are a significant reason why CH_4 emission factors for gas-combustion systems are subject to high levels of uncertainties.

As to the distribution of uncertainties, a log-normal distribution is assumed for N_2O emission factors. In all likelihood, the deviations are considerably more pronounced in the vicinity of larger values than they are in the vicinity of smaller values. The emission factors for CH_4 and N_2O were determined for the year 2005, in the framework of the aforementioned research project, and are assumed to have remained constant since then.

3.2.11.4 Source-specific QA/QC and verification (1.A.4)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

For the purposes of quality assurance for data relative to *stationary combustion systems*, in the context of the aforementioned research and development project, all the input data used from literature and from the research company's own investigations were reviewed for validity. As a general principle, in description of the emissions behaviour of combustion systems, emissions data were included in subsequent calculations only if the relevant literature sources contained complete, undisputed data on the fuel used, the design of the furnace, and the furnace's operating mode during measurements. All resources of significance for inventory preparation were substantiated by the research company.

In the framework of a quality review carried out by Federal Environment Agency experts, the country-specific emission factors for CH_4 and N_2O, determined in accordance with the Tier 2 standard, were compared with the IPCC Tier 2 default factors in the IPCC Guidelines for emissions inventories (IPCC 2006). For most fuels, the values agreed well (discrepancies within one order of magnitude), although the default values for CH_4 tended to be higher than the country-specific values.

In the framework of quality assurance, calculation with the Tier 1 default values was carried out, in addition to emissions determination pursuant to Tier 2/3, for the residential and commercial/institutional sectors for the year 2005. The results are shown in Table 73.

Table 73: Emissions calculation with country-specific Tier 2/3 emission factors and with the Tier 1 default emission factors pursuant to (IPCC 2006)

	CH_4 [t]				N_2O [t]			
	Residential		Commercial and institutional		Residential		Commercial and institutional	
Emission factors	**Tier 1 default**	**Struschka 2008**	**Tier 1 default**	**Struschka 2008**	**Tier 1 default**	**Struschka 2008**	**Tier 1 default**	**Struschka 2008**
Heating oil EL	6,590	30	2,489	6.5	395	357	149	139
Fuel gases	5,290	2,459	2,496	77	106	266	50	163
Coal fuels	13,452	4,568	6	58	67	340	1	5.6
Wood	60,194	20,001	5,749	1,081	803	284	77	6.2
Total	**85,526**	**27,058**	**10,740**	**1,223**	**1,371**	**1,247**	**279**	**313.8**

The emissions for the commercial/institutional ("small consumers") sector include the emissions of the areas of agriculture, forestry and fisheries.

For N_2O, the emissions-calculation results obtained with both methods showed good agreement. Larger discrepancies were seen in determination of CH_4 emissions. Presumably, this is due to the fact that methane emissions of combustion systems depend strongly on the combustion technology used. Differences in installation structures (i.e. in sector composition), from country to country, thus manifest themselves much more strongly in total emissions (as determined) than in nitrous-oxide emissions. The default emission factor for heating oil, in particular, is very high. The technology-specific emission factor given in IPCC 2006 for boilers shows considerably better agreement with the pertinent country-specific factor for Germany.

3.2.11.5 Source-specific recalculations (1.A.4)

As a result of corrections made in the provisional Energy Balance 2009, a few slight changes in the activity data for 2009 had to be made. A significant change resulted for natural gas, for which the now-available final Energy Balance 2009 shows considerable downward corrections.

Table 74: Recalculations in CRF 1.A.4 (stationary & mobile)

Units [Gg] Year	NIR 2011 Total	NIR 2012 Total	Difference, absolute gas	liquid	solid	Total	Difference, relative Total
2009	146,052	141,800	-2,999	-633	-621	-4,252	-2.91%

For *mobile sources*, significant recalculations, with respect to the Submission 2011, were carried out solely for the year 2009. For that category and year, the Energy Balance – and, thus, the applicable activity data – were revised both for mobile residential sources (1.A.4.b ii) and for agricultural transports (1.A.4.c ii). The figures for high-seas fisheries (1.A.4.c iii) remain unchanged, however, since they are based on unchanged data for fleet size and installed engine power. The changed activity data are summarised in the following tables.

Table 75: Corrected and unchanged activity data, for 2009, for mobile sources in 1.A.4

	Units	1.A.4.b ii Petrol	1.A.4.c ii Diesel fuel	Petrol	1.A.4.c iii Diesel fuel
Submission 2012	[TJ]	3,445	51,967	2,498	878
Submission 2011		2,177	48,048	4,039	878
Absolute difference		1,268	3,920	-1,541	0
Relative difference	[%]	58	8	-38	0

Within source category 1.A.4.b ii, the above-described corrections had the following impacts on the GG emissions reported for 2009:

Table 76: Resulting recalculation of the 2009 GG emissions reported for 1.A.4.b ii

	Units	2009
Submission 2012	[Gg CO_2 equiv.]	255
Submission 2011		161
Absolute difference		94
Relative difference	[%]	58

In source category 1.A.4.c ii, corrections of the EF(CH_4) for diesel fuel, for the entire time series, were also carried out, in addition to the adjusments of the activity data for 2009. In sum, the various changes overlap, with varying impacts on the calculated emissions: For example, the CH_4 emissions for the years 1990 to 2008 have increased, because the EF for that period have been corrected upward, slightly, while those emissions decreased slightly for 2009, since the corrected EF(CH_4) for that year is slightly lower than the previously used value.

Table 77: Change in EF(CH_4) for diesel fuel in agricultural vehicles and machinery

	Units	1990	1995	2000	2005	2006	2007	2008	2009
Submission 2012	[Gg/TJ]	7.61	7.17	6.65	5.70	5.50	5.33	5.18	4.66
Submission 2011		ABL: 6.0 NBL: 8.0	7.00	6.00	5.00	5.00	5.00	5.00	5.00
Absolute difference		ABL: 1.61 NBL: -0.39	0.17	0.65	0.70	0.50	0.33	0.18	-0.34
Relative difference	[%]	ABL: 26.83 NBL: -4.88	2.41	10.82	13.92	10.07	6.65	3.69	-6.72

By contrast, CO_2 and nitrous oxide emissions have changed only for 2009. CO_2 emissions underwent a considerable upward correction, due to the above-described increase in diesel-fuel consumption, while N_2O emissions, which originate predominantly in petrol consumption, underwent a downward correction and are thus lower than they were as reported in the Submission 2011. Because CO_2 emissions predominate, the total GG emissions have changed hardly at all, with the exception of those for 2009.

The various effects, which function partly in opposite directions, on emissions reported for agricultural transports are shown in the following table.

Table 78: Resulting recalculation of the greenhouse-gas emissions reported for 1.A.4.c ii

		Units	1990	1995	2000	2005	2006	2007	2008	2009
Submission 2012	CH_4	[Gg]	0.67	0.57	0.53	0.43	0.42	0.41	0.41	0.33
	CO_2		5,061	4,509	4,389	3,814	3,878	3,847	3,916	4,025
	N_2O		0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06
	GG	[Gg CO_2 eq.]	5,100	4,544	4,422	3,843	3,907	3,875	3,945	4,051
Submission 2011	CH_4	[Gg]	0.61	0.56	0.49	0.39	0.40	0.40	0.40	0.39
	CO_2		5,061	4,509	4,389	3,814	3,878	3,847	3,916	3,846
	N_2O		0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.06
	GG	[Gg CO_2 eq.]	5,098	4,543	4,422	3,842	3,906	3,875	3,945	3,874
Absolute difference	CH_4	[Gg]	0.06	0.01	0.04	0.03	0.02	0.02	0.01	-0.05
	CO_2		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	179.14
	N_2O		*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	-0.002
	GG	[Gg CO_2 eq.]	1.32	0.20	0.75	0.69	0.51	0.33	0.19	177.43
Relative difference	CH_4	[%]	10.28	1.72	7.31	8.41	6.12	4.01	2.26	-14.08
	CO_2		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	4.66
	N_2O		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	-2.83
	GG		*0.03*	*0.00*	*0.02*	*0.02*	*0.01*	*0.01*	*0.00*	4.58

3.2.11.6 Source-specific planned improvements (1.A.4)

At present, no improvements are planned with respect to reporting on *stationary combustion systems*.

Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.4.c iii.

3.2.12 Other (1.A.5)

Source category 1.A.5 comprises the combustion-related emissions of the military sector. It is divided into the source categories 1.A.5.a *"Stationary"* and 1.A.5.b *"Mobile"*.

3.2.12.1 Source category description (1.A.5)

CRF 1.A.5	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**CO_2**	**L**	**T**	**11,811.1**	**(0.97%)**	**1,297.6**	**(0.14%)**	**-89.01%**
All fuels	CH_4	-	-	235.6	(0.02%)	4.4	(0.00%)	-98.15%
All fuels	N_2O	-	-	70.4	(0.01%)	9.4	(0.00%)	-86.71%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS/D
CH_4	CS	NS	CS/D
N_2O	CS	NS	CS/D

The source category *Other* is a key category of CO2 emissions in terms of both emissions level and trend.

The following figure shows the emissions trend as of 1990.

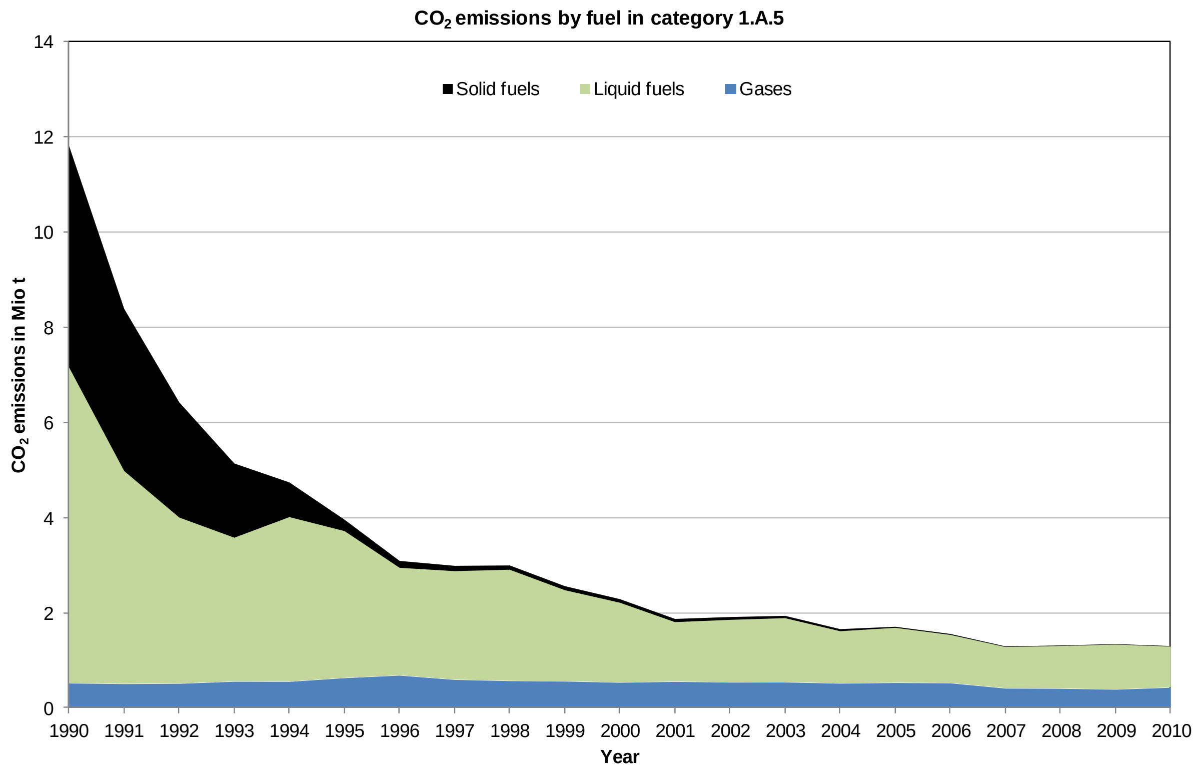


Figure 37: Development of CO_2 emissions in source category 1.A.5

A particularly large emissions reduction has occurred in source category 1.A.5. It is due a) to the closure of many military facilities and b) to marked changes in fuel inputs in stationary combustion systems. A trend is occurring in which gaseous and liquid fuels are supplanting solid fuels.

3.2.12.2 Methodological issues (1.A.5)

Activity data

The Energy Balance of the Federal Republic of Germany (AGEB) provides the basis for the activity data used. Since the Energy Balance does not provide separate listings of military agencies' final energy consumption as of 1995 – and includes that consumption only in line

67, under "commercial, institutional and other consumers" – additional sources of energy statistics had to be found for source category 1.A.5.

For source category **1.A.5.a**, use is made of data of the Federal Ministry of Defence (BMVg, 2011), which has reported the "Energy input for heat production in the German Federal Armed Forces", by fuels and for 2000-2010, to the Federal Environment Agency. Those figures are deducted from the figures in Energy Balance line 67 (commercial, institutional) and are reported in 1.A.5, rather than in 1.A.4. For the 2008 report year, use of wood in source category 1.A.5.a has been reported for the first time.

Until 1994, military fuel-consumption (diesel fuel and petrol) and aircraft-fuel-consumption (jet kerosine) data for source category **1.A.5.b** were taken from the Energy Balances. Since the Energy Balances lack separate data for the military sector for subsequent years, the official mineral-oil data for the Federal Republic of Germany, published by the Federal Office of Economics and Export Control (BAFA) (BAFA, 2011), are used for the period as of 1994. The consumption figures in that source, which are given in units of 1000 t, are converted into TJ on the basis of the pertinent listed net calorific values.

In addition, use of lubricants and the CO_2 emissions resulting from their co-combustion are recorded. For all years as of 1993, the underlying data on domestic deliveries to military agencies have been taken from the official mineral-oil data of the Federal Office of Economics and Export Control (BAFA). They are converted to TJ via a net calorific value of 40 GJ/t. For the years 1990 through 1992, extrapolation has been carried out on the basis of trends in fuel inputs. To date, a conservative estimate has been applied whereby 50 % of the input quantities are co-combusted and thus produce CO_2 emissions.

In the present report, inputs of lubricants, and the CO_2 emissions resulting from co-combustion of lubricants, are being included for the first time. For all years as of 1993, the underlying data on domestic deliveries to military agencies have been taken from the official mineral-oil data of the Federal Office of Economics and Export Control (BAFA). For the years 1990 through 1992, extrapolation has been carried out on the basis of trends in fuel inputs.

Emission factors

The database for the emission factors used for source category **1.A.5.a** consists of the results of a research project carried out by the University of Stuttgart, under commission to the Federal Environment Agency (STRUSCHKA, 2008). Within that project, device-related and source-category-specific emission factors for combustion systems in military agencies were calculated, with a high level of detail, for all important emissions components for the reference year 2005. The method used to determine the factors conforms to the procedure described for source category 1.A.4. Table 79 shows the sectoral emission factors used.

With regard to the CO_2 emission factors used for the military transports considered under **1.A.5.b**, the reader's attention is called to the documentation in Annex Chapter 18.6 on "*CO_2 emission factors*". In general, the same country-specific values are used in this context that are used for the road-transport sector (diesel fuel, gasoline) and for the civil aviation sector (jet kerosene, avgas). For methane and nitrous oxide, country-specific values are also used for ground transports and for use of avgas. For jet kerosene, IPCC default figures are used, in light of the fact that the aircraft used by the sector differ strongly from those used in civil aviation. The same applies to calculation of CO_2 emissions from co-combustion of lubricants. The emission factors for methane and nitrous oxide from co-combustion of lubricants are already taken into account in the relevant emission factors for the fuels used. The emissions themselves are thus included in quantities calculated for the various fuels, and they are reported here as "IE" (included elsewhere).

Table 79: Sectoral emission factors for the military sector

Military	CH_4	N_2O
	[kg/TJ]	
- Stationary combustion in offices		
Hard coal	2.0	4.8
Lignite briquettes	242	0.37
Heating oil EL	0.017	0.56
Natural gas	0.042	0.29
- Military transports		
Diesel fuel	6.0	1.0
Petrol	37.0	3.7
Kerosene	0.5	2.0
Avgas	8.2	2.3
Lubricants	IE	IE

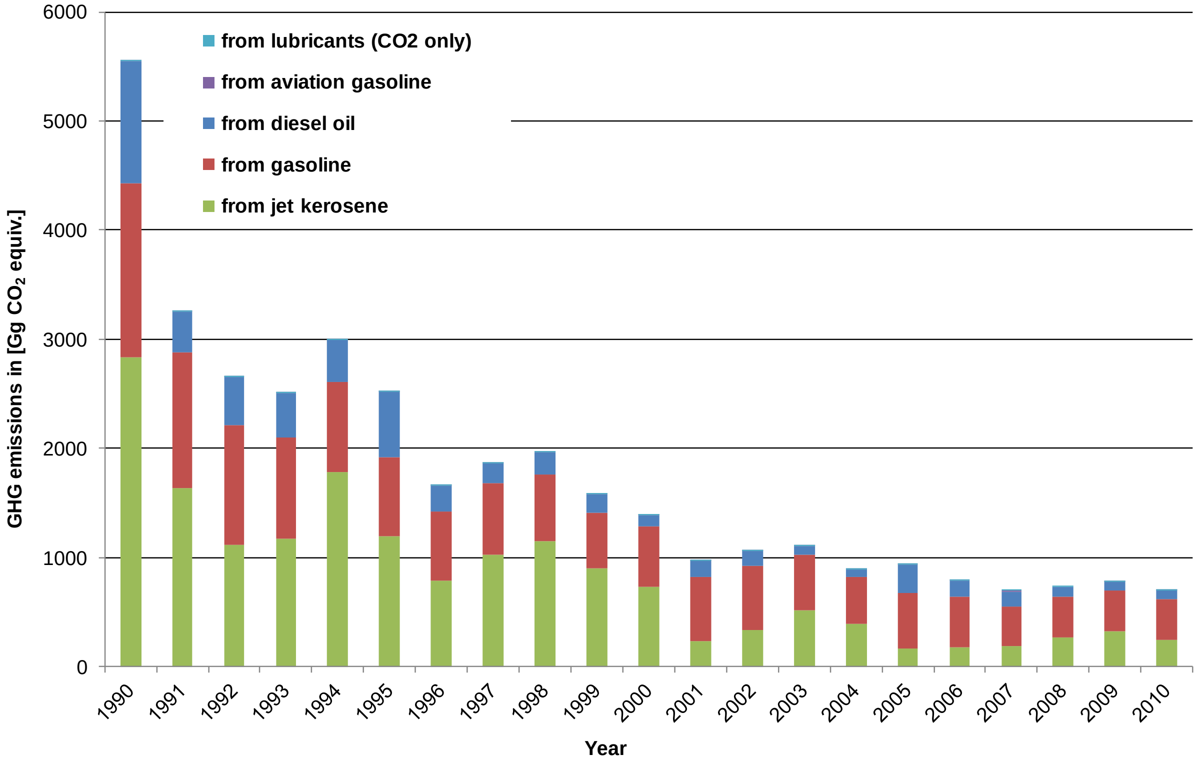


Figure 38: Development of greenhouse-gas emissions in military transports, 1990 – 2010

3.2.12.3 Uncertainties and time-series consistency (1.A.5)

Information regarding the uncertainties for the emission factors is provided in the description for source category 1.A.4. Annex 2 Chapter 13.6 in the NIR 2007 describes how the uncertainties for the activity data were determined.

3.2.12.4 Source-specific quality assurance / control and verification (1.A.5)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

In addition, the implied emission factors (IEF) for military transports were compared with those of other countries. The country-specific emission factors for CO_2 compare well with the IPCC default figures and with the values used by other countries. Such comparisons are extremely difficult to carry out for methane and nitrous oxide, however, due to this source category's highly heterogeneous composition.

Since no other sources of data for Germany are known, it is currently not possible to verify the emissions reported here via comparison.

3.2.12.5 Source-specific recalculations (1.A.5)

No recalculations are required in the category **1.A.5.a Stationary**.

For **military transports (1.A.5.b Mobile)**, minimal recalculations with regard to the 2011 report were carried out to take account of very minor corrections (fractions of 1%) in the activity data for kerosene and avgas.

Table 80: Correction of the activity data for avgas, 1995 - 2008

	Units	1995	2000	2005	2006	2007	2008
Submission 2012	[TJ]	6.350	1.090	0.260	2.480	14.840	0.000
Submission 2011		6.353	1.088	0.261	2.480	14.839	0.000
Absolute difference		-0.003	0.002	-0.001	0.000	0.001	0.000
Relative difference	[%]	-0.053	0.193	-0.420	-0.017	0.007	0.000

Table 81: Correction of the activity data for kerosene, 1995 - 2008

	Units	1995	2000	2005	2006	2007	2008
Submission 2012	[TJ]	16,143	9,862	2,200	2,441	2,554	3,597
Submission 2011		16,143	9,862	2,200	2,441	2,554	3,597
Absolute difference		-0.240	0.000	0.000	0.000	0.002	-0.002
Relative difference	[%]	-0.0015	0.0000	0.0000	0.0000	0.00006	-0.00004

Table 82: Resulting recalculation of GG emissions, 1995 - 2008

	Units	1995	2000	2005	2006	2007	2008
Submission 2012	[Gg CO_2 equiv.]	2,518	1,384	930	784	691	734
Submission 2011		2,518	1,384	930	784	691	734
Absolute difference		-0.0180	0.0001	-0.0002	0.0001	0.0000	-0.0002
Relative difference	[%]	-0.0007	0.00001	-0.00002	0.00001	0.00000	-0.00003

3.2.13 Military

Emissions from international deployments by the Federal Armed Forces, under a UN mandate, are not recorded as a separate activity for purposes of German emission inventories. Such recording will be again be a matter for discussion in the framework of the National Emissions Reporting System. For various reasons, the relevant required activity data are not provided.

This practice does not lead to any omissions in the inventories, since the fuel inputs associated with such deployments are included in national military consumption figures.

The basis for activity data for military fuels consists of the Official Mineral Oil Statistics for the Federal Republic of Germany (BAFA, 2011).

In the CSE, source category 1.A.5 includes, under stationary sources, heat production of military agencies; under mobile sources, it includes military transports and aviation.

3.3 Fugitive emissions from fuels (1.B)

During all stages of fuel production and use, from extraction of fossil fuels to their final use, fuel components can escape or be released as fugitive emissions.

While methane is the most important emission within the source category "solid fuels", fugitive emissions of oil and natural gas also include substantial amounts of carbon dioxide and NMVOC. Source category 1.B. is not a source for fluorinated gases.

Carbon dioxide emissions have decreased by 3 % with respect to 1990. The important factors in this development include processing of acid gas (1.B.2.b.ii) and flaring (1.B.2.c).

Emissions of **nitrous oxide** originate in flaring (1.B.2.c) in oil and gas production, and in gas processing. They are very low. As a result of improvements in extraction equipment, emissions decreased by 80 % with respect to 1990.

Methane emissions have been influenced primarily by sharp emissions decreases in the area of active mining (1.B.1.a) – caused mainly by reduced mining activity – and by increasing use of methane from decommissioned mines (1.B.1.c). With respect to 1990, methane emissions in category 1.B have decreased by over 67 %.

Emissions of volatile organic compounds (**VOC**) have decreased by nearly 66 % since 1990. The decrease is due to implementation of the Technical Instructions on Air Quality Control (TA-Luft 2002), to decreases in emissions from petrol storage and from fuelling of motor vehicles (1.B.2.a.v) – as a result of implementation of the 20th and 21st Ordinances on the Execution of the Federal Immission Control Act (BimSchV) – and to reduced petrol consumption. Figure 39 shows trends for non-methane-containing volatile organic compounds (**NMVOC**).

Sulphur dioxide emissions have decreased by over 73 % since 1990. The sharp reductions in such emissions seen especially at the beginning of the 1990s were due especially to closures in the eastern German industrial sector, to use of improved filters and to switching from lignite to other fuels. In subsequent years, decreasing production of hard-coal coke (1.B.1.b) and improved filter technologies in desulphurisation of natural gas (1.B.2.b.ii) had the largest effects on emissions.

Carbon monoxide emissions have decreased by nearly 90 % since 1990, primarily as a result of decreasing production of hard-coal coke (1.B.1.b) and discontinuation of city-gas deliveries via the public gas-distribution network (1.B.2.b.iv).

Additional details relative to sulphur dioxide, carbon monoxide and NMVOC are described in the "Informative Inventory Report", available at iir.umweltbundesamt.de. Those details are not presented in the present report, since those gases are not greenhouse gases.

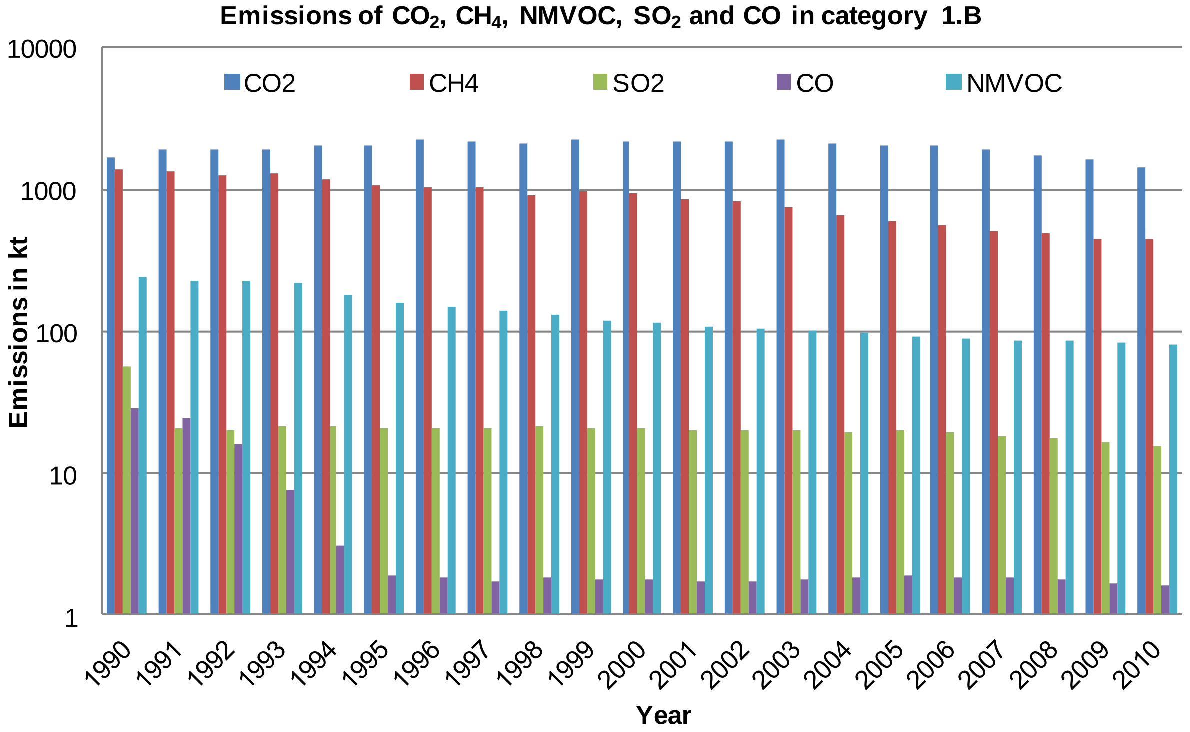


Figure 39: Emissions of CO_2, CH_4, NMVOC, SO_2 and CO in source category 1.B[27].

3.3.1 *Solid fuels (1.B.1)*

The source category "Solid fuels" (1.B.1) consists of three sub-source categories – the source category "Coal mining" (1.B.1.a), the source category "Coal transformation" (1.B.1.b) and the source category "Other" (1.B.1.c).

Table 83 presents the scheme for source category allocation and the relevant calculation methods (Table 84).

[27] For the sake of clarity, N_2O emissions are not included here. They decreased from 3,555kg in 1990 to 2,914kg in 2009.

Table 83: Allocation of methane emissions to areas of the CRF

Source category			Included emissions
1.B.1.a. Coal mining			
	i.	**Underground mining**	
		Mining activities	Emissions from active underground hard-coal mining. The total emissions from pit gas flows and pit-gas removal are reduced by the amount of pit gas used.
		Follow-up mining activities	Emissions from processing, storage and transport of hard coal
	ii.	**Open-pit mining**	
		Mining activities	Emissions from active open-pit lignite mining. Here, the entire potential methane content of German lignite is used as the basis – this methane is assumed to be emitted, in its entirety, during mining. Any later emissions of methane, during further processing, are thus already taken into account. No pit-gas collection or use takes place in open-pit mining.
		Follow-up mining activities	No separate listing – the emissions are already included in "mining activities"
1.B.1.b. Coal transformation – processing			Emissions from coal processing. This area takes account of specific emissions that occur in hard-coal processing (hard-coal coke, hard-coal briquettes). Emissions from lignite processing (lignite coke, coal dust, dry coal, fluidised-bed coal, lignite briquettes, lignite granulate) are already included in 1.B.1.a.ii "Mining activities". The assumed activity data cover the total for all processed products from hard coal and lignite.
1.B.1.c. Other			
		Decommissioned coal mines	Methane emissions for decommissioned hard-coal mines are listed here. No methane emissions from decommissioned lignite mines are recorded. Specification of activity data is not required.

In keeping with allocation of emissions to the various areas of the CRF table for "1.B.1 – Fugitive emissions from solid fuels", the following Table 84 presents calculated values for 2010 activity data, along with information regarding the origin of the data.

Table 84: Calculation of methane emissions from coal mining for 2009

			Activity data [Mt]	CH_4 emissions [Gg]
1.B.1.a. Coal mining			**182.30** (= 1.B.1.a.i + 1.B.1.a.ii)	(= 1.B.1.a.i + 1.B.1.a.ii) 129.88 + 1.86 **= 131.84**
	i.	**Underground mining**	**12.900**[28] Hard-coal production 1)	= **mining and follow-up mining-related activities** = 122.55 + 7.43 **= 129.98**
		Mining activities		= AD * EF = 12.900 * 9.5 **= 122.55**
		Follow-up mining activities		**= 7.43**
	ii.	**Open-pit mining**	**169.4** Lignite mining 1)	= **mining activities** **= 1.86**
		Mining activities		= AD * EF = 169.4 * 0.011 **= 1.86**
		Follow-up mining activities		(included in 1.B.1.a.ii) IE
1.B.1.b. Coal transformation – processing			**14.40** Total for processed products 2) 1)	$AD_{hard\text{-}coal\ prod.} * EF_{hard\text{-}coal\ prod.}$ + $AD_{lignite\ prod.} * EF_{lignite\ prod.}$ = 8.15 * 0.049 + 6.25 * 0 **= 0.40**
1.B.1.c. Other				= **Decommissioned coal mines** **= 0.7**
		Decommissioned coal mines	**NO**	Potential emissions, minus gas usage **= 0.7**

1) pursuant to STATISTIK DER KOHLENWIRTSCHAFT (n.y.)
2) Hard-coal coke, hard-coal briquettes, lignite coke, coal dust, dry coal, fluidised-bed coal, lignite briquettes, lignite granulate

3.3.1.1 Coal mining and handling (1.B.1.a)

3.3.1.1.1 General description of the source category Coal mining and handling (1.B.1.a)

CRF 1.B.1.a	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Solid fuels	**CH_4**	**L**	**T/T2**	18,415.2	(1.51%)	2,769.9	(0.29%)	-84.96%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	AS	CS

The source category *Coal production* is a key category of CH_4 emissions in terms of emissions level and trend.

For the source category Coal mining and handling (1.B.1.a), the only truly significant emissions tend to be those from ongoing extraction (coal-seam methane, CSM). Emissions from hard-coal processing are listed in source category 1.B.1.b, while emissions from decomissioned hard-coal mines (coal-mine methane, CMM) are listed in source category

[28] Not including small mines

1.B.1.c. This breakdown applies only to hard coal. For lignite, the chosen calculation procedure places all emissions in 1.B.1.a(ii).

During coal production, transport and storage, methane can escape from coal and the rock surrounding it. The amount of methane released depends primarily on the amount of methane stored in the coal. All of the emissions that result from this relationship – but not the greenhouse gases caused by coal combustion – are to be recorded in this source category.

In the mining sector, a distinction is made between open-pit mines, in which raw materials are extracted from pits open to the surface, and closed-pit mines, in which seams are mined underground. In Germany, hard coal is mined in 3 coal fields (Reviere), in a total of 5 mines (all closed-pit), while lignite is mined in 4 coal fields, primarily with the open-pit method (11 pits; since 2003 all lignite mining has been open-pit).

In underground coal mining, ventilation systems are used to keep mine methane concentrations within safe limits for mining. Such systems can emit significant amounts of methane into the atmosphere as they ventilate the air and gas mixtures prevailing in underground mines. Hard-coal mining is the principal source of fugitive emissions of CH_4. Some methane is suctioned off directly from seams and ancillary rocks and used, as pit gas.

Since mid-2009, a fraction of non-usable pit gas has been converted into CO_2, via combustion in a high-temperature flare. In 2010, that JI project combusted 0.26 Gg CH_4, thereby preventing about 0.2 Gg of CH_4 emissions.

Hard-coal production in 2010 amounted to some 13 million t of marketable production. Lignite production in 2010 totalled 170 million t (STATISTIK DER KOHLENWIRTSCHAFT, n.y.). As a result, hard-coal production decreased by about 6 % from the previous year, while lignite production decreased by about 0.3 %.

Methane emissions from hard-coal mining have decreased since 1990 as a result of decreasing production and increasing use of pit gas. Emissions from open-pit lignite mining have also decreased, also as a result of production decreases.

3.3.1.1.2 Methodological issues (1.B.1.a)

For calculation of CH_4 emissions from coal mining, emissions are determined for the areas of underground hard-coal mining, pit-gas use, hard-coal storage and open-pit lignite mining.

Emissions from underground hard-coal mining are calculated pursuant to the Tier 3 method, in a procedure that meets requirements pertaining to mine-specific emissions determination. For safety reasons, gas compositions and air flows are measured continuously in all pit systems. The resulting data is used to determine levels of methane emissions. The association of the German hard-coal mining industry (Gesamtverband Steinkohle) aggregates the individual measurements to determine total methane amounts. It then makes the resulting statistics available for the inventory (STATISTIK DER KOHLENWIRTSCHAFT,, n.y.). Expert review is carried out by the competent state supervisory authority (the mining authority – Bergamt).

An implied emission factor (IEF) of 9.5 kg/t (2010) has been derived from the total methane emissions figures and from the relevant activity data for hard-coal mining. This calculation takes pit-gas usage into account. The measurements show only actually emitted methane amounts.

For calculation of CH_4 emissions from hard-coal storage, the activity data for hard-coal production is used as a basis and then multiplied by the emission factor of 0.576 kg/t. That emission factor has been taken from a study of the Fraunhofer Institute for Systems and Innovation Research (FhG-ISI) (1993).

Emissions from open-pit lignite mining have been calculated, in keeping with the Tier 2 approach, pursuant to the relevant equation in the IPCC Reference Manual (IPCC, 1996b).

The activity data (crude lignite) have been taken from the STATISTIK DER KOHLENWIRTSCHAFT (n.y.). According to the DEBRIV German lignite-industry association (Deutscher Braunkohlen-Industrie-Verein e.V; DEBRIV 2004), an average emission factor of 0.015 m^3 CH_4/t (corresponds to 0.011 kg CH_4/t) is assumed. This emission factor is based on a 1989 study of RWE Rheinbraun AG (DEBRIV, 2004) and is documented by publications of the Öko-Institut e.V. Institute for Applied Ecology and of the DGMK (German Society for Petroleum and Coal Science and Technology; research report / Forschungsbericht 448-2, 1992). This value is considerably lower than the emission factor used prior to 2005, 0.11 m^3 CH_4/t, which was derived from the EF for American hard lignite. Such American EF cannot be applied to German soft lignite, since the latter's temperature did not exceed 50°C during the coalification process. Significant methane releases occur only at temperatures above 80°C.

No lignite storage takes place; usage is "mine-mouth", i.e. extracted coal is moved directly to processing and to power stations.

3.3.1.1.3 Uncertainties and time-series consistency (1.B.1.a)

The uncertainties in the activity data result primarily from inaccuracies in weighing of extracted coal. Via surveys of experts carried out during the NASE workshop of 11/2004, the relevant error has been quantified as <3 %.

Uncertainties in calculation of methane releases result from inaccuracies in methane measurements. As a result of the facts that underground measurements of methane concentrations are carried out primarily for safety reasons, and that their most precise measurement range does not fall within the range of common gas-release concentrations, the available measuring equipment can be expected to have a technical measurement inaccuracy of about 10 %.

Methane releases from hard coal, during storage and transport, fluctuate considerably in keeping with storage duration and grain-size distribution. An uncertainty of 15 % is assumed (LANGE 1988 / BATZ 1995, along with information communicated personally at the NASE workshop 11/2004).

The emission factor used for calculating methane emissions from lignite production is based on maximum methane content levels and thus represents the upper limit of possible methane emissions. It thus already includes possible emissions from transport and storage. Numerous studies have shown that a negative uncertainty of - 33 % must be assumed (DEBRIV / DGMK research report / Forschungsbericht 448-2, DGMK 1992).

Apart from the emission factor for pit-gas release from underground hard-coal mining, the emission factors are consistent in the time series, within the meaning of comparability throughout the time series. For the activity data, a consistent source is used throughout the entire time series.

3.3.1.1.4 Source-specific quality assurance / control and verification (1.B.1.a)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity.

For underground hard-coal mining, the IPCC Reference Manual (1996b) recommends emission factors on the order of 10 to 25 m³/t. Conversion of the German emission factors, using a conversion factor of 0.67 Gg/10^6 m³ (pursuant to IPCC Reference Manual, 1996b: at 20° C, 1 atmosphere) yields the individual values listed in Table 85. When production, storage and deductable pit-gas use are combined in one emission factor, the resulting value per tonne of coal (marketable production) lies within the recommended range.

Table 85: Emission factors for CH_4 from coal mining, for 2009

Emission factors	Hard coal (Steinkohle) EF m^3 CH_4/t	Hard coal (Steinkohle) EF kg/t	Lignite (Braunkohle) EF m^3 CH_4/t	Lignite (Braunkohle) EF kg/t
CH_4 from extraction	20.62	13.82	0.016	0.011
CH_4 from extraction, minus pit gas used	14.18	9.5	-	-
CH_4 from storage	0.87	0.58	-	-
CH_4 from mining (extraction and storage, minus pit-gas used)	15.05	10.08	0.016	0.011

The IPCC Reference Manual (1996b) does not recommend any specific emission-factor levels for open-pit lignite mining.

In the framework of verification for the 2005 report, various data sources for activity data in coal mining, and the relevant EF used, were compared with the corresponding sources and EF of other countries.

A by-country comparison of specific emission factors for underground coal mining shows a broad range, with Germany in the lower part of the range, in a position comparable to that of the Czech Republic. France's EF lies considerably higher within the range, while Poland's is considerably lower. Both of these countries' EF lie outside of the UNFCCC's default values.

A by-country comparison of specific emission factors for open-pit coal mining shows that Poland, France (where production was discontinued in 2002) and Germany have relatively low emission factors that are below the default values. The reason for this is that the relevant coal in these countries has very low methane content, as a result of its degree of coalification and its geological history. Consequently, suitably low emission factors have to be applied to it. The comparison value for the Czech Republic is considerably higher, since its coal is not the "lignite" found in Germany, which has a low degree of coalification; instead, its coal is largely "sub-bituminous coal", which has a higher degree of coalification and higher methane content.

3.3.1.1.5 Source-specific recalculations (1.B.1.a)

No recalculations are required.

3.3.1.1.6 Source-specific planned improvements (1.B.1.a)

No improvements are planned at present.

3.3.1.2 Solid fuel transformation (1.B.1.b)

3.3.1.2.1 Source category description (1.B.1)

1.B.1.b.	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Solid fuels	CH_4	-	-	18.1	(0.00%)	8.4	(0.00%)	-53.52%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	CS	AS	CS
CO, NMVOC, SO_2	CS	AS	CS

The source category *Solid fuel transformation* is not a key category.

3.3.1.2.2 Methodological issues (1.B.1.b)

The IPCC Reference Manual does not describe any methods for this source category (IPCC 1996b, p.1.110f). The country-specific method that is used is based on activity data from the STATISTIK DER KOHLENWIRTSCHAFT (n.y.) and on corresponding emission factors.

Production of low-temperature lignite coke took place solely in the new German Länder and, for purposes of the inventory, is of relevance only for the base year. Production was discontinued after 1992.

The majority of emission factors for non- greenhouse gases from coking plants have been obtained from BFI (2012). The emission factors for fugitive sources, as provided by that data source, have been allocated, by definition, to source category 1.B.1.b. That data source's emission factors for contained sources have been allocated to source category 1.A.1.c, however, since those emissions result primarily from bottom-heating of coke ovens. For some gases – including CO, for example – emissions from coking plants are calculated in both source categories. For CO, a methods change was made with respect to the Resubmission 2010, because the previously used emission factors considerably overestimated the actual emissions and did not correctly reflect the emissions' origin. For example, until the Resubmission 2010, higher CO emissions were reported in 1.B.1.b than were reported in 1.A.1.c., and yet the CO emissions from fugitive sources, pursuant to BFI (2012), are lower, by a factor of about 55, than emissions from bottom-heating (1.A.1.c). In addition, use of the emission factors determined by the BFI yields ebenfalls 3 % to 22 % lower values for emissions from bottom-heating, for the years 1990 to 2007 (cf. Chapter 3.2.8.5).

Calculation procedure

Emissions from hard-coal-coke production have been calculated pursuant to the Tier 2 approach, in a manner similar to that of the IPCC Reference Manual's equation for CH_4 emissions from coal mining:

$$\text{Emissions [Gg CH}_4\text{]} =$$

$$\text{EF [m}^3\text{ CH}_4\text{ /t] * AD}_{\text{transformation product}}\text{* conversion factor [Gg/10}^6\text{m}^3\text{]}$$

The activity data for hard-coal-coke production have been taken from the publication STATISTIK DER KOHLENWIRTSCHAFT (n.y.).

The methane emission factor used for calculation of CH_4 emissions from hard-coal-coke production (coking plants) is 0.049 kg methane per tonne of hard-coal coke (DMT 2005). It is used for the entire time series.

In the CSE, the source category "coal transformation" is covered by the time series for hard-coal-coke production (coking plants).

No emissions are to be expected from processed lignite products, since the EF used for 1.B.1.a corresponds to the gas content of the lignite occurring in Germany.

3.3.1.2.3 Uncertainties and time-series consistency (1.B.1.b)

The emission factors remain at the same level in the time series and are thus consistent within the meaning of comparability throughout the time series. For the activity data, a consistent source is used throughout the entire time series.

3.3.1.2.4 Source-specific quality assurance / control and verification (1.B.1.b)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity.

In consideration of emission factors, the IPCC conversion factor of 0.67 $Gg/10^6m^3$ at 20°C and 1 atmosphere (IPCC et al; 1996, Reference Manual, p. 1.108) should be applied to the units used in Germany: normal cubic metres at 1.01325 bar and 0°C (DIN 2004, DIN No. 1343). The German practice of using normal cubic metres should also be noted in consideration of the IPCC default EF, and of figures from other published sources. In use of EF data published in Germany, it is assumed that the relevant figures use normal cubic metres (substantiated via survey of experts at the NaSE workshop 11/2004)

The guideline figures are oriented to 20°C and 1,013 mbar. In keeping with methane's isobaric proportionality, the factor 1.07 can be used to convert Nm^3 into m^3.

Conversion factor, normal cubic metres ⇔ kilogrammes:

0.717 Nm^3/kg (1.01325 bar, 0°C) **= 0.67 $Gg/10^6m^3$** (20°C, 1 atmosphere) *** 1.07 Nm^3/m^3**

3.3.1.2.5 Source-specific recalculations (1.B.1.b)

As a result of the methods change with respect to the Resubmission 2010, as described in Chapter 3.3.1.2.2, the CO emissions from coking plants reported in 1.B.1.b were recalculated. In the interest of transparency, the following Table 86 directly juxtaposes the changes in CO emissions from coking plants in the two important source categories (1.B.1.c and 1.A.1.c). While the CO emissions from coking plants reported in 1.B.1.b have decreased to 0.9% – 1.5% of the corresponding values from the Resubmission 2010, the CO emissions from coking plants reported overall have decreased by only 55% – 67% (cf. Chapter 3.2.8.5).

Table 86: Recalculation of CO emissions (1.B.1.c)

	1 A 1 c (Total for all fuels)	1 B 1 b (product-related EF)	Total	1 A 1 c (product-related EF)	1 B 1 b	Total	1 A 1 c	1 B 1 b	Total
1990	17,063	28,128	45,191	14,556	264	14,820	-2,507	-27,864	-30,371
1991	14,768	22,788	37,556	13,013	236	13,249	-1,755	-22,552	-24,307
1992	13,871	19,148	33,018	12,196	221	12,417	-1,675	-18,927	-20,602
1993	11,368	13,890	25,258	10,001	181	10,182	-1,367	-13,709	-15,076
1994	10,442	10,919	21,361	9,041	164	9,205	-1,401	-10,755	-12,156
1995	11,346	11,102	22,448	9,192	167	9,359	-2,153	-10,935	-13,089
1996	11,014	10,662	21,676	8,828	160	8,988	-2,186	-10,502	-12,688
1997	10,759	10,744	21,503	8,896	161	9,057	-1,863	-10,583	-12,446
1998	10,207	10,280	20,487	8,512	154	8,666	-1,695	-10,126	-11,821
1999	8,543	8,568	17,111	7,094	129	7,223	-1,449	-8,439	-9,888
2000	9,448	9,115	18,563	7,547	137	7,684	-1,901	-8,978	-10,879
2001	7,760	7,265	15,025	6,015	109	6,124	-1,744	-7,156	-8,900
2002	7,689	7,226	14,915	5,983	108	6,092	-1,706	-7,118	-8,824
2003	6,703	7,827	14,530	6,481	117	6,598	-222	-7,710	-7,932
2004	7,357	8,462	15,819	7,007	127	7,133	-351	-8,335	-8,686
2005	7,311	8,397	15,708	6,953	126	7,079	-358	-8,271	-8,629
2006	7,219	8,370	15,589	6,930	126	7,056	-289	-8,244	-8,533
2007	7,720	8,441	16,161	6,989	127	7,116	-731	-8,314	-9,045

3.3.1.2.6 Source-specific planned improvements (1.B.1.b)

No improvements are planned at present.

3.3.1.3 Other (1.B.1.c)

3.3.1.3.1 Source category description (1.B.1.c)

1.B.1.c.	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Solid fuels	**CH_4**	**-**	**T**	**1,806.8**	**(0.15%)**	**15.1**	**(0.00%)**	**-99.17%**

Gas	Method used	Source for the activity data	Emission factors used
CH_4	CS	AS	CS
CO, NMVOC, SO_2	CS	AS	CS

The source category *Other* is a key category of CH_4 emissions from solid fuels in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-99.17 %), and thus an extremely low emissions level has been attained (in 2010, emissions amounted to 0.43 % of the contribution of the smallest key category identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

Emissions from decommissioned hard-coal mines play a significant role in this sub-source category. As well as active mines, decommissioned hard coal mines (degassing) represent another relevant source of fugitive CH_4 emissions.

When a hard-coal mine is decommissioned, methane can escape from neighbouring rock, and from coal remaining in the mine, into the mine's network of shafts and passageways. Since the mine is no longer artificially ventilated, the methane collects and can then reach the surface via gas pathways in the overlying rock or via the mine's own shafts and passageways.

Such pit gas was long seen primarily as a source of danger (in active hard-coal mines) and as a negative environmental factor (in decommissioned hard-coal mines). Recently, increasing attention has been given to the gas' positive characteristics as a fuel (use for energy recovery). In the past, use of pit gas was rarely cost-effective (as shown by the example of the state of North Rhine – Westphalia). This situation changed fundamentally in 2000 with the Renewable Energy Sources Act (EEG). Although pit gas is a fossil fuel in finite supply, its use supports climate protection, and thus the gas was included in the EEG. The Act requires network operators to accept, and provide specified compensation for, electricity generated with pit gas and fed into the grid. As a result, the $AD_{CMM\ collection}$ increased from 1.429 million m³ in 1998 to 255.4 million m³ in 2010. The reason for the lower rate of pit-gas use, with respect to the previous year, is that the production of such gas dropped.

The following figure highlights the law's impacts on actual emissions. Such emissions have been decreasing considerably since 2000, primarily as a result of steadily increasing use of pit/mine gas from decommissioned mines. The gas quantities being used from active mines have been decreasing, since the sector's gas production has been decreasing as decommissioning of numerous mines has continued. In qualitative terms, the gas quantity being used is still very high.

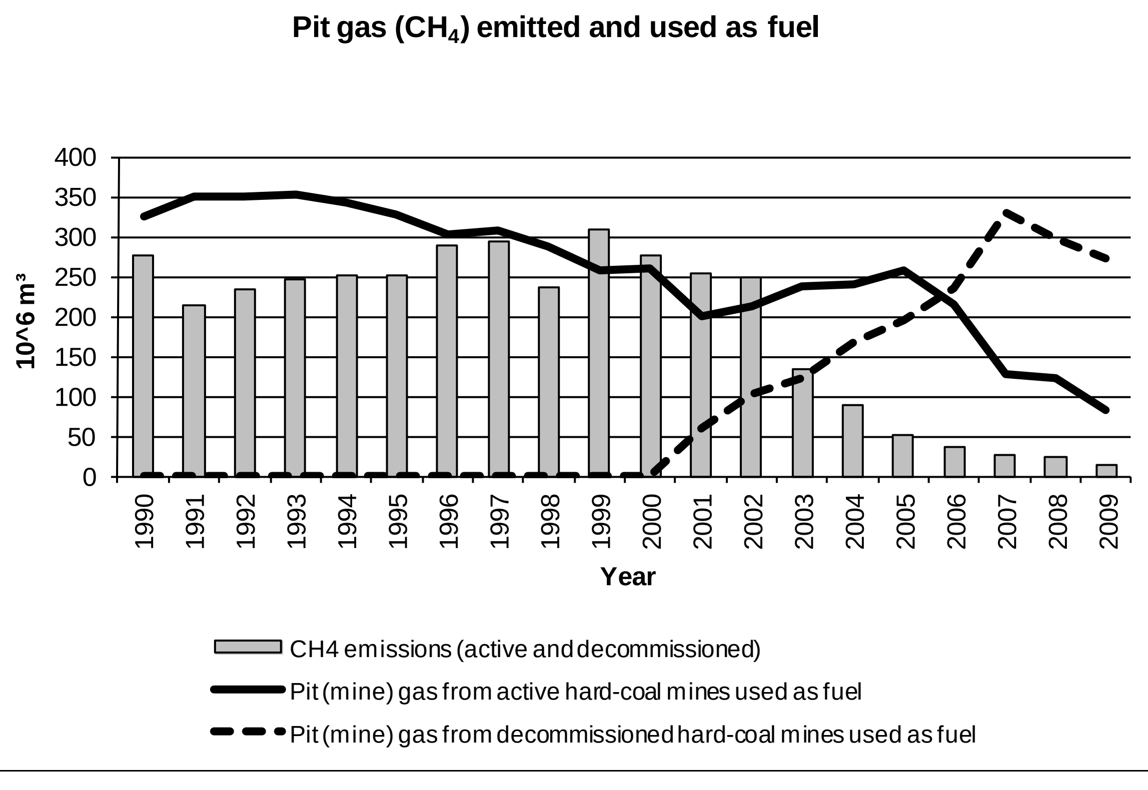


Figure 40: Comparison of used and emitted CH_4 from pit gas

In emissions reporting, quantities of pit gas used must be determined separately from released quantities of CH_4, must be broken down by active and decommissioned mines and must then be listed in source category 1.A. as energy production with relevant emissions (i.e. must be suitably balanced).

3.3.1.3.2 Methodological issues (1.B.1.c)

The IPCC Reference Manual does not describe any methods for the sub-source category "Other" (IPCC et al, 1996, Reference Manual, p.1.110f).

As well as active mines and coal processing, decommissioned hard-coal mines (degassing) represent another relevant source of fugitive CH_4 emissions.

No emissions are to be expected from decommissioned open-pit lignite mines, since the EF used for 1.B.1.a corresponds to the gas content of the lignite occurring in Germany. Lignite that remains in decommissioned open-pit mines does not continue to release gas (DEBRIV).

This source category is subdivided into the following sub-areas:

- Underground mines, decommissioned hard-coal mines
- Decommissioned hard-coal mines, with pit-gas use

3.3.1.3.3 Uncertainties and time-series consistency (1.B.1.c)

It is quite practicable to determine the quantities of methane used; an uncertainty of < 3 % due to measurement inaccuracies is assumed. The total quantities of available methane in question have been estimated solely on the basis of experts' knowledge. In this area, an uncertainty of 50 % has been assumed.

The time series for potential methane emissions and amounts of methane used both originate from reliable sources and are consistent throughout.

3.3.1.3.4 Source-specific QA/QC and verification (1.B.1.c)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity.

In consideration of emissions, it must be noted that the IPCC conversion factor is 0.67 Gg/106 m3 at 20°C and 1 atmosphere (IPCC Reference Manual, 1996b: p. 1.108), while figures in Germany are given in normal cubic metres at 1.01325 bar and 0°C (DIN 2004, DIN No. 1343). Users of emissions data published in Germany should assume that the relevant figures are in normal cubic metres.

The IPCC Guideline figures are oriented to 20°C and 1,013 mbar. In keeping with methane's isobaric proportionality, the factor 1.07 can be used to convert Nm^3 into m^3.

3.3.1.3.5 Source-specific recalculations (1.B.1.c)

Recalculations were carried out on the basis of updated figures from the German hard-coal mining association (Gesamtverband Steinkohle - GVSt).

The listed emissions quantity consists of a highly uncertain estimate of total emissions from decommissioned mines (experts' assessment: ± 50 %, source: Deutsche Montan Technologie GmbH, DMT 2005), minus the quantity of methane used. The figures have been verified via the research project "Potential for pit-gas releases and pit-gas use" ("Potential zur Freisetzung und Verwertung von Grubengas") (DMT, 2011). The relevant were carried out for all regions with deposits in Germany. In addition, it was determined that a CO_2 fraction escapes along with pit gas.

3.3.1.3.6 Source-specific planned improvements (1.B.1.c)

Scientific estimates of the relevant quantities of fugitive methane emissions from decommissioned sections of mines are now available. To date, experts have placed these emissions at about 260 million m³ and assumed that some 0.5 million to 1 million m³ of these escape into the atmosphere. Fugitive releases at ground surface amount to no more than 0.02 ‰ of total gas releases. The determined emissions have been verified, via research projects, to the year 2009. Plans call for the estimates for subsequent years to be verified as well.

3.3.2 Oil and natural gas (1.B.2)

The overarching category 1.B.2 comprises a total of 14 source categories. These categories are further subdivided, in keeping with oil and gas industry criteria, and in keeping with the industry's process chains. In the emissions database, data on fugitive emissions from oil and natural gas are included with data for the pertinent source categories and sub-source categories. Emissions of source categories under the overarching CRF category 1.B.2 have been determined primarily via the Tier-2 method (IPCC) or the "simpler methodology" (EMEP).

To improve emissions reporting, and in order to fulfil a range of different reporting requirements, a new approach relative to the IPCC and EMEP methods was developed in the main process "Definition of the bases for calculation" (cf. UBA 2005d: p. 24) before the inventory was prepared. This approach for determining emissions, applied under the **working title "logistics"**, was described in detail in the NIR 2008.

3.3.2.1 Recalculations and time-series consistency (1.B.2 all)

New findings relative to the areas of exploration, extraction and processing of oil and natural gas have led to emissions recalculations in relevant source categories. The resulting changes have been especially large for NMVOC emissions in the category 1.B.2.a.ii. In addition, CH_4 and NMVOC emissions in 1.B.2.a.v, in the area of handling of petrol, have been calculated with the help of more-specific emission factors.

Via evaluation of a research project, methane emissions in 1.B.2.b.v "Use of natural gas" have been allocated to sub-source categories.

Table 87: Recalculations for carbon dioxide, methane and NMVOC in source category 1.B.2

1.B.2 Oil and natural gas	CO_2		CH_4		NMVOC	
	1990	2009	1990	2009	1990	2009
Submission 2011	1,715.1 kt	1,658.0 kt	362.9 kt	349.7 kt	286.3 kt	123.7 kt
Submission 2012	1,690.6 kt	1,637.3 kt	406.0 kt	315.8 kt	235.4 kt	82.4 kt
Difference	**-1%**	**-1%**	**+12%**	**-10%**	**-18%**	**-33%**

3.3.2.2 Planned improvements (1.B.2, all)

The results produced by a research project of Müller-BBM (2009a) include an analysis of the source categories 1.B.2.a.i-vi, which need to be improved. Additional studies will be carried out in order to obtain still-lacking emission factors and activity data for these categories.

Research projects are underway to verify emission factors for storage of natural gas. Plans also call for verification of emission factors for gas distribution.

3.3.2.3 Oil (1.B.2.a)

CRF 1.B.2.a	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Liquid fuels	CH_4	-	-	716.7	(0.06%)	272.8	(0.03%)	-61.94%
Liquid fuels	CO_2	-	-	1.4	(0.00%)	1.3	(0.00%)	-7.58%

3.3.2.3.1 Oil, Exploration (1.B.2.a.i)

Gas	Method used	Source for the activity data	Emission factors used
CO_2, CH_4	Tier 1	AS	D
NMVOC	Tier 1	AS	CS

The source category 1.B.2.a.i "Oil, exploration" is not a key category.

3.3.2.3.1.1 Source category description (1.B.2.a.i)

This source category's emissions consist of emissions from activities of drilling companies and of other participants in the exploration sector. Gas and oil exploration takes place in Germany. In 2010, 16 successful drilling operations, with a total drilling distance of 51,410.75 m, were carried out (the annual report of the WEG association of oil and gas producers (Wirtschaftsverband Erdöl- und Erdgasgewinnung - WEG 2011): table on overall drilling success, p. 54). The underlying exploration statistics do not differentiate between drilling for oil and drilling for gas.

3.3.2.3.1.2 Methodological issues (1.B.2.a.i)

Emissions for successful drilling (WEG, 2011) are calculated on the basis of the default factor pursuant to the IPCC GPG 2000 for CO_2, 0.48 kg / well, and of the default factor for methane, 64 kg / well.

3.3.2.3.1.3 Uncertainties and time-series consistency (1.B.2.a.i)

The uncertainties for the emission factors in the source category are in keeping with the uncertainties for the default factors (IPCC GPG 2000; Chapter 2.7.1.6).

3.3.2.3.1.4 Source-specific quality assurance / control and verification (1.B.2.a.i)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The results of quality assurance were taken into account in determination and documentation of emissions.

Due to a lack of country-specific data, an external assessment (Müller-BBM, 2009a) was commissioned. In its source-category analysis, that assessment found that the default factors are applicable to Germany.

3.3.2.3.1.5 Source-specific recalculations (1.B.2.a.i)

No recalculations are required.

3.3.2.3.1.6 Source-specific planned improvements (1.B.2.a.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.2 Oil, production (1.B.2.a.ii)

Gas	Method used	Source for the activity data	Emission factors used
CO_2, CH_4	Tier 2	AS	CS
NMVOC	Tier 2	AS	CS

The source category 1.B.2.a.ii "Oil, production" is not a key category.

3.3.2.3.2.1 Source category description (1.B.2.a.ii)

This source category's emissions are produced in the petroleum industry's extraction (crude oil) and pre-treatment of raw materials (petroleum).

According to the annual report of the WEG German oil and gas industry association (WEG, 2010), German petroleum extraction in 2011 amounted to some 2.5 million tonnes.

The first treatment that extracted petroleum (crude oil) undergoes in processing facilities serves the purposes of removing gases, water and salt from the oil. Crude oil in the form in which it appears at wellheads contains impurities, gases and water, and thus does not conform to requirements for safe, easy transport in pipelines. No substance transformations take place. Impurities – especially gases (petroleum gas), salts and water – are removed, in order to yield crude oil of suitable quality for transport in pipelines.

3.3.2.3.2.2 Methodological issues (1.B.2.a.ii)

Because Germany's oil fields are old, oil production in Germany is highly energy-intensive (thermal extraction, operation of pumps to inject water into oil-bearing layers). The emission factors listed in the 2010 WEG report (CO_2, about 100 kg/t; CH_4, about 0.11 kg/t) include both emissions from external energy production (which is not a focus of reporting for this source category) and actual emissions from extraction. Via discussions between experts of the Federal Environment Agency (UBA) and of WEG, it proved possible to determine emissions from extraction and pre-processing for the 2012 report.

3.3.2.3.2.3 Uncertainties and time-series consistency (1.B.2.a.ii)

In this source category, the uncertainty for the activity data is given as 5 to 10 %. The figures are based on estimates of WEG experts and national experts.

The uncertainties for the emission factors in the source category amount to 10%.

3.3.2.3.2.4 Source-specific quality assurance / control and verification (1.B.2.a.ii)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The results of quality assurance were taken into account in determination and documentation of emissions.

3.3.2.3.2.5 Source-specific recalculations (1.B.2.a.ii)

Recalculations have been carried out for all gases. They were carried out as a result of the transition from default factors to country-specific factors. The resulting changes were especially significant for NMVOC emissions.

	CO_2 [Gg]		CH_4 [Gg]		NMVOC [Gg]	
	1990	2009	1990	2009	1990	2009
Submission 2011	1.1 kt	0.9 kt	10.3 kt	7.6 kt	52.7 kt	40.9 kt
Submission 2012	1.4 kt	1.4 kt	0.1 kt	0.02 kt	0.5 kt	0.2 kt
Difference	**0.3 kt**	**0.5 kt**	**10.2 kt**	**7.6 kt**	**52.2 kt**	**40.7 kt**

3.3.2.3.2.6 Source-specific planned improvements (1.B.2.a.ii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.3 Oil, transport (1.B.2.a.iii)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	AS	CS
NMVOC	Tier 2	AS	CS

The source category 1.B.2.a.iii "Oil, transport" is not a key category.

3.3.2.3.3.1 Source category description (1.B.2.a.iii)

This source category's emissions are tied to activities of logistics companies and of operators of pipelines and pipeline networks. Following first treatment, crude oil is transported to refineries.

Almost all transports of crude oil take place via pipelines. Pipelines are stationary and, normally, run underground. In contrast to other types of transports, petroleum transports are not interrupted by handling processes.

As of 2009, the Federal Republic of Germany's network of long-distance pipelines for crude-oil imports had a total length of 1,834 km and a throughput of about 100.6 million tonnes of crude oil (MWV, 2011, p. 38ff).

In 2005, Germany had a total of 3,331 km of crude oil pipelines. A total of 33.6 million tonnes of oil passed through them in that year (MWV, 2006, Mineralölversorgung mit Pipelines).

Pursuant to *Federal Statistical Office* (STATISTISCHES BUNDESAMT) Fachserie 8, Reihe 4, Table 2.1, Number 31, inland-waterway tanker ships transported 5,600 t of crude oil in 2010.

3.3.2.3.3.2 Methodological issues (1.B.2.a.iii)

Via expert estimation, the **emission factor** for methane was determined to be 0.011 kg/t.

3.3.2.3.3.3 Uncertainties and time-series consistency (1.B.2.a.iii)

The uncertainties for the emission factors amount to 20%.

Methane emissions jumped considerably from 1997 to 1998. This can be explained in that the WEG association did not have measurements for derivation of emission factors until 1998. For the years prior to that year, the value of 6.75 g/t from the GPG (2000) was used, along with a value from the literature (SCHÖN UND WALTZ, 1993).

3.3.2.3.3.4 Source-specific quality assurance / control and verification (1.B.2.a.iii)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.3.3.5 Source-specific recalculations (1.B.2.a.iii)

Recalculations have been carried out to take account of the improved emission factors for methane and NMVOC. Pursuant to surveyed experts, no CO_2 emissions occur.

3.3.2.3.3.6 Source-specific planned improvements (1.B.2.a.iii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.4 Oil, refining and storage (1.B.2.a.iv)

Gas	Method used	Source for the activity data	Emission factors used
CO_2, CH_4	Tier 2	AS	CS
SO_2	Tier 2	AS	CS
NMVOC	Tier 2 Tier 1 (cleaning)	AS M (cleaning)	CS M (cleaning)

The source category 1.B.2.a.iv "Oil, refining and storage" is not a key category.

3.3.2.3.4.1 Source category description (1.B.2.a.iv)

Refining

This source category's emissions consist of emissions from activities of refineries and of refining companies in the petroleum industry. Crude oil and intermediate petroleum products are processed in Germany. For the most part, the companies concerned receive crude oil for refining and processing. Such processing takes place in state-of-the-art plants. In 2009, a total of 14 crude-oil refineries, and 9 lubricating-oil and used-oil refineries, were in operation in Germany. The total crude-oil input was 113.2 million t in 2009. (MWV, 2010: p. 47).

Storage

Tank-storage facilities in refineries

Refinery tank storage systems are used to store both crude oil and intermediate and finished petroleum products. They thus differ from non-refinery tank storage systems in terms of both the products they store and the quantities they handle. The storage capacity of refinery tank-storage facilities in Germany was 22,489,679 m³ in 2010 (BAFA, 2011).

The relevant emissions originate primarily in the conveyance and sealing systems used in refineries.

With regard to tank-storage systems in refineries, interim results can be taken from the research project[29] "Aufbereitung von Daten der Emissionserklärungen gemäß 11. BimSchV; Bereich Lageranlagen" ("Processing of data from emissions declarations pursuant to the 11th

[29] Müller-BBM (2009b): Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCCC- und UNECE-Berichterstattung; Bereich Lageranlagen", Bericht Nr. (report number) M74 244/7, UBA FKZ 3707 42 103/01, 31 p..

Ordinance on the Execution of the Federal Immission Control Act; the area of storage systems"); Müller-BBM, FKZ 3707 42 103/01, 2009b).

Tank-storage facilities outside of refineries

Tank-storage facilities outside of refineries are used especially for interim storage of heating oil, petrol and diesel fuel. All in all, the storage capacity of petroleum-storage facilities in Germany amounted to 43,206,560 m³ in 2010 (BAFA, 2011).

Cleaning

Tanks are emptied and cleaned for purposes of tank inspections and repairs. In tank cleaning, a distinction is made between crude-oil tanks and product tanks. Because of the sediment deposits involved, cleaning of crude-oil tanks, in comparison to cleaning of product tanks, is a considerably more involved process. Product tanks contain no sedimentable substances and thus are cleaned only when the products they contain are changed.

Pursuant to a research report of the German Society for Petroleum and Coal Science and Technology (DGMK; research report 499-01 (2000)), a total of 30 to 35 cleaning operations for crude-oil tanks in 2000 produced some 50,000 kg of NMVOC emissions. Emissions from product-tank cleaning are estimated to amount to 666 kg of NMVOC. No more-recent pertinent findings are currently available.

3.3.2.3.4.2 Methodological issues (1.B.2.a.iv)

Refining

With regard to emissions of NMVOC and CH_4 in the area of processing, the activity data are taken from the "Jahresbericht Mineralöl-Zahlen" ("Annual report on petroleum data") of the Association of the German Petroleum Industry (Mineralölwirtschaftsverband e.V.; MWV). The emission factors used are based on experts' estimates.

The SO_2 emissions occurring in desulphurisation of crude oil and petroleum are calculated as the product of the activity data (quantity of sulphur produced by refineries) and the estimated emission facto.

Storage

Tank-storage facilities in refineries

Pursuant to Müller-BBM (sub-project on storage facilities, 2009b), crude-oil-distillation capacity (in 2010, about 118 million t; MWV, 2011, p. 27) is used as the activity data for purposes of estimating emissions from storage in refineries.

The fugitive-VOC-emissions value specified in VDI Guideline 2440, 0.16 kg/t, may be used as the emission factor. For 2009, this leads to NMVOC emissions of 16,992 t and CH_4 emissions of 1,888 t.

Tank-storage facilities outside of refineries

According to Müller-BBM (sub-project on storage systems, 2009b), no emission factors can be derived, via evaluation of emissions declarations for storage systems, that would be representative of individual systems. This is due, so the same source, to the clearly widely differing emissions behaviour of different individual systems.

It was possible, however, to form aggregated emission factors. For each relevant group of data, this was done by correlating the sums of all emissions with the sums of all capacities.

For non-refinery tank-storage systems, storage of liquid petroleum products can be differentiated from storage of gaseous petroleum products, since the relevant data are suitably differentiated. (Müller-BBM, 2009a)

As a result, the following emission factors can be estimated:

	NMVOC	CH_4	Units
Storage – liquid petroleum products	100	5	g/m³
Storage – gaseous petroleum products	500	150	g/m³

3.3.2.3.4.3 Uncertainties and time-series consistency (1.B.2.a.iv)

For the emissions data, the source-category uncertainties are given as 20 to 25 %. These figures are based on estimates of experts of the WEG, and of national experts, and from the research project FKZ 3707 42 103/01 of Müller-BBM from 2009(b). The uncertainties for the area of cleaning are given as 50%, since they are based on older estimates.

3.3.2.3.4.4 Source-specific quality assurance / control and verification (1.B.2.a.iv)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For source category 1.B.2.a.iv (in the present case, with 1.B.2.a.ii, iii and v), a comparison with the IPCC default values (IPCC 1996b) shows good agreement. Table 1.62 (ibid.: p. 1.130) lists emission factors for this area in a sum ranging from 110 to 1,660 kg/PJ. Conversion of the German emission factor for 2008, 0.018 kg CH_4 / t crude oil, using the lower net calorific value of crude oil (42.7 MJ/kg), produces an emission factor of 467.5 kg/PJ. This value lies below the range for the default emission factor in the Reference Manual. Similarly, the emission factor listed by Austria for the year 2000, 0.033 kg/t crude oil, agrees well with the German emission factor determined on a country-specific basis.

According to Müller-BBM, the emission factors for NMVOC are confirmed – at least in terms of their order of magnitude – via results of independent analysis. For example, in the framework of a bottom-up analysis of a refinery tank-storage system, carried out by Müller-BBM, a value of 300 g/m³ was obtained, while a value of 200 g/m³ was obtained via measurements of middle-distillate tanks.

3.3.2.3.4.5 Source-specific recalculations (1.B.2.a.iv)

No recalculations are required.

3.3.2.3.4.6 Source-specific planned improvements (1.B.2.a.iv)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.3.5 Oil, distribution of oil products (1.B.2.a.v)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	AS	CS
NMVOC	Tier 2	AS	CS

The source category 1.B.2.a.v "Oil, distribution of oil products" is not a key category.

No decision tree is available for determining emissions from distribution (transport and transfer), nor is any relevant method prescribed (IPCC GPG 2000: Chapter 2 Energy). The only recourse in this case is to proceed by analogy to source category 1.B.2.a.iii.

3.3.2.3.5.1 Source category description (1.B.2.a.v)

Distribution

General information

Petroleum products are transported inland-waterway tanker ships, product pipelines, railway tank cars and road tankers, and they are transferred from tanks to other tanks. Germany's domestic sales of petroleum products totalled 112,018,000 t in 2010 (MWV, 2011, p. 51). Domestic sales of petrol, pursuant to MWV (ibid.), amounted to 19,634,000 t in 2010.

Inland-waterway tanker ships

Such ships' tanks retain considerable quantities of petrol vapours after their petrol has been unloaded. When the ships change loads or spend time in port, their tanks have to be ventilated. For an average number of 277 instances of ventilation per year, so BiPRO (research project: "Evaluierung der Anforderungen der 20. BImSchV für Binnentankschiffe im Hinblick auf die Wirksamkeit der Emissionsminderung klimarelevanter Gase" ("Evaluation of the requirements of the 20th Ordinance on the Execution of the Federal Immission Control Act with regard to the effectiveness of control of emissions of climate-relevant gases"), FKZ 3709 45 326, 2010), the emitted quantities amount to 336 - 650 t NMVOC.

Tanker cars

About 13 million m³ of petrol fuels are transported annually in Germany via railway tank cars. Transfer/handling (filling/unloading) and tank losses result in emissions of only 1,260 t NMVOC and of 140 t CH_4 (total of 1,400 t VOC) per year (UBA, 2004b).

The emissions situation points to the high technical standards that have been attained in railway tank cars and pertinent handling facilities.

Cleaning of transport vehicles

Tank interiors are cleaned prior to tank repairs, prior to safety inspections, in connection with product changes and in connection with lease changes.

The inventory currently covers cleaning of railway tank cars. The residual amounts remaining in railway tank cars' tanks after the tanks have been emptied – normally, between 0 and 30 litres (up to several hundred litres in exceptional cases) – are not normally able to evaporate completely. They thus produce emissions when the insides of tanks are cleaned.

Each year, some 2,500 cleaning operations are carried out on railway tank cars that transport petrol. The emissions released, via exhaust air, in connection with cleaning of tank cars' interiors amount to about 36,000 kg NMVOC and 4,000 kg CH_4 per year (a total of 40,000 kg/a VOC) (UBA 2004b, p.34).

On the whole, oil consumption is expected to stagnate or decrease. As a result, numbers of oil storage facilities can be expected to decrease as well. In light of these trends, a long-term increase in the average transport distance for petroleum products – currently 200 km (loc. cit.) – can be expected.

Any additional measures for prevention and reduction measures could affect emissions in this source category only slightly. At the same time, emissions can be somewhat further reduced from their current levels via a combination of various technical and organizational measures. Emissions during handling – for example, during transfer to railway tank cars – are produced especially by residual amounts of petrol that remain after tanks have been emptied. Such left-over quantities in tanks can release emissions via manholes the next time the tanks are filled. Study is thus underway to determine the extent to which "best practice" is being followed at all handling stations, and whether this extent has to be taken into account in emissions determination. In addition, improvements of fill nozzles enhance efficiency in prevention of VOC emissions during fuelling.

Petrol stations

Germany currently has 14,744 petrol stations (MWV 2011). In 2010, the stations sold some 19.6 million t of petrol and 32.1 million t of diesel fuel.

Table 88: Activity data for calculation of emissions in 1.B.2.a.v

Activity data	1990	2010	Change
Number of petrol stations	19,317	14,744	- 24 %
Petrol distribution	31,257 kt	19,634 kt	- 37 %
Diesel-fuel distribution	21,817 kt	32,128 kt	+ 47 %

Significant quantities of fugitive VOC emissions are released into the environment during transfers from tanker vehicles to storage facilities and during refuelling of vehicles. The applicable regulations for petrol stations, under immissions-control law, for limiting such emissions are set forth in two Ordinances for Execution of the Federal Immissions Control Act (BImSchV) that were issued in 1992 and 1993. The relevant provisions cover the areas of both transfer and storage of petrol (20th BImSchV) and of refuelling of vehicles with petrol at petrol stations (21st BImSchV).

Table 89: Emission factors for petrol fuels during refuelling and transfer/storage

Emission factor (2010)	CH_4	NMVOC
Refuelling	0.2053 kg/t	1.848 kg/t
Transfer/storage of petrol fuels	0.52 kg/t	4.68 kg/t
Transfer/storage of petrol fuels	0.3 g/t	2.7 g/t

Successful use of required emissions-control equipment, such as gas-balancing (20th BImSchV) and gas-recovery (21st BImSchV) systems, along with use of automatic monitoring systems (via the amendment of the 21st BImSchV of 6 May 2002), have brought about a continual decrease in VOC emissions.

In the main, the emissions are fugitive emissions that occur in transfers (filling/unloading) and as losses from containers (tank breathing losses). In the area regulated by the 20th BImSchV, such emissions have decreased from about 86,000 tonnes (1993) to about 6,000 tonnes (2009), and in the area regulated by the 21st BImSchV, they have dropped from nearly 60,000 tonnes (1993) to about 9,500 tonnes (2009).

3.3.2.3.5.2 Methodological issues (1.B.2.a.v)

Distribution

Currently, the inventory covers emissions relative to distribution of petrol, diesel fuel, jet fuel and light heating oil. Emissions from distribution of petrol predominate within that group. The emission factors for petrol have been obtained via estimates of UBA experts, while those for the other fuels have been obtained from the publication of M. Winkler (2004). The IPCC Synthesis and Assessment Report Part I (IPCC, 2004) noted that the IEF of the source category *Refining / storage* is the lowest among those of Annex I countries. The low IEF for this source category is due to implementation of technical requirements from national legal provisions relative to equipping of systems for storage, transfer and transport of volatile petroleum products. The *Technical Instructions on Air Quality Control* (TA luft, 2002) require the use of structurally tight valves, flanged joints and connections, pumps and compressors, as well as storage of petroleum products in fixed-roof tanks with connections to gas-collection lines.

The calculation procedures use country-specific emission factors and activity data for NMVOC and methane emissions.

Cleaning

Pursuant to the UBA text (2004b), a total of 1/3 of all relevant transports are carried out with railway tank cars. The remaining 2/3 of all transports are carried out with other means – primarily with road tankers.

The 1/3 to 2/3 relationship given by the report is assumed to be also applicable to the emissions occurring in connection with cleaning. Currently, the inventory includes 36,000 kg of NMVOC emissions from cleaning of railway tank cars. Emissions from cleaning of other transport equipment – primarily road tankers – are derived from that figure; they amount to about 70,000 kg NMVOC.

More thorough emissions collection upon opening of manholes of railway tank cars (a volume of about 14.6 m^3 escapes), along with more thorough treatment of exhaust from cleaning of tanks' interiors, could further reduce VOC emissions. Exhaust cleansing is assumed to be carried out via one-stage active-charcoal adsorption. For an initial load of 1 kg/m^3, exhaust concentration levels can be reduced by 99.5 %, to less than 5 g/m^3. As a result, the remaining emissions amount to only 1.1 t. This is equivalent to a reduction of about 97 % (UBA, 2004b, p. 34) from the determined level of 36.5 t/a (without adsorption).

Other transfer processes

Emissions from refuelling of aircraft are also of interest with regard to this source category. Experts consider such emissions to be very low, however, since the equipment used for such refuelling is fitted with dry couplings.

Emissions from filling of private (residential) heating-oil tanks are also considered in this category. Thanks to high safety standards, those emissions are also very low, however.

Given that the applicable emission factor is only 0.74 g/t, only 15 t of methane are emitted in such filling.

3.3.2.3.5.3 Uncertainties and time-series consistency (1.B.2.a.v)

For the emissions data, the source-category uncertainties are given as 20 %. These figures are based on estimates of WEG experts and national experts, and they lie within the range listed for a number of relevant default emission factors (IPCC GPG 2000; Chapter 2.7.1.6.).

3.3.2.3.5.4 Source-specific quality assurance / control and verification (1.B.2.a.v)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

NMVOC emissions from filling, within refineries, of vehicles for road, railway and waterway transports (EMEP/CORINAIR Emission Inventory Guidebook – 2005 SNAP 050501) account for an average of 0.2 % of all NMVOC emissions throughout Europe. Emissions from the actual relevant transport processes, and from fuel storage outside of refineries (but not in petrol stations), account for an additional 0.9 % of such emissions (SNAP 050502). Emissions from fuel storage in the area of petrol stations account for 2.3 % of such emissions. The listed emission factors are 200-500 g/t of transferred petrol for SNAP 050501, 600-3120 g/t for SNAP 050502 and 2000-4500 g/t for SNAP 050503. No further verification results are available at present.

3.3.2.3.5.5 Source-specific recalculations (1.B.2.a.v)

Inclusion of transfer processes in connection with aircraft refuelling, with distribution of light heating oil, with refuelling with diesel fuel and with drip losses during vehicle refuelling has led to recalculations. An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

	NMVOC [Gg]		CH_4 [Gg]	
	1990	2009	1990	2009
Submission 2011	130.3 kt	15.7 kt	14.5 kt	1.7 kt
Submission 2012	136.6 kt	21.5 kt	15.2 kt	2.4 kt
Difference	**6.3 kt**	**5.8 kt**	**0.7 kt**	**0.7 kt**

3.3.2.3.5.6 Source-specific planned improvements (1.B.2.a.v)

A research project will be carried out to update data for cleaning of railway tank cars (UBA 2004b) and to obtain data for other cleaning areas, such as cleaning of inland-waterway tanker ships and road tankers.

3.3.2.3.6 Oil, other (1.B.2.a.vi)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	IE	IE	IE
NMVOC	IE	IE	IE

The source category 1.B.2.a.vi "Oil, other" is not a key category.

3.3.2.3.6.1 Source category description (1.B.2.a.vi)

No decision tree or other guidelines for determining distribution emissions are available. Pursuant to the reporting guidelines of the EMEP Emission Inventory Guidebook, no instructions relative to other emissions are available.

3.3.2.3.6.2 Methodological issues (1.B.2.a.vi)

No results are available for this source category.

3.3.2.3.6.3 Uncertainties and time-series consistency (1.B.2.a.vi)

No information relative to uncertainties and time-series consistency is required.

3.3.2.3.6.4 Source-specific quality assurance / control and verification (1.B.2.a.vi)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.3.6.5 Source-specific recalculations (1.B.2.a.vi)

No recalculations are required.

3.3.2.3.6.6 Source-specific planned improvements (1.B.2.a.vi)

No improvements are planned at present.

3.3.2.4 Natural gas (1.B.2.b)

CRF 1.B.2.b	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Gaseous fuels	**CH_4**	**L**	**-/T2**	**7,400.1**	**(0.61%)**	**6,173.9**	**(0.65%)**	**-16.57%**
Gaseous fuels	CO_2	-	-	1,408.7	(0.12%)	1,166.0	(0.12%)	-17.22%

The source category 1.B.2.b "Natural gas" is a key category of CH_4 emissions in terms of emissions level and trend.

3.3.2.4.1 Natural gas, exploration (1.B.2.b.i)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	IE	IE	IE
NMVOC	IE	IE	IE

The source category 1.B.2.b.i "Natural gas, exploration" is a key category of CH_4, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

3.3.2.4.1.1 Source category description (1.B.2.b.i)

Source category 1.B.2.b.i is considered together with source category 1.B.2.a.i (Oil, exploration). Consequently, the aggregated, non-subdivided data of 1.B.2.b.i are included in source category 1.B.2.a.i.

3.3.2.4.1.2 Methodological issues (1.B.2.b.i)

The approach used in the calculation procedures is equivalent to that used for source category 1.B.2.a.i.

3.3.2.4.1.3 Uncertainties and time-series consistency (1.B.2.b.i)

See 1.B.2.a.i for explanations of uncertainties and time-series consistency.

3.3.2.4.1.4 Source-specific quality assurance / control and verification (1.B.2.b.i)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

See 1.B.2.a.i for an explanation of source-specific quality assurance / control and verification.

3.3.2.4.1.5 Source-specific recalculations (1.B.2.b.i)

The recalculations are described under 1.B.2.a.i.

3.3.2.4.1.6 Source-specific planned improvements (1.B.2.b.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.2 *Natural gas, production and processing (1.B.2.b.ii)*

Gas	Method used	Source for the activity data	Emission factors used
CO_2, CH_4	Tier 2	AS	CS
CO (only processing)	Tier 1	AS	CS
SO_2, NMVOC	Tier 2	AS	CS

The source category 1.B.2.b.ii "Natural gas, production and processing" is a key category of CH_4, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

Emissions were determined using the methods set forth in IPCC GPG (2000: Figure 2.12 Decision Tree for Natural Gas Systems, page 2.80; here, "Box 4", and "Box 3" where applicable).

3.3.2.4.2.1 Source category description (1.B.2.b.ii)

The emissions of this source category consist of emissions from the activities of extraction, pretreatment and processing. In 2010, a total of 12.7 billion m³ of natural gas were extracted in Germany (WEG 2011, p. 40, natural gas extraction). Of that quantity, 40 % was acid gas. In Germany, pretreatment is carried out in near-wellhead systems directly at gas fields. Emissions can be produced by various types of plants, throughout a spectrum ranging from pretreatment to completion of processing.

Pretreatment systems (processing)

After being brought up from underground reserves, natural gas is first treated in drying plants. Such plants separate out associated water from reserves, liquid hydrocarbons and various solids. Glycol is then used to remove the water vapour remaining in the gas (WEG 2008a[30], p. 25).

Acid gas

The natural gas drawn from Germany's Zechstein geological formation contains hydrogen sulphide. In this original state, the gas, known as "acid gas", has to be subjected to special treatment. Such gas is transported via separate, specially protected pipelines (due the hazardousness of hydrogen sulphide) to central processing plants that wash out its hydrogen sulphide via chemical and physical processes.

The natural gas that leaves these processing plants is ready for use. The hydrogen sulphide is converted into elementary sulphur and is used primarily by the chemical industry, as a basic raw material. Sulphur production from natural gas production in Germany amounted to about 927,353 million tonnes in 2009 (WEG, 2011, p. 51).

3.3.2.4.2.2 Methodological issues (1.B.2.b.ii)

Natural gas

The specific emission factors were derived by the Federal Environment Agency, on the basis of research in the literature (SCHÖN, WALZ et al., 1993) and queries to relevant companies. They have been carried forward continuously for the years 1990 to 1994. For years as of 1995, specific emission factors have been determined with the support of the WEG association. Research has shown the resulting emission factors for methane to be considerably lower than the corresponding values given in the literature.

Acid gas

For calculation of CO_2 and CH_4 emissions from acid-gas processing, a split factor of 0.4 relative to the activity data is applied (total natural gas extraction = 12.7 billion m³). That split factor is based on the WEG report on acid-gas processing (WEG, 2008a).

The CO_2 emission factor used for acid-gas processing, 0.23 t / 1,000 m³, is the emission factor from Austria; according to the WEG, the two desulphurisation plants operated in Germany are comparable to the Austrian plant.

3.3.2.4.2.3 Uncertainties and time-series consistency (1.B.2.b.ii)

For the emissions data, the source-category uncertainties are given as 10 to 30 %. These figures are based on estimates of WEG experts and national experts, and they lie within the range listed for a number of relevant default emission factors (IPCC GPG 2000; Chapter 2.7.1.6.).

3.3.2.4.2.4 Source-specific quality assurance / control and verification (1.B.2.b.ii)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

[30] WEG 2008a: Erdgas-Erdöl, Entstehung-Suche-Förderung, Hannover, 34 p.

The results of quality assurance were taken into account in determination and documentation of emissions.

3.3.2.4.2.5 Source-specific recalculations (1.B.2.b.ii)

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

	CO_2		CH_4	
	1990	**2009**	**1990**	**2009**
Submission 2011	1422.4 kt	1351.1 kt	57.5 kt	40.9 kt
Submission 2012	1408.7 kt	1336.2 kt	59.9 kt	3.8 kt
Difference	**-13.7 kt**	**-14.9 kt**	**+2.4 kt**	**-37.1 kt**

3.3.2.4.2.6 Source-specific planned improvements (1.B.2.bi.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.3 Gas, transmission (1.B.2.b.iii)

Gas	Method used	Source for the activity data	Emission factors used
CH_4 (transmission)	Tier 3	AS	CS
CH_4 (storage)	Tier 2	AS	CS

The source category 1.B.2.b.iii "Natural gas, transmission" is a key category of CH_4, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

Emissions were determined using the methods set forth in IPCC GPG (2000: Figure 2.12 Decision Tree for Natural Gas Systems, page 2.80; here, "Box 4", and "Box 3" where applicable).

3.3.2.4.3.1 Source category description (1.B.2.b.iii)

This source category's emissions consist of emissions from activities of gas producers and suppliers. In Germany, natural gases (natural gas and oil gas) are transported from production and processing companies/plants to gas suppliers and other processors. In practice, such transports take place via both pipelines (high-pressure pipelines) and containers (tanks). Until 1997, significant amounts of city gas were transported via pipelines.

Gas is moved via high-pressure pipelines (with pressure exceeding 1 bar) made of special plastics and steel / ductile-cast iron parts.

Some of the natural gas is stored in underground reservoirs to permit, and guard against, interruptions of pipeline transports.

Gas is also transported in tanks, via tanker ships, on inland waterways.

3.3.2.4.3.2 Methodological issues (1.B.2.b.iii)

Pipelines (high-pressure pipelines)

Some of the gas extracted in Germany is moved via pipelines from gas fields and their pumping stations (either on land or offshore). The companies that operate the most important long-distance gas pipelines in Germany are organised within the *Wirtschaftsverband Erdöl- und Erdgasgewinnung* association of oil and gas producers (WEG; pipelines from pump stations to gas suppliers) and in the *Federal Association of the German Gas and Water Industry* (BGW; pipelines from gas suppliers to end customers).

Containers (tanks), and their transport via inland-waterway tanker ships, road tankers and railway tank cars

In Germany, natural gas is first transported in tanks, via tanker ships on inland waterways, to storage reservoirs and to processing companies, before then being transported to customers via pipelines or in tanks (cf. source category 1.B.2.b.iv). No tank transports take place via tanker trucks on roads or railway tank cars; the quantities in question normally preclude such transports (cf. source category 1.B.2.b.iv, Chapter 3.3.2.4.4).

Storage reservoirs

Both natural and man-made underground storage reservoirs are used for safe storage of large amounts of natural gas. Germany has some 40 underground storage reservoirs. Many of these storage reservoirs are located in depleted oil and natural-gas fields. In such fields, the natural cavities in porous rock provide the storage capacity. Depending on the size of the geological structures concerned, porous-rock reservoirs can hold between 100 million m³ and several billions of m³ of gas. About half of the stored gas is used for purposes of load balancing. It is referred to as *working gas*. The remaining gas, known as *cushion gas*, functions as a pressure buffer and keeps water in the reservoir from seeping into wellholes. Cavern reservoirs consist of caverns that have formed in underground salt formations via leaching processes. An average-sized cavern can hold about 30 million m³ of usable gas. In addition, it will hold a gas cushion ranging from 10 million m³ to 30 million m³ in size. As of the end of 2010, Germany's underground gas-storage reservoirs had a working-gas volume of over 21 billion m³. Further expansions are currently in progress (cf. WEG, 2011: p. 23).

3.3.2.4.3.3 Uncertainties and time-series consistency (1.B.2.b.iii)

See 1.B.2. for explanations of uncertainties and time-series consistency.

3.3.2.4.3.4 Source-specific quality assurance / control and verification (1.B.2.b.iii)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

3.3.2.4.3.5 Source-specific recalculations (1.B.2.b.iii)

No recalculations are required.

3.3.2.4.3.6 Source-specific planned improvements (1.B.2.b.iii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.4 Natural gas, distribution (1.B.2.b.iv)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 3	AS	CS

The source category 1.B.2.b.iv "Natural gas, distribution" is a key category of CH_4, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

3.3.2.4.4.1 Source category description (1.B.2.b.iv)

This source category's emissions consist of emissions from activities of companies that supply gas to customers. In Germany, natural gas is distributed to users primarily via pipeline networks. Gas is distributed via low-pressure pipelines (with pressure up to 100 mbar) and medium-pressure pipelines (with pressure between 100 mbar and 1 bar), made of special plastics, steel / ductile-cast iron and grey cast iron. To prevent double-counting, the entire high-pressure pipeline network of companies involved in gas production and long-distance gas transports has been combined within 1.B.2.b.iii.

Emissions caused by gas distribution have decreased by some 4 %, even though gas throughput has increased considerably and the distribution network has been enlarged by over 85 % with respect to its size in 1990. One important reason for this improvement is that the gas-distribution network has been modernised, especially in eastern Germany. In particular, the share of grey cast iron lines in the low-pressure network has been reduced, with such lines being supplanted by low-emissions plastic pipelines. Another reason for the reduction is that fugitive losses in distribution have been reduced through a range of technical improvements (tightly sealing fittings such as flanges, valves, pumps, compressors) undertaken in keeping with emissions-control provisions in relevant regulations (TA Luft 1986 and 2002; VDI-Richtlinie (VDI Guideline) 2440, 11-2000). The main framework data relative to such measures are summarised in the following table.

Table 90: Gas-distribution network and its methane emissions

Parameter	1990	1995	2000	2005	2010
Total length of pipeline network [km]	245,852	320,878	369,390	411,954	456,124
Total methane emissions [t]	199,567	204,309	192,281	190,904	192,362
Implied emission factor [kg/km]	811.7	636.7	520.5	463.4	421.7
Change in the emission factor with respect to the base year	0 %	22 %	36 %	43 %	48 %

Some of the natural gas is stored in above-ground reservoirs (spherical tanks) to permit, and guard against, interruptions of pipeline transports. Tanks filled with gas, for distribution and transport, are transported via tanker ships (on inland waterways), railway tank cars and tanker trucks.

Gas is also sold in special containers (small tanks, flasks). Such containers are transported as unit loads, usually in larger packages, bunches or containers.

Distribution via pipelines

Relevant calculations are carried out on the basis of available network statistics on the composition of distribution networks in the low-pressure and medium-pressure sectors. In the early 1990s, emissions from distribution of city gas were also taken into account in calculations. In 1990, the city-gas distribution network accounted for a total of 16 % of the entire gas network. Of that share, 15 % consisted of grey cast iron lines and 84 % consisted of steel and ductile cast iron lines. The following table provides an overview of trends in the way the network is structured. The table includes an overview of distribution networks for city gas. A particularly noticeable development is that the plastic pipeline network in the medium-pressure sector has been expanded by 400 %.

Table 91: Structure of the gas-distribution network

Gas-distribution network		Length of the distribution network		
Pressure level	**Material**	**1990 [km]**	**2010 [km]**	**Change [%]**
Low pressure	Grey cast iron	17,260	809	-95
	Plastic	23,894	42,445	+78
	Steel and ductile cast iron	119,761	164,969	+37
Medium pressure	Plastic	43,307	179,319	+414
	Steel and ductile cast iron	41,622	68,582	+65
Total		**245,844**	**456,124**	**+86**

General information relative to fulfillment of good inventory practice, pursuant to the Guidelines, is provided in the section for 1.B.2 (cf. Chapter 3.3.2).

3.3.2.4.4.2 Methodological issues (1.B.2.b.iv)

Distribution via containers

Containers used to distribute gas (tanks of transport equipment, and flasks) are filled at filling plants. Filled tanks are transported via inland ships, railway tank cars and road tankers. Gas in containers (flasks) is also transported by customers (i.e. not as commercial cargo) prior to being used. To a small extent, gas consumers also store gas temporarily before using it (cf. the consumption information, for the various source categories, provided under 1.A).

Storage reservoirs

Medium quantities of gas are stored in man-made above-ground reservoirs. Germany uses spherical tanks for this purpose.

3.3.2.4.4.3 Uncertainties and time-series consistency (1.B.2.b.iv)

See 1.B.2. for explanations of uncertainties and time-series consistency.

3.3.2.4.4.4 Source-specific quality assurance / control and verification (1.B.2.b.iv)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

3.3.2.4.4.5 Source-specific recalculations (1.B.2.b.iv)

No recalculations are required.

3.3.2.4.4.6 Source-specific planned improvements (1.B.2.b.iv)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.5 Natural gas, other leaks (1.B.2.b.v)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	AS	CS

The source category 1.B.2.b.v "Natural gas, other leaks" is a key category of CH_4, in terms of both level and trend, pursuant to the classification of the aggregated source category 1.B.2.b "Natural gas".

No decision tree or other guidelines are available for determination of emissions from distribution (cf. IPCC GPG 2000: Chapter 2 Energy).

Pursuant to the reporting guidelines of the EMEP Emission Inventory Guidebook, no instructions relative to "other" emissions are available (EMEP 2005: Group 5: Extraction & distribution of fossil fuels and geothermal energy).

3.3.2.4.5.1 Source category description (1.B.2.b.v)

The source category describes emissions from leakage in the industrial sector and in the areas of private households and commerce/trade/services. The activity data are based on results obtained by the Working Group on Energy Balances (AGEB) and on the current gas statistics of the German Association of Energy and Water Industries (BDEW).

No city gas has been fed into the grid in Germany since 1997.

3.3.2.4.5.2 Methodological issues (1.B.2.b.v)

The emission factors are country-specific. They were determined via the research project "Methanemissionen durch den Einsatz von Gas in Deutschland von 1990 bis 1997 mit einem Ausblick auf 2010" ("Methane emissions via gas use in Germany from 1990 to 1997, with an outlook for 2010"); Frauenhofer ISI, 2000.

3.3.2.4.5.3 Uncertainties and time-series consistency (1.B.2.b.v)

For the emissions data, the source-category uncertainties are given as 20 %. That figure is based on estimates of experts, and it lies within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.5.4 Source-specific quality assurance / control and verification (1.B.2.b.v)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

3.3.2.4.5.5 Source-specific recalculations (1.B.2.b.v)

Recalculations throughout the entire time series were carried out to take account of differentiation by residential / institutional and commercial and industry, as well as to take account of the new country-specific emission factors.

3.3.2.4.5.6 Source-specific planned improvements (1.B.2.b.v)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.6 Venting and flaring (1.B.2.c)

CRF 1.B.2.c	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Venting & flaring	CH_4	-	-	409.3	(0.03%)	138.2	(0.01%)	-66.22%
Venting & flaring	CO_2	-	-	280.5	(0.02%)	283.5	(0.03%)	1.07%
Venting & flaring	N_2O	-	-	1.1	(0.00%)	0.2	(0.00%)	-80.98%

The source category 1.B.2.c "Venting and flaring" is not a key category.

The source categories in the overarching group of fugitive emissions from 1.B.2.c "Venting and flaring" cover greenhouse-gas and pollutant emissions either vented and flared directly into the atmosphere.

3.3.2.4.7 Venting and flaring, oil (1.B.2.c.i)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	AS	CS
CH_4 (extraction)	Tier 2	AS	CS
CH_4 (refineries)	Tier 1	AS	D
N_2O (only extraction)	Tier 2	AS	CS
NMVOC (only refineries)	Tier 1	AS	D

The source category 1.B.2.c.i "Venting and flaring, oil" is not a key category.

No methods for determining the relevant emissions have been prescribed (cf. IPCC GPG, 2000); only the decision tree for refineries (cf. 1.B.2.a.iii) includes venting and flaring as a criterion.

3.3.2.4.7.1 Source category description (1.B.2.c.i)

Pursuant to general requirements of the Technical Instructions on Air Quality Control (TA Luft; 2002), gases, steam, hydrogen and hydrogen sulphide released from pressure valves and venting equipment must be collected in a gas-collection system. Wherever possible, gases so collected are burned in process combustion. Where such use is not possible, the gases are piped to a flare. Flares used for flaring of such gases must fulfill at least the requirements for flares for combustion of gases from operational disruptions and from safety valves. For refineries and other types of plants in source categories 1.B.2, flares are indispensable safety components. In crude-oil refining, excessive pressures can build up in process systems, for various reasons. Such excessive pressures have to be reduced via safety valves, to prevent tanks and pipelines from bursting. Safety valves release relevant products into pipelines that lead to flares. Flares carry out controlled burning of gases released via excessive pressures. When in place, flare-gas recovery systems liquify the majority of such gases and return them to refining processes or to refinery combustion systems. In the process, more than 99 % of the hydrocarbons in the gases are converted to CO_2 and H_2O. When a plant has such systems are in operation, therefore, its flarehead will seldom show more than a small pilot flame.

3.3.2.4.7.2 Methodological issues (1.B.2.c.i)

The source category's emissions are determined on the basis of the research report "Stand und Entwicklung von Treibhausgasemissionen in den Vorketten für Erdöl und Erdgas" ("Status of and trends in greenhouse-gas emissions in upstream processes for oil and natural gas") (ÖKO-INSTITUT e.V. 2006a). For the area of extraction, they are verified via expert discussions with the WEG association.

The source category's emissions include flaring losses of onshore installations. Venting emissions are taken into account in 1.B.2.a.iv. In addition, flaring emissions in refineries are determined with emission factors developed by experts.

The results of quality assurance are taken into account in determination and documentation of emissions.

3.3.2.4.7.3 Uncertainties and time-series consistency (1.B.2.c.i)

For the emissions data, the source-category uncertainties are given as 10 to 25 %. Those figures are based on estimates of national experts, and they lie within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.7.4 Source-specific quality assurance / control and verification (1.B.2.c.i)

See 1.B.2.a (Chapter 3.3.2.3) for an explanation of source-specific quality assurance / control and verification.

3.3.2.4.7.5 Source-specific recalculations (1.B.2.c.i)

Recalculations were carried out for carbon dioxide, NMVOC and methane, to take account of new emission factors.

An overview of the nature and extent of the recalculations carried out in CRF 1.B.2 is provided in Chapter 3.3.2.1.

3.3.2.4.7.6 Source-specific planned improvements (1.B.2.c.i)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.8 Venting and flaring, gas (1.B.2.c.ii)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	AS	CS
CH_4	Tier 2	AS	CS
N_2O	Tier 2	AS	CS
NMVOC	Tier 2	AS	CS

Pursuant to the classification of the aggregated source category 1.B.2.c "Venting and flaring", the source category 1.B.2.c.ii "Venting and flaring, gas" is not a key category.

No methods for determining the relevant emissions have been prescribed (cf. IPCC GPG, 2000); only the decision tree for refineries (cf. 1.B.2.a.iv) includes venting and flaring as a criterion.

3.3.2.4.8.1 Source category description (1.B.2.c.ii)

For a description of the source category, see 1.B.2.c.i.

3.3.2.4.8.2 Methodological issues (1.B.2.c.ii)

For a description of the source category, see 1.B.2.c.i.

The SO_2 emissions are obtained from the activity data of 12,092,000 m³ of flared natural gas (WEG 2011, p. 45) and an emission factor of 0.140 kg / 1,000 m³, a factor based on an average H_2S content of 5 % by volume.

Venting emissions are taken into account in source category 1.B.2.b.iii.

3.3.2.4.8.3 Uncertainties and time-series consistency (1.B.2.c.ii)

For the emissions data, the source-category uncertainties are given as 25 %. That figure is based on estimates of national experts, and it lies within the range listed for relevant default emission factors (IPCC GPG 2000, Chapter 2.7.1.6.).

3.3.2.4.8.4 Source-specific quality assurance / control and verification (1.B.2.c.ii)

See 1.B.2.b (Chapter 3.3.2.4) for an explanation of source-specific quality assurance / control and verification.

3.3.2.4.8.5 Source-specific recalculations (1.B.2.c.ii)

As a result of remarks made by the Expert Review Team (ERT) during the in-country review 2010, nitrous oxide emissions were recalculated with emission factors from the Good Practice Guidance 2000 (Table 2.16) for flaring in gas production and in gas processing.

3.3.2.4.8.6 Source-specific planned improvements (1.B.2.c.ii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.5 Geothermal energy (1.B.2.d)

3.3.2.5.1 Source category description (1.B.2.d)

The source category 1.B.2.d "Geothermal energy" is not a key category.

Geothermal energy is a renewable form of energy. Geothermal energy systems that tap geothermal heat to a depth of 400 metres are classified as "near-surface" geothermal energy systems. Near-surface geothermal systems generate heating and cooling energy by means of heat pumps. They are also used for heating service water. Geothermal energy systems that tap geothermal heat at depths greater than 400 metres are classified as "deep" geothermal energy systems. Geothermal heating stations use the heat in their thermal-water flows directly, and provide heating and cooling to end consumers, via district / local heating and cooling networks. Geothermal power stations convert the heat in their thermal-water flows into electricity. In most cases, they produce heat as well, via processes for combined heat/power (CHP) production.

As of the end of 2010, a total of 21 deep geothermal energy systems, with electricity output of 7.34 MW and thermal output of 188 MW, were in operation. A total of 13 systems, with electricity output of 42.2 MW and thermal output of 210 MW, are under construction. An additional 81 systems, with planned capacity of 76 MW of electrical output and 196 MW of thermal output, are planned.

Operation of geothermal power stations and heat stations in Germany produces no emissions of climate-relevant gases. The thermal-water circuits of such installations are closed and airtight, both above and below ground level. As a result, no emissions occur during their operation. What is more, releases of the gases dissolved in their heat-carrying fluids – primarily H_2, CH_4, CO_2 and H_2S – would not produce concentrations that would require reporting (cf. "Umwelteffekte einer geothermischen Stromerzeugung, Analyse und Bewertung der klein- und großräumigen Umwelteffekte einer geothermischen Stromerzeugung" ("Environmental effects of geothermal power generation; analysis and assessment of small-scale and large-scale environmental impacts of geothermal power generation")), FKZ 205 42 110, Chapter A.2.3.5). For this reason, the emissions are reported as "NO". In 2010, all geothermal energy systems met their own power requirements (primarily power for operating pumps) by drawing electricity from the grid. In the report, that use is included in the relevant source categories.

3.3.2.5.2 Methodological issues (1.B.2.d)

The IPCC Reference Manual does not describe any methods for source category 1.B.2.d "Other" (IPCC, 1996b: p. 1.132f).

No emission factors for greenhouse gases and pollutants that could escape in connection with drilling for tapping of geothermal energy (both near-surface and deep energy) are known for Germany at present. As is known from oil and gas exploration, however, it is clear that virtually any drilling will lead to releases of gases bound in underground layers – and the gases involved can include H_2, CH_4, CO_2, H_2S and Rn (cf. "Environmental effects of geothermal electricity production; analysis and assessment of the small-scale and large-scale environmental effects of geothermal electricity production", FKZ 205 42 110, Chapter A.2.1.5). Drilling to tap near-surface geothermal energy can be expected to produce only very slight emissions. In all drilling to tap deep geothermal energy, "blow-out preventers" are used to prevent gas releases. In addition, drilling fluids are used to drive any gases released into boreholes back into the rock layers traversed in drilling.

3.3.2.5.3 Uncertainties and time-series consistency (1.B.2.d)

No explainations of uncertainties and time-series consistency are required.

3.3.2.5.4 Source-specific quality assurance / control and verification (1.B.2.d)

No explanations relative to source-specific quality assurance / control and verification are required. Verification is not possible at present.

3.3.2.5.5 Source-specific recalculations (1.B.2.d)

No recalculations are required.

3.3.2.5.6 Planned improvements (1.B.2.d)

Even though the quantities involved are expected to be very small, plans call for quantification of gas releases from exploratory drilling in cases in which no blow-out preventers are used (in the near-surface range to depths of 400 m).

In a departure from the standard concept for such processes, use of fluorinated substances to enhance the efficiency of geothermal electricity and heat generation in low-temperature thermal power stations is currently being tested. The implications of such technical developments, relative to safety and emissions, are being determined by the Federal Environment Agency (UBA). In a workshop ("Effektivität und Umweltverträglichkeit in geothermischen Niedertemperatur-Kreisprozessen"; "Effectiveness and environmental compatibility in low-temperature geothermal circuit processes") held at the Deutscher Bundeskongress Geothermie (a national congress on geothermal energy) that took place in November 2011, such implications were presented and discussed.

4 INDUSTRIAL PROCESSES (CRF SECTOR 2)

4.1 Overview (CRF Sector 2)

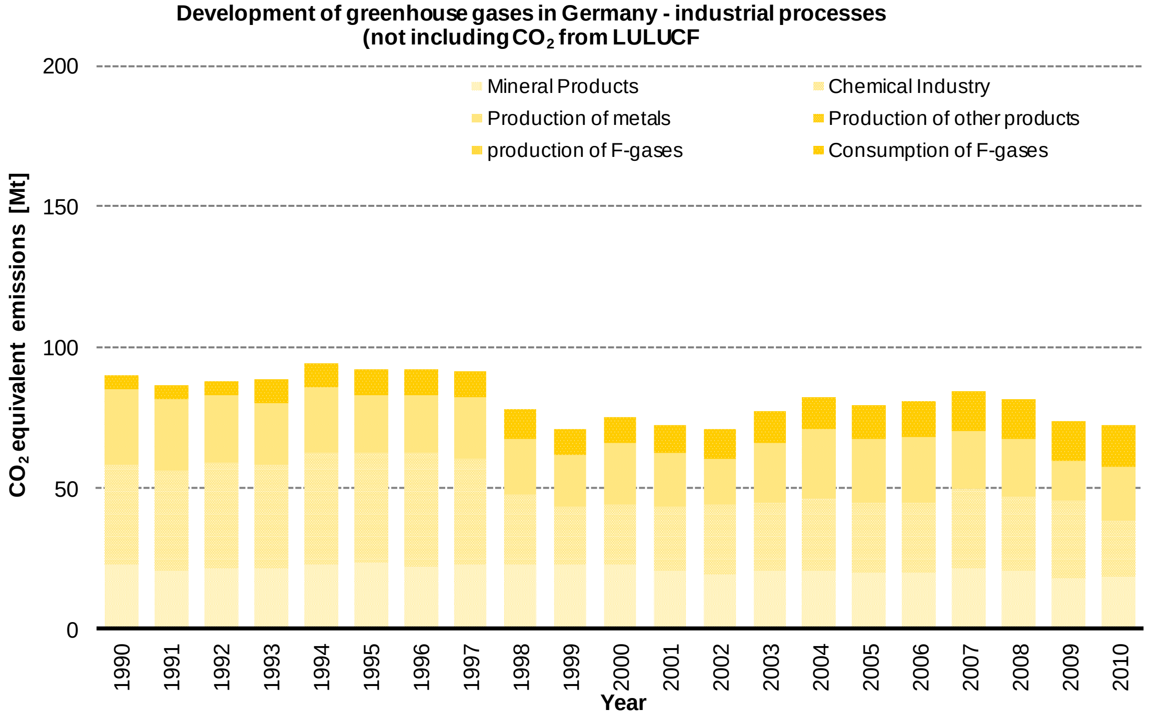


Figure 41: Overview of greenhouse-gas emissions in CRF Sector 2

4.2 Mineral products (2.A)

Source category 2.A Mineral products is divided into sub-source categories 2.A.1 through 2.A.7. These fields include:

- Cement production (2.A.1),
- Lime burning (2.A.2),
- Limestone and dolomite use (2.A.3),
- Soda ash production and use (2.A.4),
- Bitumen roofing (2.A.5),
- Road paving with asphalt (2.A.6), and
- in Other, glass production (2.A.7.a) and ceramics production (2.A.7.b).

4.2.1 Mineral Products: Cement production (2.A.1)

4.2.1.1 Source category description (2.A.1)

CRF 2.A.1	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Clinker production	**CO_2**	**L**	**T**	**15,145.8**	**(1.24%)**	**12,187.7**	**(1.28%)**	**-19.53%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	AS	CS
NO_X, SO_2	CS	AS	CS

The source category *Cement production* is a key category of CO_2 emissions in terms of emissions level and trend.

The remarks below refer only to production of cement clinkers, because clinker grinding is not relevant as a dust source in the present context.

The clinker-burning process emits climate-relevant gases. CO_2 accounts for the great majority of these emissions. The CO_2 emissions from pertinent raw materials are tied directly to the quantities of cement clinkers that are produced. Pursuant to the German Cement Works Association (VDZ, 2011) clinker production in 2010 amounted to 22,996 kt[31]. Raw-material-related CO_2 emissions are calculated with a country-specific emission factor, as determined by the *German Cement Works Association* (VDZ) from plant-specific data, of 0.53 t CO_2/t cement clinkers. Clinker production produced raw-material-related CO_2 emissions of 12,188 kt CO_2 in 2010.

[31] Provisional value (rounded off).

Table 92: Production and CO_2 emissions in the German cement industry

Year	Clinker production	Emission factor	Raw-material-related CO_2 emissions	Cement production (from German clinkers)
	[kt/a]	[t CO_2/t]	[kt/a]	(kt/a)
1990	28,577	0.53	15,146	37,772,000
1991	25,670		13,605	34,341,000
1992	26,983		14,301	37,331,000
1993	27,146		14,387	36,649,000
1994	28,658		15,189	40,512,000
1995	29,072		15,408	35,862,276
1996	27,669		14,664	34,318,315
1997	28,535		15,124	34,147,612
1998	29,039		15,391	35,601,157
1999	29,462		15,615	37,438,106
2000	28,494		15,102	35,413,823
2001	25,227		13,370	32,117,712
2002	23,954		12,696	31,009,278
2003	25,233		13,373	32,749,441
2004	26,281		13,929	31,853,656
2005	24,379		12,921	31,009,226
2006	24,921		13,208	33,629,885
2007	26,992		14,306	33,382,323
2008	25,366		13,444	33,581,301
2009	23,232		12,313	30,441,010
2010	22,996		12,188	29,914,868

Source: BdZ 1995 (until 1994); VDZ, 2011 (as of 1995)

4.2.1.2 Methodological issues (2.A.1)

Activity data

Activity data are determined via summation of figures for individual plants (until 1994, activity data were determined on the basis of data of the BDZ). As of 1995, following optimisation of data collection within the association, activity data were compiled by the VDZ, and by its cement-industry research institute (located in Düsseldorf), via surveys of German cement works and use of BDZ figures. In the main, the data consists of data published in the framework of CO_2 monitoring, supplemented with data for plants that are not BDZ members (in part, also VDZ estimates).

Table 92 summarises the activity data for cement clinkers and cement, and the raw-material-related CO_2 emissions as determined from clinker production, for the years 1990 through 2010.

Emission factors

The emission factor used for emissions calculation, 0.53 t CO_2 / t cement clinkers, is based on mass-weighted figures for individual plants, i.e. the VDZ determined the emission factor by aggregating plant-specific data relative to fractions of CaO and other metal oxides (MgO; in raw materials, and containing carbonate) in clinkers. The emission factor was confirmed in the framework of a research project (VdZ, 2009).

In the German cement industry, dust separated from exhaust gas is returned to the burning process. As a result, carbonate release from clinker raw materials can be determined directly from clinkers' metal-oxide content, without any need to take account of significant losses via the exhaust-gas pathway.

The emission factor of 0.53 t CO_2 / t cement clinkers was applied to the entire time series.

Raw-material-related CO_2 emissions in the cement industry are determined, in accordance with the *IPCC-GPG*, via the following equation:

CO_2 emissions = emission factor ($EF_{Klinker}$) x clinker production

(Table 92 shows calculated CO_2 emissions for the German cement industry for the years covered by the report.)

4.2.1.3 Uncertainties and time-series consistency (2.A.1)

For the activity data, time-series consistency is assured by the long period of time over which the association has collected pertinent data; for the emission factor, it is assured via use of a standard approach for all relevant years.

The listed uncertainties were determined via expert assessment pursuant to Tier 1 of the IPCC GPG rules (2000: Chapter 6.3 p. 6.12).

Most companies are required to report clinker-production data within the framework of CO_2-emissions trading. The EU monitoring guidelines for emissions trading specify a maximum accuracy of 2.5 %. The uncertainties for the activity data used were thus estimated as -2.5 % and +2.5 %.

The uncertainty for the emission factor used was estimated as +/- 2 %. This was confirmed via surveys in the framework of a research project (VdZ, 2009).

4.2.1.4 Source-specific quality assurance / control and verification (2.A.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

For purposes of quality assurance, all data used, including data from the BDZ, from the VDZ and comparative data from the literature, were checked for plausibility. The determined emission factor for raw-material-related CO_2 emissions has been compared with the relevant figures of other countries. The small deviation (< 5 %) from the IPCC Tier 1 default factor of the IPCC Reference Manual, 0.5071 t CO_2 / t clinkers (IPCC 1996b: Chapter 2.3.2, p. 2.6), results from the sometimes-higher lime content of German clinkers (64 % to 67 % CaO) and an average MgO content, which is not taken into account in the default value, of 1.5 %. The procedure used corresponds to the Tier 2 method of the IPCC-GPG (IPCC, 2000), and it is considered to be more precise than utilisation of default emission factors.

The emission factor used differs only slightly (1 %) from the emission factor used in connection with the ETS in Germany, an emission factor which is checked by authorities and reviewed in light of companies' obligations to provide records. To date, no calculations relative to the emission factor prior to the year 2000 are available. The same figure – the result of an expert assessment – has been used for all relevant years in that period.

4.2.1.5 Source-specific recalculations (2.A.1)

No recalculations are required.

4.2.1.6 Planned improvements (source-specific) (2.A.1)

No source-category-specific improvements are planned.

4.2.2 Mineral Products: Lime production (2.A.2)

4.2.2.1 Source category description (2.A.2)

CRF 2.A.2	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Limestone and dolomite	**CO_2**	**L**	**-/T2**	**6,176.5**	**(0.51%)**	**5,019.3**	**(0.53%)**	**-18.74%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	AS	D
NO_X, SO_2	CS	AS	CS

The source category *Lime production* is a key category of CO_2 emissions in terms of emissions level.

The statements made below regarding source category 2.A.2 refer solely to the amounts of burnt lime and dolomite lime produced in German lime works. Information about other lime-producing and lime-using sectors is provided in Chapter 4.2.3 (CRF 2.A.3), in the interest of preserving the international comparability of Chapter 4.2.2 (CRF 2.A.2).

Because of the wide range of applications covered by the sector's products, lime production is normally more insulated from economic fluctuations than is production of other mineral products, such as cement. Production has fluctuated relatively little since the end of the 1990s, with the exception of the fluctuation seen in 2009. In 2009, production decreased by more than 20 % from the previous year, as a result of economic factors. As a result of economic recovery, production increased by 11 % in 2010, to somewhat more than 6 million t. Nonetheless, it is still about 11 % below the corresponding production quantity in 2008.

Table 93: Production and CO_2 emissions in the German lime industry

Year	Lime		Dolomite lime	
	Production [t]	CO_2 emissions [Millions of t]	Production [t]	CO_2 emissions [Millions of t]
1990	7,180,057	5.636	591,595	0.540
1991	6,347,938	4.983	593,321	0.542
1992	6,434,344	5.051	575,955	0.526
1993	6,718,472	5.274	516,470	0.472
1994	7,365,100	5.782	505,995	0.462
1995	7,461,872	5.858	545,026	0.498
1996	6,881,431	5.402	545,575	0.498
1997	6,975,146	5.475	531,268	0.485
1998	6,666,164	5.233	558,373	0.510
1999	6,681,273	5.245	481,123	0.439
2000	6,856,478	5.382	525,522	0.480
2001	6,534,447	5.130	512,527	0.468
2002	6,462,040	5.073	516,271	0.471
2003	6,599,930	5.181	436,887	0.399
2004	6,561,720	5.151	459,679	0.420
2005	6,407,324	5.030	464,345	0.424
2006	6,515,915	5.115	462,533	0.422
2007	6,738,764	5.290	459,405	0.419
2008	6,733,805	5.286	455,066	0.415
2009	5,393,103	4.234	335,013	0.306
2010	6,004,296	4.713	335,077	0.306

Source: Own extrapolation on the basis of BV KALK, 2011

Production of dolomite lime, of which significantly smaller amounts are produced, basically exhibits similar fluctuations. On the other hand, production in the years 2003 to 2008 was considerably lower than in 2002 and the years before then (in 2003, production decreased by about 15 %). Between 1990 (the base year) and 2008, production decreased by about 23 %. Between 1990 and 2009, production decreased by 43 % (the production decrease of more than 26 % in 2009, which was due to economic factors, was not offset in 2010).

With a constant emission factor, CO_2 emissions and lime / dolomite-lime production depend linearly on each other; as a result, the above statements apply to CO_2 emissions mutatis mutandis.

4.2.2.2 Methodological issues (2.A.2)

In burning of limestone and dolomite, CO_2 is released, and it reaches the atmosphere via the exhaust gas of the process. The pertinent emissions level is obtained by multiplying the amount of product in question (lime or dolomite lime) and the relevant emission factor.

Emission factors

The pertinent CO_2 emissions are calculated with the help of the relevant stoichiometric factors:

EF_{lime} : 0.785 t CO_2/t lime
$EF_{dolomite\ lime}$: 0.913 t CO_2/t dolomite lime

Here, it is assumed that 100 % of the lime consists of CaO, and that 100 % of the dolomite lime consists of CaO • MgO. This approach can lead to overestimation of emissions, since it does not take account of any impurities in the relevant raw materials or of any incomplete deacidification. In principle, this approach corresponds to the specifications of the *IPPC*

Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000, Chapter 3.1.2).

Activity data

The German Lime Association (BVK) collects the production data for the entire time series, on a plant-specific basis, and makes them available for reporting purposes. The quantities produced by plants that are not included in the German Lime Association's association statistics are estimated on the basis of existing information (such as operator figures, data published in the framework of emissions trading) and then added to the German Lime Association's figures. This ensures that all of German lime production is taken into account.

4.2.2.3 Uncertainties and time-series consistency (2.A.2)

The EU monitoring guidelines for emissions trading call for activity rates to have an accuracy of 2.5 %. Since the German Lime Association's (BV Kalk's) lime-production data are based on operators' figures as provided in the framework of CO_2-emissions trading, and since the plants not included in the association's statistics (and thus assessed after the fact) represent only a small share of the total number of plants concerned, the **uncertainties** for the **activity rates** used are estimated to be 2.5 % and +2.5 %. These figures apply to both burnt lime and dolomite lime.

The uncertainties for the emission factors used for burnt lime were estimated as -11 % and +5 %. The uncertainties for the emission factors used for dolomite lime were estimated as -30 % and +2 %.

4.2.2.4 Source-specific quality assurance / control and verification (2.A.2)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Production amounts are determined, by the German Lime Association (BV Kalk), via several different concurrent procedures; their quality is thus adequately assured (Tier 2).

The estimated emissions and collected production-quantity data were compared with findings from emissions trading and with national statistical data. The IPCC default factors used are suitable for the country-specific method.

4.2.2.5 Source-specific recalculations (2.A.2)

No source-specific recalculations are required. .

4.2.2.6 Planned improvements (source-specific) (2.A.2)

No source-category-specific improvements are planned.

4.2.3 Mineral Products: Limestone and dolomite use (2.A.3)

4.2.3.1 Source category description (2.A.3)

CRF 2.A.3	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
IE	CO_2	-	-	IE	IE	IE	IE	IE

Gas	Method used	Source for the activity data	Emission factors used
CO_2		IE	

At present, emissions of this source category are not reported separately; instead, they are reported in the source categories that use limestone and dolomite. For the sake of simplicity, reference will be made to "limestone" (except in special cases requiring explanation), even where the sum of limestone and dolomite is meant.

In this source category, all production and use of limestone and dolomite are considered in balance form, and the results are compared with the inventory source categories (cf. Table 94). The "limestone balance" project provides a substance-flow analysis, in the form of amounts balance sheets that can be combined into time series. This methodological work was carried out in a research project that drew on all of the Federal Environment Agency's available expertise (UBA 2006). In 2010, this balance was updated up to the last available data year for the complete data set in 2008. This balance evaluation identified data-availability problems, although it proved possible to derive relevant solutions and to identify the impacts of use of the 1996 and 2006 IPCC Guidelines as alternatives. A pertinent short report that was prepared co-operatively, by the Federal Institute for Geosciences and Natural Resources (BGR) and the Federal Environment Agency, includes completely recalculated time series for limestone use (UBA 2010).

Table 94: Limestone balance sheet for use of limestone in areas with, and without, relevance with regard to carbon-dioxide emissions

Limestone use in Germany, in millions of tonnes					
[Millions of t]	**1990**	**1995**	**2000**	**2008**	**CRF reference**
Production					
Domestic production (change in statistics from 1994 to 1995)	110.500	76.790	95.100	91.659	2.A.3
Imports	1.299	2.275	3.301	5.214	2.A.3
Exports	0.201	0.389	0.278	1.367	2.A.3
Total production	**111.598**	**78.676**	**98.123**	**95.506**	2.A.3
Use					
Cement industry	34.203	35.131	34.522	29.601	2.A.1
Lime industry	13.733	14.143	13.031	12.319	2.A.2
Soda ash production	2.275	1.831	1.706	1.745	2.A.4.a
Glass production	0.700	0.890	0.970	0.902	2.A.7.a
Sintering (preparation of iron ores)	4.681	4.600	4.273	4.541	2.C.1
Pig iron (blast furnace)	0.756	0.751	0.924	0.790	2.C.1
Sugar production (lime furnaces)	0.686	0.784	0.796	0.655	2.D.2
Flue-gas desulphurisation in power stations	1.362	1.401	2.580	2.303	1.A.1.a
Agriculture and forestry	2.437	3.233	3.469	3.410	LULUCF
Water and sludge treatment	0.051	0.062	0.047	0.226	NE
Other sectors (such as construction, other construction-materials industry and chemical industry, etc.)	50.716	15.851	35.804	39.014	NE
Total use	**111.598**	**78.676**	**98.123**	**95.506**	2.A.3
Auxiliary balance (limestone included in raw materials)					
Ceramics production					
- Brick production	1.028	1.384	1.190	0.751	2.A.7.b

Source: Compilation of the Federal Environment Agency, from UBA 2006 (Tab. 3-23, direct link http://www.uba.de/uba-info-medien/3102.html) and UBA 2010 (Tab. 1-2), without updating relative to studies – data were most recently available for 2008

In terms of quantity, and taken together, emissions-related uses of limestone in cement and lime production have a significance similar to that of so-called "other areas". At the same time, emissions-related uses are showing a slightly decreasing trend, although their overall order of magnitude has not changed.

For overview purposes, the following table shows those CO_2 emissions calculated within the inventory that cannot always be separately drawn from the CRF tables (2.C.1, 1.A.1.a) and that do not appear as sums in the CRF tables:

Table 95: CO_2 emissions from limestone use (overview, 2.A.3)

[Millions of t]	1990	1995	2000	2010	CRF reference
Cement industry	15.1	15.4	15.1	12.2	2.A.1
Lime industry	6.2	6.4	5.9	5.0	2.A.2
Glass production	0.7	0.8	0.7	0.8	2.A.7.a
Brick production	0.5	0.6	0.5	0.3	2.A.7.b
Iron and steel industry	2.4	2.4	2.3	2.1	2.C.1, aggregated
Flue-gas desulphurisation in power stations	0.6	0.7	1.1	1.0	1.A.1.a, aggregated
Agriculture and forestry	1.3	1.6	2.1	1.7	LULUCF
Total from limestone use	26.8	27.8	27.8	23.1	

Source: Compilation of the Federal Environment Agency, from the various source categories

4.2.3.2 Methodological issues (2.A.3)

The purpose of the balance account is to provide an overview of national limestone use (activity data). Emissions calculations are carried out for those source categories in which CO_2 emissions are produced via limestone use:

- 1.A.1.a Flue-gas desulphurisation in power stations (addition of limestone)
- 2.A.1 Cement-clinker production (limestone fraction in the relevant raw materials)
- 2.A.2 Limestone production (limestone inputs)
- 2.A.7.a Glass production (limestone fraction in the relevant raw materials)
- 2.A.7.b Ceramic-brick production (limestone fraction in the relevant raw materials)
- 2.C.1 Iron and steel production (limestone input for pig iron and sinter)
- 5.B+5.G Soil liming in agriculture and forestry (LULUCF)

Limestone is also used in other sectors that are not mentioned in the present section. Such uses either a) involve kilns for lime-burning, and thus are subsumed in the data compilation in 2.A.2, or b) produce no direct emissions, as is the case in soda and sugar production[32]. With the exception of quantities used in production of ceramic products, all limestone quantities used are included in production as determined and thus can be derived from the limestone balance (sheet).

In spite of the consistency of the limestone balance sheet, the resulting CO_2 emissions can be calculated more precisely, and in ways that are more specifically suitable, in source categories with a sectoral focus. For example, the natural limestone fraction in raw materials used for clinker production can be estimated. That fraction is taken into account source-category-specifically in 2.A.7.b, along with emissions-causing porosity agents. The uses considered source-category-specifically for the glass industry, in 2.A.7.a, include much more than limestone use – for example, they also include use of soda ash and other carbonates.

As a result, the pertinent data are updated in the relevant source categories (cf. the above list). In addition, pertinent methodological aspects are explained in the relevant source-category chapters (cf. chapters 19.1.2.3, 4.2.8 and 4.4.1).

[32] This refers to the process in which limestone is burned to obtain CO_2, which then recarbonises in cleaning processes. The pertinent CO_2 emissions occur only when lime is applied in agriculture (carbolic lime); this is reported under CRF 4 and 5.

To prevent double-counting with other source categories, and to ensure comparability with future inventories, in keeping with IPCC GL 2006, no CO_2 emissions are aggregated in the present section. In this regard, cf. also the following comparison:

Relevance to the IPCC Guidelines

The IPCC Guidelines 2006 (GL 2006), which are not yet applicable, but are methodologically more refined than earlier guidelines, call for emissions from use of limestone and other carbonates to be calculated in the context of those source categories in which the relevant uses occur. All emissions-related balance entries are calculated and reported at suitable locations in the global consideration pursuant to GL 2006. Separate designation as "limestone use", in addition to inclusion within category-specific calculations, is no longer required in such calculation and reporting[33].

When, in CRF category 2.A.3, the rules of the IPCC Guidelines 1996 (GL 1996) are strictly followed, all explicitly specified limestone uses are described and the emissions for all such uses are calculated and summed, a distorted picture of the importance of emissions from limestone use results. In updating of the limestone balance sheet, such distortion was studied, also with regard to different possibilities for deriving limestone-input quantities. If source-category-specific circumstances were not taken into account, only balance-sheet positions based on statistical data could be aggregated under 2.A.3. In the source categories themselves, by contrast, limestone inputs can be calculated on the basis of actual requirements, although such quantities can hardly be entered into the balance in any transparent manner.

Table 96: Comparison of balance-sheet positions with emissions relevance pursuant to GL 1996 (report category 2.A.3), for 2008, as gained from model calculations with specific key figures ("from key figures") and from statistical information ("statistical")

	CO_2	2.A.3[34]	From key figures	Statistical
Balance-sheet position (limestone use, in millions of tonnes of limestone)				
1.A.1.a Flue-gas desulphurisation (REA) in large combustion installations	x	x	2.303	1.745
2.A.7.a Glass production (total)	x	x	0.902	0.356
2.A.7.b Ceramics production (external "auxiliary balance")	x	x	0.751	0.000
2.C.1 Iron and steel production	x	x	5.331	3.437
CO_2 emissions from limestone, in millions of tonnes (for simplicity, calculated with dolomite included)	**x**	**x**	**4.1 (CO_2)**	**2.4 (CO_2)**

Source: Calculation of Federal Environment Agency (UBA); Table 3 from UBA 2010

The comparative emissions described here are not included in aggregated form in the CRF tables for 2.A.3, and they not included, in aggregated form, in key-source determination. The source-category-specifically calculated emissions are included in the aforementioned source categories, however, and they have been included in key-source determination for those categories[35].

[33] There does continue to be a separate position 2A4 "Other Process Uses of Carbonates", but that position would have no application within the context of German emissions inventories.

[34] IPCC 1996

[35] Limestone use under 1.A.1.a and under 2.C.1 is included in key sources determined pursuant to Tier 1.

4.2.3.3 Uncertainties and time-series consistency (2.A.3)

Information regarding uncertainties for activity rates and emission factors for the relevant limestone uses is provided in the relevant source-category chapters.

4.2.3.4 Source-specific quality assurance / control and verification (2.A.3)

General quality control and quality assurance, in keeping with the requirements of the QSE manual and its associated documents, have been carried out in those source categories into which source category 2.A.3 was divided, pursuant to the IPCC Guidelines.

The activity data and the emission factors for the relevant limestone uses are verified and updated in the relevant source categories.

The data surveys from the limestone-balance research project, and the updating carried out by the Federal Institute for Geosciences and Natural Resources (BGR) and the Federal Environment Agency, do not point to any persisting inventory gaps, and thus the surveys are considered adequate.

Allocation of limestone uses was intensively discussed in connection with the 2010 and 2011 inventory reviews, but no inventory adjustments, relative to emissions levels, were derived from such discussion.

4.2.3.5 Source-specific recalculations (2.A.3)

Because it solely provides the relevant overall framework, the balance (sheet) described in the present context is not subject to requirements for annual recalculations.

Recalculations for individual balance-sheet entries have been described and explained in those source categories in which limestone inputs are significant. For purposes of the present report, (moderate) recalculations were carried out solely in the area of flue-gas desulphurisation as of 2008 (Chapter 19.1.2.3).

4.2.3.6 Source-specific planned improvements (2.A.3)

No improvements, and no annual updating of the limestone balance sheet, are planned at present.

4.2.4 Mineral Products: Soda ash production and use (2.A.4)

4.2.4.1 Source category description (2.A.4)

CRF 2.A.4	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Soda ash use	CO_2	-	-	426.7	(0.03%)	322.8	(0.03%)	-24.36%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS/D

The source category *Soda ash production and use* is not a key category.

In Germany, soda ash is produced only chemically. The country has 3 production facilities, all of which use the Solvay process[36]. With respect to the calcium carbonate it uses, that

[36] Ammonia-soda process pursuant to Ernst Solvay

process is CO_2-neutral, since the carbon dioxide in the limestone is bound within the product, soda ash (Na_2CO_3), and is released only during product use.

On the other hand, coke is used in the calcination part of the process, and this produces additional carbon-dioxide emissions. An amount of some 100 kg of coke is assumed per tonne of soda ash; this was determined in a research project for the preparation of relevant Best Available Technique Reference Documents (BREF) (UBA, 2001). While this corresponds to an amount of some 380 kg CO_2 / t soda ash, these emissions are reported not here but together with energy-related emissions.

Soda ash is used in a wide range of industrial applications. The most important areas of use include the glass industry, production of detergents and cleansers and the chemical industry . It is assumed that the carbon contained in soda ash is released sooner or later, regardless of the use involved, into the air as CO_2.

Emissions resulting solely from use of soda ash correlate in a fixed way to the pertinent calculated quantities used (cf. the methodological issues in the following):

Table 97: Activity rates and use-related CO_2 emissions outside of the glass industry, since 1990

Year	Activity rate [t]	CO_2 emissions [kt]
1990	1,028,243	426.7
1991	833,285	345.8
1992	674,159	279.8
1993	669,874	278.0
1994	784,273	325.5
1995	615,403	255.4
1996	616,105	255.7
1997	693,994	288.0
1998	745,031	309.2
1999	708,245	293.9
2000	724,926	300.8
2001	763,405	316.8
2002	725,483	301.1
2003	774,433	321.4
2004	741,587	307.8
2005	753,075	312.5
2006	754,603	313.2
2007	782,857	324.9
2008	770,393	319.7
2009	666,835	276.7
2010	777,790	322.8

Source: Calculations of the Federal Environment Agency (UBA)

4.2.4.2 Methodological issues (2.A.4)

Activity data

The *Federal Statistical Office* determines the total amounts of soda ash produced in Germany. From 1995 to 2008, the sum total has comprised the categories of *light soda* (production number 2413 33 103, disodium carbonate in powder form, with a fill density of less than 700 g/l) and *heavy soda* (production number 2413 33 109, other disodium carbonate). Since 2009, light and heavy soda are reported in combination, in one position (notification number 2013 43 100). Of that quantity, only the portion "intended for sale" ("zum Absatz bestimmt") is taken into account. This prevents double-counting, since heavy soda is produced from light soda.

Since the 2010 inventory review, those soda ash inputs are determined that are not taken into account, for emissions calculations, in other source categories. The relevant calculations are oriented to the greatest possible emissions from the applicable soda ash use. The total quantity of soda ash used in Germany is determined via balancing (quantity produced plus imports and less exports). The relevant import and export quantities are taken from the foreign-trade statistics of the Federal Statistical Office (STATISTISCHES BUNDESAMT, 2011). Emissions from soda ash use in the glass industry are already taken into account, source-specifically, under source category 2.A.7.a (Glass industry). The soda ash quantities used in that category are calculated from the mixtures of glass types used, and then deducted from the soda ash use of relevance in the present section.

Since Germany has only two producers, these newly structured data must be kept confidential. Only the production quantities reported by the Federal Statistical Office through 2008 continue to be published.

Emission factor

Since the Solvay production process is neutral with regard to CO_2, an emission factor of "0" is used for production.

The quantities of coke that are used during lime burning are already taken into account in the Energy Balance, without being listed separately with regard to their CO_2 emissions.

Stoichiometrically, the emission factor for soda ash use is 415 kg CO_2 per tonne of soda ash, under the assumption that release is complete (a conservative approach). The emission factor is in keeping with the relevant IPCC requirements (IPCC, 1996b).

4.2.4.3 Uncertainties and time-series consistency (2.A.4)

Activity data

There are uncertainties regarding the production statistics given by the Federal Statistical Office, since – for example – the relation between light and heavy soda ash fluctuates widely, especially in the first years for which separate statistics are provided. Because production is emissions-neutral, readers seeking further details are referred to the NIR 2007.

The calculations of the relevant quantities of soda ash used exhibit large uncertainties (maximally, -50%/+50%), as a result of both statistical fluctuation ranges and the assumptions on which the calculations are based.

Emission factor

Since the emission factor for production of soda ash is a substantiated "zero", there is no uncertainty. The emission factor for soda ash use is subject to small, justified uncertainties in the area of product purity and the completeness of the chemical transformations involved.

4.2.4.4 Source-specific QA/QC and verification (2.A.4)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the area "production of soda ash / sodium carbonate".

It is not possible at present to verify quantitatively the input quantities of soda ash that have to be allocated to the glass industry. The pertinent estimates are conservative, however; by no means do they underestimate the quantities of relevance for the inventory. Qualitatively, the pertinent calculation results do not contradict the sales figures of soda-ash producers obtained on a sample basis.

4.2.4.5 Source-specific recalculations (2.A.4)

Recalculations had to be carried out to take account of corrected calculations relative to soda-ash inputs in the glass industry. As a result, the soda-ash quantities reported in the present context, and the pertinent emissions, increased by a factor of about 1.25, throughout the entire time series.

4.2.4.6 Source-specific planned improvements (2.A.4)

No specific improvements are planned at present. In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method still needs to be verified.

4.2.5 Mineral Products: Bitumen for roofing (2.A.5)

CRF 2.A.5	Gas	Key category	1990 Total emissions (Gg) & percentage (%)	2010 Total emissions (Gg) & percentage (%)	Trend
		- -			

Gas	Method used	Source for the activity data	Emission factors used
NMVOC	T1	AS	CS

As far as is currently known, the source category *Bitumen for roofing* produces no greenhouse-gas emissions and is thus not a key category.

4.2.5.1 Source category description (2.A.5)

Bitumen is used in production and laying of roof and sealing sheeting.

In 2010, some 178 million m^2 of roof and sealing sheeting were produced in Germany, and some 150 million m^2 of such sheeting were used (export surplus). In such production, liquid bitumen is applied, at temperatures of 150°C to 220°C, as a saturating or coating agent. This process produces emissions of organic substances (combined here as NMVOC).

Roof and sealing sheeting is laid by means of both hot and cold processes. The hot process, involving welding of sheeting, produces significant emissions of organic substances. The relevant emissions trends depend primarily on trends in quantities of polymer bitumen sheeting produced. Use of solvent-containing primers is not considered here; it is covered via the solvents model – cf. Chapter 5.2.

Emissions from production of roof and sealing sheeting have been decreasing slightly, in keeping with decreasing production quantities. Emissions from laying of roof and sealing sheeting have remained about the same, although the quantities used have been decreasing.

Substances other than NMVOC are of only subordinate relevance in terms of emissions.

4.2.5.2 Methodological issues (2.A.5)

Data on quantities of roof and sealing sheeting that are produced and used (**activity rate**) are provided by the VDD association of the bitumen, roof sheeting and sealing sheeting industry (VDD, 2011), on the basis of a cooperation agreement dating from 2009. At present, no data supplementation or extrapolation are being carried out. To obtain internationally comparable figures, production quantities are converted into quantities of input bitumen (the conversion relationship, depending on the type of sheeting concerned, varies from 1.3 to 3.3 bitumen kg/m^2).

Because of their predominating importance, only NMVOC emissions are considered and taken into account in the emissions inventory. In the process, a distinction is made between emissions from production and emissions from laying of roof and sealing sheeting.

The **emission factor** for production of roof and sealing sheeting was obtained via a calculation in accordance with current technological standards of German manufacturers (VDD, 2009). The emission factor for laying of polymer bitumen sheeting has been taken from an ecological balance sheet (IKP, 1996). That emission factor has also been adopted, by analogy, for sheeting glued primarily with hot bitumen. Thin sheeting is not glued; it is attached via nailing and produces no emissions. The implied emission factor for the source category has been increasing slightly, as a result of the increasing importance of polymer bitumen sheeting.

NMVOC emissions are calculated in keeping with a Tier 1 method, since no pertinent detailed data are available.

Table 98: Production and laying of roof and sealing sheeting with bitumen, and relevant activity rates and emission factors

	Produced or used area in 2010 [millions of m^2]	EF/ IEF [kg/ m^2]
Production of roof and sealing sheeting with bitumen	178	NMVOC 0.00035795
Laying of roof and sealing sheeting with bitumen	150	NMVOC 0.000027 – 0.000038

4.2.5.3 Uncertainties and time-series consistency (2.A.5)

Information relative to the uncertainty of the data of the VDD was obtained via consultation between the VDD and the Federal Environment Agency. The total uncertainty for the activity data for production and laying of sheeting is estimated to be about +/-1 %. That figure, in turn, leads to a higher uncertainty, of about +/-2.5 %, for the calculated bitumen consumption.

The uncertainty for the combined emission factors for production and laying of roof and sealing sheeting is estimated to be about +/-5 %.

4.2.5.4 Source-specific quality assurance / control and verification (2.A.5)

The data provider has carried out quality control relative to the activity data. Due to a lack of relevant specialised staff within the Federal Environment Agency (UBA), it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity.

The manner in which the activity rates were determined is considered to be plausible. The emission factors accord with findings from pertinent Federal Environment Agency research projects and are plausible. In particular, the validity of the emission factors is justified in that no emissions from use of solvent-containing coatings and primers have to be taken into account in this section (that takes place in the solvents model, as noted above).

4.2.5.5 Source-specific recalculations (2.A.5)

No source-specific recalculations were required.

4.2.5.6 Source-specific planned improvements (2.A.5)

The VDD plans to carry out additional considerations relative to export-import offsetting.

4.2.6 Mineral Products: Road paving with asphalt (2.A.6)

CRF 2.A.6	Gas	Key category	1990 Total emissions (Gg) & percentage (%)	2010 Total emissions (Gg) & percentage (%)	Trend
		- -			

Gas	Method used	Source for the activity data	Emission factors used
CO	T1	AS	IE
NO_X, NMVOC, SO_2	T1	AS	CS

As far as is currently known, the source category "Road paving with asphalt" produces no greenhouse-gas emissions and is thus not a key category.

4.2.6.1 Source category description (2.A.6)

Currently, the report tables list produced quantities of mixed asphalt products and NMVOC, NO_X and SO_2 emissions.

In 2010, a total of about 45 million t of asphalt (DAV, 2011) was produced in Germany, in a total of some 653 asphalt-mixing plants. Asphalt is used primarily in road construction, where it competes directly with hydraulically bound concrete. In 1991, total production increased considerably; since 2000 it has been decreasing again.

The relevant emissions trends depend primarily on trends in production quantities. The production output decreased by 10 million tonnes in 2010, and thus the pertinent SO_2 emissions decreased by 300,000 kg.

4.2.6.2 Methodological issues (2.A.6)

No special calculation procedure is available for calculating fuel inputs in source category 1.A.2. Nonetheless, fuel inputs are taken into account via Energy Balance evaluation, and they are coupled with suitable emission factors.

The applicable quantity of mixed asphalt products produced (**activity rate**) has been taken from communications of the Deutscher Asphaltverband (DAV; German asphalt association).

The **emission factors** were determined country-specifically, in accordance with Tier 2 criteria. Emission factors for substances other than CO_2 were determined on the basis of emissions measurements for over 400 asphalt-mixing plants, for the period 1989 to 2000. The majority of the emissions occur during drying of pertinent mineral substances. Almost all of the NMVOC emissions originate in the organic raw materials used, and they are released primarily in parallel-drum operation, as well as from mixers and loading areas. On average, about 50% of the NO_X and SO_2 involved come from the mineral substances used (proportional process emissions). CO occurs primarily in incomplete combustion processes. CO emissions are calculated solely in connection with fuel inputs.

Table 99: Emission factors for production of mixed asphalt products

	NOx	NMVOC	SO_2
EF [kg/ t]	0.015	0.030	0.030

Only emissions from asphalt production are reported. Figures relative to emissions released during laying of asphalt have not yet been adequately reviewed.

4.2.6.3 Uncertainties and time-series consistency (2.A.6)

As the extensive measurement data show, the emissions lie within a comparatively narrow range. The large volume of measurement data available makes it possible to form highly reliable mean values. The only large uncertainties are found in breakdown of emissions amounts into fuel-related and process-related emissions.

The production-amount data may be considered very accurate, since the product in question is a sale-ready product, and operators report the relevant amounts to the DAV.

4.2.6.4 Source-specific quality assurance / control and verification (2.A.6)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The relevant country-specific emission factors are being evaluated in a research project.

4.2.6.5 Source-specific recalculations (2.A.6)

No source-specific recalculations were required.

4.2.6.6 Source-specific planned improvements (2.A.6)

Relevant findings currently available from a research project are to be used for specific evaluation of emission factors.

4.2.7 Mineral Products: Glass production (2.A.7.a Glass)

CRF 2.A.7.a Glass	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Glass products	CO_2	-	-	695.6	(0.06%)	761.6	(0.08%)	9.48%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	AS	CS
NO_X, NMVOC, SO_2	CS	AS	CS

The source category *Mineral products*: *glass production* is not a key category.

4.2.7.1 Source category description (2.A.7.a Glass production)

Germany's glass industry produces a wide range of different glass types with different chemical compositions. Germany's glass sector comprises the following sub-sectors: container glass, flat glass, domestic glass, special glass and mineral fibres (glass and stone wool). The largest production quantities, by percentage, are found in the sectors of container glass (about 52 % of total glass production in 2010) and flat glass (about 30 % of total glass production in 2010). Together, these sectors account for 82 % of total glass production (BV Glas, 2011).

A large number of primary and secondary raw materials are used. A distinction is made between natural raw materials, synthetic raw materials and the additives used in small amounts (refining agents, colouring agents and decolouring agents). The most important natural raw materials include sand, limestone, dolomite, feldspar and igneous rocks. The most important synthetic raw material used in production of high-volume glasses such as flat glass and container glass is soda ash (cf. also 4.2.4.1). Glass cullet (including cullet from within production operations and from outside sources) is an important secondary raw material.

In production, homogeneous glass mixtures combining primary and secondary raw materials are melted down at temperatures between 1,450 °C and 1,650 °C. The process-related CO_2 emissions under consideration here are released from the raw-material carbonates during the melting process in the oven. CO_2 emissions – in small amounts – also occur in neutralisation of HF, HCL and SO_2 in exhaust gases, with the help of limestone or other carbonates. Because the amounts involved are so small, these emissions are not considered here.

The following table shows the trends, since 1990, in activity rates, process-related CO_2 emissions and the implied emission factors resulting for all glass types overall.

Table 100: Activity rates and process-related CO_2 emissions since 1990

Year	Activity rate [t]	Process-related CO_2 emissions [t]	IEF for all glass types [t CO_2/ t $_{glass}$]
1990	6,561,849	695,617	0.106
1991	7,202,807	733,252	0.102
1992	7,228,752	718,117	0.099
1993	7,074,837	684,797	0.097
1994	7,760,000	651,580	0.084
1995	7,621,300	774,525	0.102
1996	7,519,600	750,079	0.100
1997	7,392,000	717,713	0.097
1998	7,314,000	694,763	0.095
1999	7,442,239	703,752	0.095
2000	7,505,000	731,039	0.097
2001	7,293,000	733,511	0.101
2002	7,084,000	690,484	0.097
2003	7,205,720	694,407	0.096
2004	7,088,900	696,613	0.098
2005	6,948,400	705,910	0.102
2006	7,285,600	734,991	0.101
2007	7,535,300	759,347	0.101
2008	7,513,900	753,713	0.100
2009	6,784,100	685,593	0.101
2010	7,326,700	761,563	0.104

It is clear that emissions tend to follow the trend in activity rates. At the same time, the implied emission factors indicate that the correlation is not rigid; some discrepancies do occur. The discrepancies are due to annual fluctuations in production quantities of various individual glass types, and in cullet inputs. They are thus logical and calculatorily correct.

4.2.7.2 Methodological issues (2.A.7.a glass)

The currently valid *IPCC Good Practice Guidance* (2000) contains no proposals or information relative to calculation of process-related CO_2 emissions for the glass industry. In keeping with the general recommendations of the *IPCC Good Practice Guidance*, therefore, a special method had to be developed. The NIR 2007 provides a detailed discussion of the relevant methods (Chapter 4.1.7.2, p. 251ff).

The CO_2 emissions (the main pollutant) are calculated via a Tier 2 method, because the activity rates are tied to specific emission factors (that are in keeping with the relevant carbonate concentrations). The following carbonates are taken into account as the main sources of CO_2 formation during the melting process: Calcium carbonate ($CaCO_3$), soda ash / sodium carbonate (Na_2CO_3), magnesium carbonate ($MgCO_3$) and barium carbonate ($BaCO_3$). The CO_2 emissions are reported in the present context; raw-materials inputs – limestone and soda ash – are considered under 2.A.3 (cf. 4.2.3) and 2.A.4 (cf. 4.2.4), respectively.

The production figures (**activity rates**) are taken from the regularly appearing annual reports of the national glass industry association (Bundesverband Glasindustrie; BV Glas, 2011). "Production" refers to the amount of glass produced, which is considered to be equivalent to the amount of glass melted down. Further processing and treatment of glass and glass objects are not considered.

The following activity rates were determined for 2010:

Table 101: Glass: Activity rates for the various industry sectors (types of glass)

Industry sector	Activity rate for 2010 [thousands of t]
Container glass	3797.0
Flat glass	2183.1
Special glass	345.4
Domestic glass	193.5
Glass fibre and wool	289.1
Stone wool	518.6

Source: BV Glas, 2011

The following sector-specific cullet percentages are assumed:

Table 102: Cullet percentages for the various types of glass

Industry sector	Cullet percentage [%] in the input raw material
Container glass	59 – 65 (annually varying)
Flat glass	35 (entire time series)
Special glass	30 (entire time series)
Domestic glass	20 (entire time series)
Glass fibre and wool	40 (entire time series)
Stone wool	40 (entire time series)

Source: HVG, 2008

The cullet percentage for container glass is known only for the western German Länder as of 1990. For Germany as a whole, it is known for the period since 1995. No data are available for the new German Länder for the period from 1990 to 1994. For that reason, an average cullet percentage input was estimated on the basis of the various glass sectors' average percentages of total glass production. In 2007, the firm of Gesellschaft für Glasrecycling und Abfallvermeidung mbH (GGA) was forced to cease operations, under cartel law. As a result, no reliable cullet-input data have been available from that source since 2007. For the time being, the relevant data are being cross-checked against quantity surveys pursuant to the Ordinance on Packaging (Verpackungs-Verordnung) and against waste-management data provided by the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, Fachserie (specialised series) 19 Reihe (series) 1, Table 1.2). At present, the last available GGA data is still being used.

Since the exhaust gases occurring during the melting process are drawn off together with combustion-related exhaust gases – i.e. as a collective exhaust-gas stream – measurements cannot be used to determine the CO_2 quantities produced by the German glass industry. For this reason, a calculation procedure is used that is based on the weight shares for the aforementioned carbonates and on cullet input in the container-glass and flat-glass industry. Figures on the chemical composition of the various types of glass produced in Germany have been taken from VDI-Richtlinie (guideline) 2578 (VDI, 1999) and from the ATV-DVWK Merkblatt (standards sheet of the German Association for Water, Wastewater and Waste) 374 (ATV, 2004).

The procedure used to determine **emission factors** for the various glass oxides involved and the pertinent emissions is described in detail in the NIR 2007 (Chapter 4.1.7.2, p. 251ff).

The following emission factors were calculated for the various industry sectors. The factors vary annually in keeping with variations in cullet inputs (and thus ranges are given):

Table 103: CO_2-emission factors for various glass types (calculated in comparison with figures from the CORINAIR manual)

Glass type	Calculated emission factor [kg CO_2/ t $_{molten\ glass}$] - stoichiometric / incl. cullet input-			Default emission factors [kg CO_2/ t $_{molten\ glass}$] - pursuant to CORINAIR -		
Container glass	193	/	49 - 86	171	-	229
Flat glass	208	/	135		210	
Domestic glass	120	/	96		-	
Special glass	113	/	79	0	-	178
Glass fibre	198	/	119	0	-	470
Stone wool	299	/	179	238	-	527
Unspecified	174	/	139		-	

4.2.7.3 Uncertainties and time-series consistency (2.A.7.a glass)

The production data have been taken from the internal statistics of the BV Glas glass-industry association. Since that association represents nearly all of Germany's container-glass and flat-glass manufacturers, the sectoral data it provides are highly accurate. An uncertainty of 5 % was thus assumed. The association's representation of all other glass sectors is incomplete, and thus the association cannot guarantee the completeness of the data for such other sectors. For this reason, an uncertainty of 10 % was assumed for those areas. Until about 2002, BV Glas also cross-checked the data against data of the *Federal Statistical Office*.

The uncertainty in the cullet figures for container glass lies within the customary range for statistical determinations. For the new German Länder, an uncertainty of 20 % has been assumed, because no statistical survey has been carried out; only an estimate is available. Updating of GGA figures, in connection with comparisons with cullet inputs as determined from waste statistics, increases the uncertainties. As part of this effect, the data are obtained from waste-treatment installations. As a result, the data lack the cullet quantities delivered directly from the dual systems to glass producers. What is more, the data do not show whether processed container-glass waste is used in glass furnaces. In addition, the data lack information regarding cullet imports and exports. Cross-checking of the data from 2007 (53 %) shows good agreement with the assumed pertinent value of 60 %.

The figures on cullet use for all other glass types are considerably less precise, however, since only estimates are available for those areas. An uncertainty of 20 % was thus assumed. That uncertainty is also assumed for container glass as of 2007.

As to CO_2-emission factors, an uncertainty of 10 % was assumed, for all industry sectors.

4.2.7.4 Source-specific quality assurance / control and verification (2.A.7.a glass)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The calculated emission factors were compared with several different sources, including the CORINAIR manual and the "Baden-Württemberg 2004 emissions declaration" ("Emissionserklärung 2004 Baden-Württemberg"; UMEG 2004). According to that comparison, the calculated emission factors may be considered accurate.

The calculated emissions were also cross-checked against the ETS data for Germany. In the process, a need for further checking was determined, since slightly higher carbon-dioxide emissions are reported in the framework of emissions trading than can be calculated via the inventory methods described here. On the other hand, the ETS data also include the emissions that occur in production of sodium water glass. When those emissions are deduced from the ETS data, only a very small difference remains, a difference that lies within the uncertainty for the emission factors. The inventory calculations' failure to include sodium water-glass production is not a shortcoming. All relevant soda-ash quantities – and, thus, those for sodium water-glass production – are taken into account under 2.A.4.b (Chapter 4.2.4).

The information provided regarding the chemical composition of the various glass types continues to be considered correct in the present context. The applicable rate of cullet input, for which inadequate data are available (cf. Chapter 4.2.7.3 Uncertainties and time-series consistency (2.A.7.a glass)), has considerable influence in this regard.

4.2.7.5 Source-specific recalculations (2.A.7.a glass)

Minimal source-specific recalculations were carried out relative to the activity data for 2009.

4.2.7.6 Planned improvements (source-specific) (2.A.7.a, glass)

At present, review of various items of information relative to cullet input is planned. Such review could lead to improvements and slight changes in the relevant emissions level.

4.2.8 Mineral Products: Ceramics production (2.A.7.b Ceramics)

CRF 2.A.7.b Ceramics	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Bricks and tiles	CO_2	-	-	531.1	(0.04%)	308.6	(0.03%)	-41.90%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	NS	CS
NO_X, NMVOC, SO_2	CS	NS	CS

The source category *Mineral products*: *ceramics production* is not a key category.

4.2.8.1 Source category description (2.A.7.b ceramics)

The process-related emissions in the ceramics industry originate in the following sub-category elements:

1. "Production of ceramic products": This time series shows the quantity produced by the entire ceramics industry in Germany. The non-CO_2 emissions for the entire ceramics industry are calculated via these activity data. Process-related CO_2 emissions, on the other hand, are calculated only for the sub-quantities "roof tiles" and " masonry bricks" (see below).
2. "Brick production" (CO_2); "roof tile" product: Production of roof tiles is a subset of the aforementioned activity rate for the entire ceramics industry. It is used only for calculation of process-related CO_2 emissions (with consideration of proportions of limestone and organic impurities).

3. "Brick production" (CO_2); "roof tile" product: Production of masonry bricks is also a subset of the aforementioned activity rate for the entire ceramics industry. This production figure is also used only for calculation of process-related CO_2 emissions (with consideration of porosity agents, as well as of proportions of limestone and organic impurities in the pertinent raw materials).

Table 104: Activity rates and process-related CO_2 emissions in the ceramics industry (CRF 2.A.7.b)(rounded)

	1990	1991	1992	1993	1994	1995 [kt]	1996	1997	1998	1999	2000
Ceramics products of which:	21595	20772	22769	24534	30458	24730	22663	22939	22798	22395	21199
Masonry bricks	16524	15691	17302	18827	23925	18827	16965	17298	17048	16591	15383
Roof tiles	1758	1946	2216	2349	2611	2466	2598	2521	2658	2849	2924
Process-related CO_2 emissions											
Masonry bricks	481	457	503	548	696	548	494	503	496	483	448
Roof tiles	50	56	63	67	75	71	74	72	76	81	84
Total	**531**	**512**	**567**	**615**	**771**	**618**	**568**	**575**	**572**	**564**	**531**
	2001	**2002**	**2003**	**2004**	**2005 [kt]**	**2006**	**2007**	**2008**	**2009**	**2010**	
Ceramics products of which:	18003	16500	16443	16796	14643	16019	16035	13867	12866	12653	
Masonry bricks	12771	11686	11631	11697	9881	10883	10885	9302	9058	8463	
Roof tiles	2642	2381	2383	2601	2485	2648	2618	2254	1919	2179	
Process-related CO_2 emissions											
Masonry bricks	372	340	338	340	288	316	317	271	264	246	
Roof tiles	76	68	68	74	71	76	75	64	55	62	
Total	**447**	**408**	**407**	**415**	**359**	**392**	**392**	**335**	**319**	**308**	

4.2.8.2 Methodological issues (2.A.7.b ceramics)

The IPCC Good Practice Guidance contains no proposals or information relative to calculation of process-related CO_2 emissions for the ceramics industry.

The CO_2 emissions are calculated via a Tier 1 method, because no detailed data are available and because this source category is not a key category.

Activity data

Official statistics are of limited use in determining actual production trends in the brick industry, in terms of weights, since such statistics list masonry-brick production in cubic metres and roof tiles in numbers of tiles. Produced weight quantities can be determined only via conversion factors. The conversion factors used for masonry bricks and roof tiles consist of values obtained by the Bundesverband der Deutschen Ziegelindustrie (German brick-industry association) from experience.

Emission factors

Process-related CO_2 emissions originate in the raw materials for production of roof tiles and masonry bricks (normally, locally available loams and clays with varying concentrations of $CaCO_3$ (limestone) and, in some cases, with organic impurities). On the basis of information from the German brick-industry association (Bundesverband der deutschen Ziegelindustrie), an emission factor of 28.6 kg / $t_{product}$ is assumed for process-related CO_2 emissions from $CaCO_3$ and organic impurities in raw materials. That figure corresponds to a mean $CaCO_3$ fraction of 65 kg/t in the raw meal.

Porous masonry bricks account for about half of all masonry bricks produced in Germany. They are produced by adding organic porosity agents to the raw materials. When the bricks are fired, these agents burn, creating hollows. Most of the porosity agents used are renewable resources (such as sludges from the paper industry, spent liquors from pulp production). Non-renewable substances (especially polystyrene) are also used, however. The resulting CO_2 emissions are minimal by comparison to those from the limestone fractions in the raw materials. Nonetheless, they are taken into account in the inventory via a slightly higher CO_2-emission factor for masonry bricks (29.1 kg CO_2/t masonry bricks, as opposed to 28.6 kg CO_2/t for roof tiles).

The determined activity rates and resulting CO_2 emissions are shown in Table 104. The process-related CO_2 emissions for this sub - source category, at considerably less than one million tonnes of carbon dioxide, are not particularly important.

4.2.8.3 Uncertainties and time-series consistency (2.A.7.b ceramics)

Due to the need for conversion of area and volume figures into produced quantities, the uncertainty for the three activity rates is estimated at +/- 20 %; no other uncertainty factors are relevant.

The uncertainties for the **CO_2-emission factors** used for production of masonry bricks and roof tiles are determined primarily by the uncertainty relative to the $CaCO_3$ quantities contained in the raw materials (+/- 30 %).

The time series are consistent for activity rates for production of masonry bricks and roof tiles, and the related CO_2-emission factors are consistent as well. Some changes have occurred, throughout the time series, in availability of statistics for various product types. These changes accounted for only about 1 % of the amounts of bricks produced, and for less than 0.5 % of total ceramics production, however.

The **activity rate** for total ceramics production contains a methods discontinuity that results from a substantial change in the available statistical data. For masonry bricks and roof tiles, figures in thousands of t were available until 1994. As of 1995, the figures are only in thousands of m^3 or thousands of units (piece count). In the NIR 2007, the relevant impacts are discussed in detail. On the other hand, the methods discontinuity is irrelevant with regard to CO_2 emissions.

4.2.8.4 Source-specific quality assurance / control and verification (2.A.7.b ceramics)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data from greenhouse-gas emissions trading cannot be compared directly with relevant emissions data from the National Inventory. The reason for this is that, in emissions trading, installations (plants) are included and grouped in accordance with threshold values, and thus data are available for only part of the ceramics industry – and only for some brick and roof-tile producers.

4.2.8.5 Source-specific recalculations (2.A.7.b ceramics)

No recalculations are required.

4.2.8.6 Planned improvements (source-specific) (2.A.7.b ceramics)

No source-category-specific improvements are planned.

4.3 Chemical industry (2.B)

Source category 2.B is divided into the sub-categories 2.B.1 through 2.B.5. These include Ammonia production (2.B.1), Nitric acid production (2.B.2), Adipic acid production (2.B.3) and Carbide production (2.B.4).

In addition, emissions from industrial carbon black production and from coke burn-off in catalyst regeneration in refineries are reported under *Other* (2.B.5). With regard to production of fertilisers, organic products, titanium dioxide and sulphuric acid, reporting covers only the pertinent precursor substances.

4.3.1 Chemical industry: Ammonia production (2.B.1)

4.3.1.1 Source category description (2.B.1)

CRF 2.B.1	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Ammonia production	**CO_2**	**L**	**T**	**5,745.0**	**(0.47%)**	**7,437.0**	**(0.78%)**	**29.45%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 3	PS	PS
NO_X			D

The source category *Chemical industry*: *ammonia production* is a key category of CO_2 emissions in terms of emissions level and trend.

Ammonia is produced on the basis of hydrogen and nitrogen, using the Haber-Bosch process, which also forms CO_2. Hydrogen is produced from synthetic gas (usually) based on natural gas, via a highly integrated process, *steam reforming*, while nitrogen is produced via air dissociation.

The various plant types for the production of ammonia cannot be divided into individual units and be compared as independent process parts, due to the highly integrated character of the procedure. In *steam reforming*, the following processes are distinguished:

- ACP – *advanced conventional process* with a fired primary reformer and secondary reforming with excess air (stoichiometric H/N ratio)
- RPR – *reduced primary reformer process*, carried out under mild conditions in a fired primary reformer, and with secondary splitting with excess air (sub-stoichiometric H/N ratio)
- HPR – *heat exchange primary reformer process* – autothermic splitting with heat exchange using a steam reformer heated with process gas (heat exchange reformer) and a separate secondary reformer or a combined autothermic reformer using excess air or enriched air (sub-stoichiometric or stoichiometric H/N ratio).

The following procedure is also used:

- Partial oxidation – Gasification of fractions of heavy mineral oil or vacuum residues in production of synthetic gas.

Ammonia is produced at five locations in Germany. The production operations use both the steam-reforming and partial-oxidation processes.

The production decrease of more than 15 % (corresponding to an amount of nearly 300 kt) in the first year after German reunification was the result of a market shake-up, over 2/3 of which was borne by the new German Länder. The production level then remained nearly constant in the succeeding years until 1994. It has not been possible to determine the reason for the renewed growth as of 1995, which returned production to the level seen in 1990. However, the growth could be due to resumption of production processes in the new German Länder, following extensive modernisations. Since 1995, production levels have fluctuated only slightly. The nearly 8% production decrease that occurred in 2009 was due to the global economic crisis. The higher IEF is higher than that of other countries, since heavy fuel oil is used in Germany, in addition to natural gas. Heavy fuel oil produces significantly higher CO_2 emissions than natural gas does.

4.3.1.2 Methodological issues (2.B.1)

In keeping with this source category's categorisation as a key category of CO_2 emissions, as of the 2010 report, emissions data for this source category are being collected and reported in accordance with the Tier 3 standard. This is being carried out on the basis of a co-operation agreement with the relevant plant operators for delivery of plant-specific data.

The operators transmit their data to the Industrieverband Agrar (IVA) agrochemical industry association. After carrying out quality assurance, that association then aggregates the data, to protect confidentiality, and forwards the resulting aggregated data to the Federal Environment Agency.

Plant operators report the following to the IVA:

- Ammonia quantities produced (**activity data**),
- The quantities of raw materials used in the process (natural gas, heavy mineral oil), less the pertinent fuel quantities used for energy purposes and so reported in the Energy Balance (TFR_i),
- The raw materials' carbon content factor (CCF_i) and carbon oxidization factor (COF_i),
- The quantity CO_2 that undergoes further processing (R_{CO2}),

Following quality assurance, the IVA aggregates the data and communicates to the Federal Environment Agency the pertinent activity rates, quantities of CO2 subjected to further processing and process-related CO_2 emissions.

CO_2 emissions:

The IVA calculates the CO_2 emissions in keeping with Equation 3.3 in the 2006 IPPC Guidelines:

$$E_{CO2} = \sum (TFR_i * CCF_i * COF_i * 44/12)$$

The recovered quantity of CO_2 that is used in other production processes – such as urea production – is included in the reported emissions.

Emission factor for NO_x:

For the NO_X emission factor, the default emission factor given in the *CORINAIR Guidebook*, 1 kg/t NH_3, is used (EMEP EEA Emission Inventory Guidebook, TFEIP-endorsed draft, May 2009).

4.3.1.3 Uncertainties and time-series consistency (2.B.1)

Using a procedure in keeping with equation 6.3 in IPCC GPGAUM, the IVA aggregates the uncertainties reported by the operators and communicates the result to the Federal Environment Agency.

The uncertainty for the activity rate is ± 0.6 %. The uncertainty for the emissions is ± 1 %.

4.3.1.4 Source-specific quality assurance / control and verification (2.B.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.3.1.5 Source-specific recalculations (2.B.1)

No recalculations are required.

4.3.1.6 Planned improvements (source-specific) (2.B.2)

In keeping with the IPCC Guidelines, reporting is to be plant-specific, in accordance with the Tier 3 reporting standard, as of the 2010 report. Consequently, no further improvements are planned.

4.3.2 *Chemical industry: Nitric acid production (2.B.2)*

4.3.2.1 Source category description (2.B.2)

CRF 2.B.2	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Nitric acid production	N_2O	-	-	3,384.4	(0.28%)	3,030.3	(0.32%)	-10.46%

Gas	Method used	Source for the activity data	Emission factors used
N_2O	Tier 3	PS	PS
NO_X			D

The source category *Chemical industry*: *nitric acid production* is not a key category.

In production of nitric acid, nitrous oxide occurs in a secondary reaction. In Germany, there are currently seven nitric acid production plants.

HNO_3 production occurs in two process stages:

- **Oxidation** of NH_3 to NO and
- **Conversion of** NO to NO_2 and **absorption** in H_2O.

Details of the process are outlined below:

Catalytic oxidation of ammonia

A mixture of ammonia and air at a ratio of 1:9 is oxidised, in the presence of a platinum catalyst alloyed with rhodium and/or palladium, at a temperature of between 800 and 950 °C. The relevant reaction, according to the Oswald process, is as follows:

$$4\,NH_3 + 5\,O_2 \rightarrow 4\,NO + 6\,H_2O$$

Simultaneously, nitrogen, nitrous oxide and water are formed by the following undesired secondary reactions:

$$4\,NH_3 + 3\,O_2 \rightarrow 2\,N_2 + 6\,H_2O$$

$$\mathbf{4\,NH_3 + 4\,O_2 \rightarrow 2\,N_2O + 6\,H_2O}$$

All three oxidation reactions are exothermic. Heat may be recovered to produce steam for the process and for export to other plants and/or to preheat the residual gas. The reaction water is condensed in a cooling condenser, during the cooling of the reaction gases, and is then conveyed into the absorption column.

4.3.2.2 Methodological issues (2.B 2)

As of the 2010 reporting round, and in keeping with the IPCC Guidelines, nitric-acid production is now reported plant-specifically, in accordance with the Tier 3 standard. This is being carried out on the basis of a co-operation agreement with the relevant plant operators for delivery of plant-specific data.

The operators of six plants transmit their data to the Industrieverband Agrar (IVA) industry association.

Plant operators report the following to the IVA:

- Nitric acid quantities produced (**activity data**),
- The EF,
- The N_2O emissions measured in the raw gas,
- Where emissions-reduction equipment is used, also the N_2O emissions measured in the emissions-reduced exhaust gas.

After carrying out quality assurance, the IVA aggregates the data, to protect confidentiality, and then transmits the so-aggregated data to the Federal Environment Agency (AR and EF). Pursuant to the IVA, the emission abatement techniques used include catalytic decomposition directly following ammonia combustion. The N_2O emissions are then calculated in keeping with the formula EM = AR * EF.

One company sends its data (AR, EF, N_2O emissions and information about any reduction equipment used) directly to the Federal Environment Agency. After carrying out quality assurance, the Federal Environment Agency then aggregates that company's data with the data provided by the IVA and enters the resulting so-aggregated data into the CSE emissions database.

Until 2006, production quantities correlated with the N_2O emissions. Subsequently, a decoupling of production quantities and N_2O emissions has become apparent that is due to use of emissions-reduction equipment.

NO_X **emission factor:**

For the NO_X emission factor, the default emission factor given in the *CORINAIR Guidebook*, 10 kg/t NH_3, is used (EMEP EEA Emission Inventory Guidebook, TFEIP-endorsed draft, May 2009).

4.3.2.3 Uncertainties and time-series consistency (2.B.2)

Activity rate:

The activity-rate uncertainty, as provided by the operators, has been determined, as specified by the IVA / the Federal Environment Agency, in keeping with Equation 6.3 in IPCC GPGAUM. The pertinent uncertainty is ± 1 %.

Emission factor:

For the N_2O emission factor, the operators give an uncertainty of ± 5 %.

4.3.2.4 Source-specific quality assurance / control and verification (2.B.2)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.3.2.5 Source-specific recalculations (2.B.2)

No recalculations are required.

4.3.2.6 Planned improvements (source-specific) (2.B.2)

In keeping with the IPCC Guidelines, reporting is to be plant-specific, in accordance with the Tier 3 reporting standard, as of the 2010 report. Consequently, no further improvements are planned.

4.3.3 Chemical industry: Adipic acid production (2.B.3)

4.3.3.1 Source category description (2.B.3)

CRF 2.B.3	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Adipic acid production	**N_2O**	**L**	**T**	**18,804.6**	**(1.54%)**	**716.4**	**(0.08%)**	**-96.19%**

Gas	Method used	Source for the activity data	Emission factors used
N_2O	T3	PS	D, PS
NO_X, CO			NE

The source category *Chemical industry*: *adipic acid production* is a key category of N_2O emissions in terms of emissions level and trend.

The EF calculation for N_2O emissions from adipic acid production conforms to the Tier 3a method specified in the IPCC Guidelines for National Greenhouse Gas Inventories 2006.

On an industrial scale, adipic acid is produced via oxidation of a mixture of cyclohexanol and cyclohexanone (ratio: 93/7). Pursuant to IPCC-GPG (2000: Tab. 3.7, note a), only one facility, located in Japan, is presumed to use pure cyclohexanol (the EF there is 264 kg/t); at other facilities, adipic acid is produced from cyclohexanol, with varying amounts of ketone and nitric acid. In that reaction, considerable amounts of nitrous oxide (N_2O) are formed. Until the end of 1993, the two sole German producers emitted all of their nitrous oxide directly into the atmosphere. One producer has since patented, and put into operation, a system for thermal decomposition of nitrous oxide into nitrogen and oxygen. Decomposition takes place nearly completely. At the end of 1997, the other producer put a catalytic reactor system into operation that, in constant operation, achieves an N_2O-decomposition rate of 96-98 %. In March 2002, operations were begun with a plant, from another producer, that also uses thermal N_2O decomposition. Following initial technical problems, the system has been in constant operation since 2003. The overall fluctuations in decomposition rates – and, thus, the remaining emissions – are maintenance-related and production-dependent. In 2009, one producer commissioned a second, additional (i.e. redundant) thermal N_2O-decomposition facility. Since that facility went into operation, N_2O-decomposition rates of over 99% have been achieved. At the end of 2009, a second producer commissioned a second, additional (i.e. redundant) decomposition reactor. N_2O emissions exhibited further significant decreases in 2009 and 2010, as a result of the installation of the two redundant waste-gas treatment facilities.

From 1990 to the present, production has more than doubled, as a result of growth in demand.

4.3.3.2 Methodological issues (2.B.3)

Until around the mid-1990s, producers provided data only on amounts produced. The IPCC default emission factors have been used to calculate nitrous oxide emissions for that period. For the subsequent period, in addition to reporting their production figures, producers also confidentially reported their N_2O emissions, along with necessary background information. This fact is highly significant with regard to the precision of the reported data; without data on technically unavoidable N_2O production, and – especially – without information as to the operating period of the relevant decomposition facilities, estimates of the reduction in nitrous oxide emissions would have been so imprecise that it would have been necessary to continue using the default EF.

The fluctuations in the emissions data are the result of disruptions of emissions-reduction systems (maintenance work, fire damage, other failures of system components) and of production increases.

4.3.3.3 Uncertainties and time-series consistency (2.B.3)

The uncertainties in time-series consistency have been eliminated, since all manufacturers now provide the relevant data. IPCC GL 2006 specifies uncertainties of +/- 0.05% for plants with thermal decomposition and of +/- 2.5% for plants with catalytic decomposition. According to producers' information, the uncertainties, regardless of what reduction process is used, lie within a range of +/- 5 to 5.9 %. The range for uncertainties relative to production quantities is given as +/-0.06 to 1 %. The EF is thus assumed to have an uncertainty of 5.9 %.

4.3.3.4 Source-specific quality assurance / control and verification (2.B.3)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Information provided by producers enjoys a high degree of confidentiality protection. For this reason, only emissions figures can be listed in the CRF tables. The reported emissions and activity rates have been reviewed by a Federal Environment Agency expert and compared with industry figures and figures from other publications.

4.3.3.5 Source-specific recalculations (2.B.3)

No recalculations are required.

4.3.3.6 Source-specific planned improvements (2.B.3)

No improvements are planned at present.

4.3.4 *Chemical industry: Carbide production (2.B.4)*

4.3.4.1 Source category description (2.B.4)

CRF 2.B.4	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Carbide production	CO_2	-	-	443.2	(0.04%)	17.1	(0.00%)	-96.14%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	T3	PS	PS (CaC_2) NO (SiC)

The source category *Chemical industry*: *carbide production* is not a key category.

During the reunification period, calcium carbide production took place primarily in the new German Länder. A short time later, production there was discontinued, while only one producer remained in the old German Länder. In the period under consideration, this producer cut his production by about half.

According to the responsible specialised association within the VCI, no silicon carbide has been produced in Germany since 1993. Emissions from this sector thus no longer occur.

4.3.4.2 Methodological issues (2.B.4)

Activity rate:

Since Germany has only one producer, the relevant data must be kept confidential. The only published data consists of that for amounts produced in the former GDR. That data was published, until 1989, by that country's central statistical authority. Those figures were used, in combination with existing estimates for 1991 and 1992, to interpolate production in the new German Länder in 1990.

Emission factor:

The stoichiometric emission factor for CO_2 is 688 kg per tonne of calcium carbide (44 g mol^{-1} / 64 g mol^{-1}). Until 1992, this emission factor was used for production in the new German Länder.

In covered furnaces, producers collect all of the carbon monoxide produced in the process and recycle it for further use. Following such use for energy recovery – i.e. following its combustion to produce carbon dioxide – it serves as an auxiliary substance for production of lime nitrogen and secondary products. Reactions in these processes yield carbon dioxide in mineral form, as black lime. In this form, it is used in agriculture.

As a result, to this day production in the old German Länder achieves a substantially lower emission factor for carbon dioxide from calcium carbide production.

Upon request, the relevant producer provides the Federal Environment Agency with data on the degree of reduction achieved – and, thus, on the emission factor involved – and on amounts produced. The total emissions are calculated as the product of activity rate and emission factor.

4.3.4.3 Uncertainties and time-series consistency (2.B.4)

Consistency is not complete, due to the described need to estimate production amounts in the new German Länder.

The uncertainties relative to the data provided by the producer are considered slight overall. The assumed reduction rate of about 80% should be seen as an average value for the time period in question. As a result of use of green petrol coke, the composition of gas in carbide furnaces has changed, and this keeps the reduction rate from climbing still higher.

4.3.4.4 Source-specific quality assurance / control and verification (2.B.4)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Producers' relevant figures enjoy a high degree of confidentiality protection. For this reason, only emissions figures can be listed in the CRF tables. No calculations for verification could be carried out. It may be noted, however, that some of the figures have also been provided to licensing authorities and thus are considered trustworthy.

4.3.4.5 Source-specific recalculations (2.B.4)

No recalculations are required.

4.3.4.6 Planned improvements (source-specific) (2.B.4)

No improvements are planned at present.

4.3.5 Chemical industry – other: Emissions from other production processes (2.B.5)

4.3.5.1 Source category description (2.B.5)

CRF 2.B.5	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Other	**CO_2**	**L**	**T/T2**	**6,888.2**	**(0.56%)**	**8,826.9**	**(0.93%)**	**28.15%**
Other	N_2O	-	-	292.7	(0.02%)	62.0	(0.01%)	-78.82%
Other	CH_4	-	-	0.3	(0.00%)	0.4	(0.00%)	70.47%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	T2 (carbon black, methanol) CS (all other)	AS (coke burn-off in catalyst regeneration) NS (all other)	CS
CH_4	T2 (carbon black) CS (all other)	NS	CS (carbon black) D (ethylene, styrene, methanol, 1.2-dichloroethane)
CO, SO_2 NMVOC			D (carbon black) CS (ethylene, styrene)

The source category *Chemical industry*: *Emissions from other production processes* is a key category of CO_2 emissions in terms of both emissions level and trend.

A range of different chemical production processes are potential sources of CO_2, CH_4 and NMVOC emissions. These processes include production of carbon black, ethylene (ethene), ethylene dichloride (1,2-dichloroethane), styrene and methanol, and, in refineries, coke burn-off for catalyst regeneration.

In refinery operations, coke burn-off for catalyst regeneration occurs in catalytic cracking plants in which desulphurised vacuum and other gasoil distillates are broken down at temperatures of about 550°C, in a water-vapour atmosphere, into refinery gas, liquid gases, gasoline fractions and medium distillates. CO_2 emissions also occur in catalyst regeneration in the reforming process, which is designed to increase octane levels in raw gasoline and to generate hydrocarbon aromates via isomerisation and ring formation. The fluid catalytic cracking (FCC) process is now the leading process used for this purpose. During cracking reactions in an FCC reactor, coke is deposited on the catalyst. That coke is then burned off, via air input, in the regenerator. In the reforming process, platinum is used as the catalyst, in combination with rhenium and tin, and applied to acidic aluminium oxide. The catalyst grows ineffective as a result of process-related deposition of coke on its active centres. In catalyst regeneration, coke is burned-off to restore proper catalytic function. CO_2 is released in these combustion processes.

Since the early 1990s, German caprolactam producers have used thermal waste-gas treatment in their production operations. N_2O emissions no longer occur in those operations.

4.3.5.2 Methodological issues (2.B.5)

CO_2 emissions

In the 2006 reporting year, reporting on CO_2 emissions into the atmosphere was added for the sources carbon-black production, methanol production, transformation processes and coke burn-off for catalyst regeneration in refineries.

For CO_2 from carbon-black production, the default emission factor from the IPCC Guidelines 2006 is used (Table 3.23, Furnace black process (default process), primary feedstock). The industry was unable to confirm the previously used EF, which was obtained via a research project. The emission factor for methanol is confidential.

With regard to refineries, only catalyst regeneration is taken into account. Reviews to date indicate that other emissions sources from refineries (heavy-oil gasification, calcination and hydrogen production) are already covered as part of refineries' own consumption (cf. Chapter 3.2.7).

CH_4 emission factors

The international guidelines give very little attention to this source category. The IPCC Guidelines list as potential sources – without any claim to completeness – production of carbon black, ethylene, dichloroethylene (1,2-dichloroethane), styrene and methanol. The Guidelines list emission factors for the processes that were identified in studies from 1987 and 1988; those IPCC default EF (1996 Guidelines) are listed in Table 105 below.

Table 105: IPCC default emission factors for CH_4 from other chemical industry processes

Carbon black	Styrene	Ethylene	1,2-dichloroethane[37]	Methanol
		[kg CH_4/t]		
0.06 (with thermal post-combustion) 28.7 (without thermal treatment)	4	1	0.4	2

The IPCC Good Practice Guidance does not discuss this subject further.

Pursuant to Point 5.2.5 of the TA Luft (Technical Instructions on Air Quality Control), German plants subject to the TA Luft must meet a standard of 50 mg/m³ (total carbon) for total mass concentration of organic substances (NMVOC and $CH_{4,}$, but not including organic substances in dust form). The current state of the art provides for thermal post-combustion of volatile organic substances from plants for production of primary organic chemicals.

In keeping with these technical standards, the three German producers of carbon black report an emission factor of 0.027 kg methane per tonne of carbon black. Since relevant technology has been in service since the 1970s, this EF is rounded off to 0.03 kg/t and applied to the entire time series.

As to the other four products, the largest German producer reports that no further methane emissions occur in those areas, thanks to thermal post-combustion. This technology has

[37] Remark: In this IPCC table (Workbook p. 2.22, Tab. 2-9 and Reference Manual p. 2.23, Tab. 2-10), dichloroethylene has been replaced with ethylene dichloride (1,2–dichloroethane). This seems appropriate, since the relevant subsequent tables (2-10 and 2-11) list only "1,2, dichloroethane" and since the source listed by the IPCC Reference Manual on p. 2.67, Stockton et al., p. 49, also speaks of the substance "ethylene dichloride".

been in service since the 1980s, and thus the pertinent emission factors can be applied to the entire time series.

Table 106: national emission factors for CH_4 from other chemical industry processes

Carbon black	Styrene	Ethylene	1,2-dichloroethane[37]	Methanol
[kg CH_4/t]				
0.03	0	0	0	0

Emission factors for NMVOC, CO and SO_2

For pollutants other than the methane considered above, the emission factors listed in Table 107 were used for Germany.

Table 107: Emission factors used in Germany for other pollutants

	Carbon black [kg CO / t]	Carbon black [kg SO_2/t][38]	Ethylene [kg NMVOC / t]	1,2 - dichloroethane [kg NMVOC / t]	Polystyrene [kg NMVOC / t]	Styrene [kg NMVOC / t]
1990	4.8 / 5	19,5 / [(39)]	5	C	1	0.02
1991	4.6 / 5	19 / 20	5	C	1	0.02
1992	4.4 / 5	18.5 / 20	5	C	1	0.02
1993	4.2	18	5	C	1	0.02
1994	4	17.5	5	C	1	0.02
1995	3.75	17	0.4	C	0.6	0.02
1996	3.5	16	0.3	C	0.4	0.02
1997	3.25	15	0.3	C	0.4	0.02
1998	3	14	0.25	C	0.32	0.02
1999	2.9	13.4	0.25	C	0.32	0.02
2000	2.8	12.8	0.2	C	0.27	0.02
2001	2.7	12.54	0.2	C	0.27	0.02
2002	2.65	12.28	0.2	C	0.27	0.02
2003	2.6	12.0	0.2	C	0.27	0.02
2004	2.55	11.7	0.2	C	0.27	0.02
2005	2.5	11.5	0.2	C	0.27	0.02
2006	2.5	11.2	0.2	C	0.27	0.02
2007	2.5	10.9	0.2	C	0.27	0.02
2008	2.5	10.6	0.2	C	0.27	0.02
2009	2.5	10.3	0.2	C	0.27	0.02
2010	2.5	10.0	0.2	C	0.27	0.02

The NMVOC emission factors for polystyrene were taken from the European Commission (EC, 2006a, BAT Reference Document (BREF), Production of Polymers), while for other products figures of German producers were used (these figures are available as confidential data). The default factors were used until 1994. The EF figures for CO and SO_2, for production of carbon black, are based on the BREF Large Volume Inorganic Chemicals - LVIC – S (EC, 2007) and are identical with the default values presented in the 2008 CORINAIR manual (first order draft).

Activity rates

The production statistics of the Federal Statistical Office include the following products (Table Table 108):

[38] Where two EF are listed, the second figure refers to the new German Länder.
[39] No EF is listed for the new German Länder, since these SO_2 emissions can be taken account of only as a lump sum.

Table 108: Reporting numbers (Meldenummern) from production statistics

Line	Polystyrene	Methanol	1,2-dichloroethane	Carbon black	Ethylene	Styrene
through 1994	4414 42	4232 11	4228 22	4113 70	4221 11	4224 60
since 1995	2416 20 350 and ...390	2414 22 100	2414 13 530	2413 11 300	2414 11 300	2414 12 500
since 2009				2013 21 300		

The figure for carbon-black production in the new German Länder in 1990 was taken from the Statistical Yearbook (Statistisches Jahrbuch) for the Federal Republic of Germany (*STATISTISCHES BUNDESAMT*, 1992: p. 234); the figures for 1991 and 1992 were estimated, due to confidentiality requirements. The other data for carbon-black production as of 1990 were obtained from the Federal Statistical Office (*STATISTISCHES BUNDESAMT*, Fachserie 4, Reihe 3.1, Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe ("manufacturing industry; production in the manufacturing industry").

4.3.5.3 Uncertainties and time-series consistency (2.B.5)

The emission factors for ethylene, methanol, 1,2-dichloroethane and styrene are based on evaluations carried out by German producers. In the 1980s, thermal post-combustion was introduced on a large scale. As a result, emissions of organic substances from German plants are low enough to be neglected. The uncertainties cannot be estimated, however. The new emission factors are valid for the entire time series. Fluctuations in the activity rates have occurred over the period under consideration. The reasons for this are unknown. Since the production-quantity data – apart from a few insignificant estimates – have come from a trustworthy source, the pertinent uncertainties may be considered small. Corrections to producers' figures might be made within a three-year period, however. In spite of the survey changes that have occurred within the period under consideration, the data are considered to be consistent.

4.3.5.4 Source-specific quality assurance / control and verification (2.B.5)

Quality control (pursuant to Tier 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out for the "carbon black" and "coke burn-off in catalyst regeneration".

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance for "methanol production" carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors for ethylene, ethylene chloride and styrene.

4.3.5.5 Source-specific recalculations (2.B.5)

No recalculations are required.

4.3.5.6 Planned improvements (source-specific) (2.B.5)

No improvements are planned at present.

4.4 Metal production (2.C)

Source category 2.C is divided into the sub-categories 2.C.1 through 2.C.5. In the CSE emissions database, sub-category Iron and steel production (2.C.1) includes sinter production, pig-iron production, iron and steel production and tempered castings. Production of ferroalloys (2.C.2) is listed directly as such in the CSE. Aluminium production (2.C.3) is sub-divided into primary aluminium and resmelted aluminium. Use of SF_6 in aluminium and magnesium production (2.C.4) is not further sub-divided. In the CSE, sub-category Other (2.C.5) includes lead production, thermal galvanisation, copper production and zinc production.

4.4.1 Metal production: Iron and steel production (2.C.1)

4.4.1.1 Source category description (2.C.1)

CRF 2.C.1	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Steel (integrated production)	**CO_2**	**L**	**T/T2**	**22,711.9**	**(1.86%)**	**18,208.0**	**(1.91%)**	**-19.83%**
Steel (integrated production)	N_2O	-	-	27.6	(0.00%)	17.3	(0.00%)	-37.36%
Steel (integrated production)	CH_4	-	-	3.9	(0.00%)	4.5	(0.00%)	13.61%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 2	NS	CS
CH_4	IE	IE	IE
N_2O	IE	IE	IE
NO_X, CO, NMVOC, SO_2	Tier 2	NS	CS

The source category *Iron and steel production* is a key category of CO_2 emissions in terms of emissions level and trend.

In 2010, a total of 31.8 million t of raw steel, from ore, was produced in Germany in six integrated steel works. Electric steel production amounted to 13.2 million t.

4.4.1.2 Methodological issues (2.C.1)

This sector comprises process-related emissions from primary steel production (via blast furnaces and oxygen-steel plants) and from electric steel plants.

Other structural elements in this source category (foundries: iron and steel casting (including malleable casting); steel production: rolled-steel production) are used for calculation of other pollutant emissions (not greenhouse-gas emissions).

Process-related CO_2 emissions from primary steel production in integrated smelters result primarily from use of reducing agents in blast furnaces. CO_2 emissions from limestone inputs in sinter plants and in pig-iron production, and CO_2 emissions from electrode consumption in electric steel production, are added to process-related emissions in sector 2.C.1.

Method for calculating the CO_2 emissions resulting from use of reducing agents in blast furnaces

Until the NIR 2009, CO_2 emissions from primary steel production were determined via the input quantities of reducing agents; those, in turn, were taken from the Energy Balance. Via use of a theoretical factor for the reducing-agent quantities required for an ideal blast-furnace process, a majority of the determined emissions were assigned to source category 2.C.1. The remaining emissions from use of reducing agents were reported under 1.A.2.a. That approach was in keeping with the allocation method for the 1st trading period of greenhouse-gas-emissions trading. Since that special method is now no longer used in emissions trading, it no longer seemed suitable for the inventory. The methods change carried out with the resubmission of the 2010 NIR will help enhance transparency and comparability in the reports.

Pursuant to the IPCC Guidelines, the CO_2 emissions in source category 2.C.1 are to be determined via a carbon balance. The reason for this requirement is that virtually all of the carbon used for primary steel production is subsequently released into the atmosphere, as CO^2, in later energy-related use, or in flaring, of the top gas that forms in the blast furnace or of the converter gas that forms in the oxygen steel converter. The share of carbon that remains in produced steel, or in that portion of pig iron that is not processed into steel, is not important by comparison to the CO_2 emissions related to use of reducing agents[40].

There are thus two ways of calculating the CO_2 emissions resulting from use of reducing agents: either via the quantity of reducing agents used (carbon input) or via the production of top gas and converter gas (carbon output). Relevant statistical information is available, at the national level, for both approaches. The two approaches produce different emissions results, however; the emissions as calculated via the quantities of top gas / converter gas used are higher, throughout, than those that result via calculation with quantities of reducing agents. That statistical difference, which has been growing in the years since 2003, cannot be logically explained. In keeping with the principle of conservative estimation, it was decided to use quantities of top gas and converter gas as the basis for the emissions calculation. That was also the procedure recommended by the Climate Secretariat's expert commission, which reviewed Germany's 2010 inventory report in September 2010.

Only part of all energy-related use of top gas and converter gas is found in source category 2.C.1. Such gas is used for other process combustion in the iron and steel industry (1.A.2.a); in coking plants, for bottom heating of coking furnaces (1.A.1.c); and for electricity generation in public power stations (1.A.1.a) and industrial power stations (1.A.2.f). The German Energy Balance provides information relative to top-gas and converter-gas consumption in all of the aforementioned source categories. Consequently, the CO_2 emissions resulting from reducing-agent inputs for primary steel production are divided among all source categories in which top gas and converter gas are burned and, thus, CO_2 is actually emitted (cf. the following figure).

[40] The average carbon fraction in the more than 2000 types of steel produced in Germany is normally considerably smaller than 2%. It is not recorded statistically, however. In any case, the pertinent deduction of non-energy-related carbon is extremely small (<1.5 %) in comparison to the total CO_2 emissions from primary steel production. Since only about 3% of the pig iron produced in Germany is not processed into oxygen steel, the pertinent deduction of non-energy-related carbon is also marginal (ca. 0.1%).

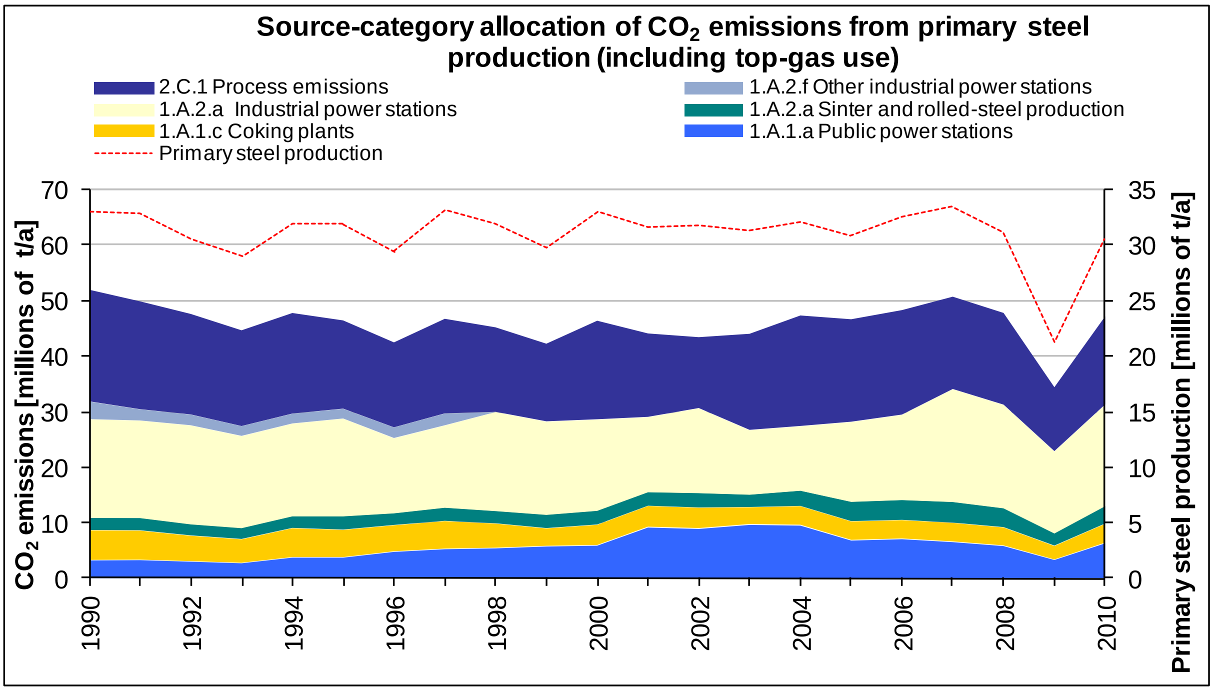


Figure 42: Chronological trend and source-category allocation of the CO_2 emissions resulting from use of reducing agents for primary steel production and from use of top gas

The sum of the CO_2 emissions shown shows good correlation with the activity rates reported for primary steel production (cf. the broken red line). Annual fluctuations in the individual source categories are probably due to changes in allocation of individual plants within official statistics. Such fluctuations have practically no impact on the total sum of reported emissions, however.

Table 109: CO_2 emissions from primary steel production (including top-gas use)

Mt CO_2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1.A.1.a Public power stations	3.236	3.283	3.008	2.719	3.744	3.745	4.796	5.282	5.440	5.782
1.A.1.c Coking plants	5.328	5.234	4.579	4.220	5.201	4.899	4.686	4.947	4.342	3.131
1.A.2.a Sinter and rolled-steel production	2.223	2.251	2.041	2.001	2.136	2.433	2.142	2.408	2.245	2.433
1.A.2.a Industry power stations	17.845	17.619	17.885	16.639	16.761	17.670	13.565	14.870	17.896	16.857
1.A.2.f Other industry power stations	3.198	2.020	1.937	1.765	1.766	1.761	1.923	2.135	0.000	0.000
2.C.1 Process emissions	20.245	19.566	18.233	17.369	18.244	16.000	15.407	17.159	15.330	14.082
Mt CO_2	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
1.A.1.a Public power stations	5.930	9.243	8.990	9.723	9.597	6.866	7.112	6.578	5.858	3.317
1.A.1.c Coking plants	3.636	3.725	3.668	3.015	3.341	3.308	3.293	3.332	3.230	2.421
1.A.2.a Sinter and rolled-steel production	2.508	2.476	2.618	2.255	2.776	3.526	3.616	3.761	3.441	2.242
1.A.2.a Industry power stations	16.500	13.567	15.337	11.657	11.643	14.432	15.406	20.395	18.698	14.812
1.A.2.f Other industry power stations	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2.C.1 Process emissions	17.879	15.131	12.856	17.432	20.046	18.587	18.953	16.749	16.639	11.601
Mt CO_2	**2010**									
1.A.1.a Public power stations	6.356									
1.A.1.c Coking plants	3.390									
1.A.2.a Sinter and rolled-steel production	3.174									
1.A.2.a Industry power stations	18.352									
1.A.2.f Other industry power stations	0.000									
2.C.1 Process emissions	15.979									

In the iron and steel industry, secondary fuels are used only in pig iron production in blast furnaces. To date, these materials have not yet been included in national statistics and the Energy Balance. For this reason, the data used consisted of figures provided by the Wirtschaftsvereinigung Stahl steel-industry association. Since the secondary fuels are used solely as substitute reducing agents, in place of coke, the CO_2 emissions resulting from their use are also included in the CO_2 emissions determined via inputs of top gas and converter gas and do not have to be calculated separately.

Determination of CO_2 emissions from limestone inputs in pig iron production

CO_2 emissions from limestone use are determined in accordance with Tier 1 (UBA 2006, FKZ 20541217/02). The steel industry uses limestone ($CaCO_3$) only in processing of iron ores (sintering plants) and in pig iron production in blast furnaces. In the oxygen steel and electric steel processes, already burnt lime for steel-mill applications (CaO) is used as a slag former; the CO_2 emissions released in producing that burnt lime are thus already reported under 2.A.2. Until 2004, limestone inputs in sinter and pig iron production were published as part of iron and steel statistics (*STATISTISCHES BUNDESAMT* Fachserie 4, Reihe 8.1). Since then, they have to be calculated from the production quantities of sinter and pig iron reported by the association, via specific input factors (kg of limestone per tonne of sinter or pig iron). Multiplying the activity rates for limestone inputs by the stoichiometric emission factor for limestone produces the CO_2-emissions figures given in Table Table 110.

Table 110: Limestone inputs and resulting CO_2 emissions in sinter and pig iron production

	Limestone input [t/a]		CO_2 emissions [t/a]		
Year	**Pig iron**	**Sinter**	**Pig iron**	**Sinter**	**Total**
1990	755,737	4,680,775	332,524	2,059,541	2,392,065
1991	757,000	4,532,000	333,080	1,994,080	2,327,160
1992	666,000	4,198,000	293,040	1,847,120	2,140,160
1993	627,000	3,891,000	275,880	1,712,040	1,987,920
1994	733,000	4,173,153	322,520	1,836,187	2,158,707
1995	751,000	4,600,000	330,440	2,024,000	2,354,440
1996	686,000	4,350,000	301,840	1,914,000	2,215,840
1997	629,000	4,471,000	276,760	1,967,240	2,244,000
1998	677,000	4,588,000	297,880	2,018,720	2,316,600
1999	817,000	4,144,000	359,480	1,823,360	2,182,840
2000	924,000	4,273,000	406,560	1,880,120	2,286,680
2001	866,000	4,136,000	381,040	1,819,840	2,200,880
2002	831,000	3,940,000	365,640	1,733,600	2,099,240
2003	832,525	4,046,711	366,311	1,780,553	2,146,864
2004	847,689	4,209,871	372,983	1,852,343	2,225,326
2005	787,724	4,306,067	346,599	1,894,669	2,241,268
2006	822,920	4,410,408	362,085	1,940,580	2,302,664
2007	840,868	4,608,067	369,982	2,027,549	2,397,531
2008	790,216	4,541,174	347,695	1,998,117	2,345,812
2009	547,680	3,496,405	240,979	1,538,418	1,779,397
2010	799,679	4,045,042	351,859	1,779,818	2,131,677

Source: until 2004: Calculations from the "limestone balance" project ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02);
as of 2005: calculations via the product-specific factors determined in the aforementioned project

Determination of CO_2 emissions from limestone inputs in pig iron production

In electric steel production, CO_2 emissions occur directly via consumption of graphite electrodes. These emissions must also be allocated to process-related CO_2 emissions for steel production. They are calculated from the quantity of produced electric steel, via an emission factor that was newly determined in 2009 (7.4 kg/t) and that is based on the specific electrode consumption per tonne of electric steel (2.06 kg/t), its carbon content (98%) and the relevant stoichiometric factor (3.667 t CO_2/t C). The contribution from electrode combustion in electric steel production, at about 0.2% of total CO_2 emissions in iron and steel production, is insignificant.

Determination of the total CO_2 emissions from iron and steel production to be reported under 2.C.1

The total process-related emissions to be reported under 2.C.1 consist of the following:

1. The CO_2 emissions resulting from use of reducing agents in primary steel production, where the relevant top gas and converter gas is not used in other source categories and thus reported under other categories as CO_2 emissions
2. The CO_2 emissions from limestone inputs in pig iron production, and
3. The CO_2 emissions from electrode consumption in electrical steel production

The relevant so-determined emissions quantities are shown in Table 112.

Table 111: Total process-related emissions to be reported under 2.C.1

Year	CO_2 emissions from use of reducing agents, where not reported in other source categories [t/a]	CO_2 emissions from limestone inputs [t/a]	CO_2 emissions from electrode consumption [t/a]	2.C.1 total [t/a]
1990	20,244,570	2,392,065	75,242	22,711,877
1991	19,566,299	2,327,160	68,464	21,961,923
1992	18,233,163	2,140,160	64,358	20,437,681
1993	17,368,898	1,987,920	59,840	19,416,658
1994	18,244,329	2,158,707	65,783	20,468,820
1995	15,999,678	2,354,440	74,794	18,428,912
1996	15,407,293	2,215,840	76,291	17,699,424
1997	17,159,145	2,244,000	87,552	19,490,696
1998	15,330,371	2,316,600	89,196	17,736,167
1999	14,081,926	2,182,840	90,457	16,355,223
2000	17,878,539	2,286,680	98,251	20,263,471
2001	15,130,790	2,200,880	96,961	17,428,630
2002	12,856,088	2,099,240	97,381	15,052,709
2003	17,432,279	2,146,864	99,048	19,678,190
2004	20,045,595	2,225,326	104,984	22,375,905
2005	18,587,293	2,241,268	100,780	20,929,341
2006	18,952,642	2,302,664	108,206	21,363,512
2007	16,749,314	2,397,531	110,721	19,257,566
2008	16,638,663	2,345,812	107,948	19,092,423
2009	11,600,674	1,779,397	83,590	13,463,660
2010	15,978,881	2,131,677	97,446	18,208,004

4.4.1.3 Uncertainties and time-series consistency (2.C.1)

The time series is consistent, since the activity rates have been determined for all plants and since the same method has been used to determine the emissions for all years concerned.

A discontinuity in methods is seen in the case of CO_2 emissions from limestone inputs, from 2004 to 2005; it results from the absence of the data source used until 2004. The time-series trend seems plausible in spite of this discontinuity. In keeping with the required calculation, the uncertainty for the activity rate here is ± 10%.

The uncertainty for the emission factor for electrode consumption is ± 3 %, while the uncertainty for the other data is ± 5 %, since it is based solely on inaccuracies in measurement and analysis.

4.4.1.4 Source-specific quality assurance / control and verification (2.C.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Determining emissions in source categories 1.A.2.a and 2.C.1 is a complex task, since the Energy Balance, emissions reporting, emissions trading and association statistics differ widely in terms of their underlying methods. In the interest of data quality assurance, regular experts' discussions are carried out for the purpose of comparing and evaluating data. As a result of the methodological differences, plausibility checks of the determined emissions quantities, using data of the German emissions trading authority, are possible only at a highly aggregated level. A research project that is currently in progress, and that is expected to be concluded in 2012, is studying ways of preparing emissions-trading data specifically for plausibility checking of reported emissions.

4.4.1.5 Source-specific recalculations (2.C.1)

The activity data for 2009 were recalculated on the basis of updated statistiscal data.

4.4.1.6 Planned improvements (source-specific) (2.C.1)

The plausibility of the consistent statistical figures, net calorific values and emission factors required for the carbon balance for primary steel production is to be reviewed via discussions among experts.

4.4.2 Metal production: Ferroalloys production (2.C.2)

4.4.2.1 Source category description (2.C.2)

CRF 2.C.2	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Ferroalloys	CO_2	-	-	429.0	(0.04%)	5.5	(0.00%)	-98.72%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	T2	IS	CS
NO_X, CO, NMVOC, SO_2			NE

The source category *Ferroalloys production* is not a key category. Ferroalloys are aggregates that are alloyed with steel. There are five ferroalloy producers in Germany; ferrochromium, ferrosilicon and silicon metal are each produced by only one company, and other ferroalloys are produced only in small quantities. According to data of the US Geological Survey, in 2009, 33,667 t of ferroalloys were produced in Germany in 2007. The only process in use since 1995 is the electric arc process, a process that releases only small amounts of process-related CO_2, with such releases occurring in electrode consumption.

Until 1995, the blast-furnace process, which produces relatively higher CO_2 emissions, was used to some extent.

4.4.2.2 Methodological issues (2.C.2)

The **emission factors** for the aforementioned two processes (blast-furnace and electric-arc processes) were determined in the research project "NEW CO_2" ("NEU-CO_2") (FKZ 203 41 253/02).

For the period since 1994, the **activity rate** is determined via data of the US Geological Survey (USGS). The most current data date from 2009. Those figures have also been used for the year 2010.

4.4.2.3 Uncertainties and time-series consistency (2.C.2)

The activity rates provided by the U.S. Geological Survey (USGS) are based partly on estimates and thus are subject to relatively large uncertainties.

For the period 2001 – 2006, data of the Federal Statistical Office (DESTATIS) on sales of ferroalloys are available. Those data are lower, by a factor of 0.7, than the production data of the USGS, however. In the interest of the consistency of the time series, the USGS data have thus also been used for those years.

The considerable decrease in the CO_2 emission factor that took place from 1994 to 1995 does not represent any inconsistency; it is the result of the change in the production process.

4.4.2.4 Source-specific quality assurance / control and verification (2.C.2)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The activity rates used, which come from the USGS, have been verified with the help of the DESTATIS figures (see above). The emissions figures were not compared with corresponding figures from other other data sources for Germany, because no other data sources for emissions in category 2.C.2 are known.

4.4.2.5 Source-specific recalculations (2.C.2)

No recalculations are required.

4.4.2.6 Planned improvements (source-specific) (2.C.2)

No improvements are planned at present.

4.4.3 Metal production: Primary aluminium production (2.C.3)

4.4.3.1 Source category description (2.C.3)

CRF 2.C.3	Gas	Key category		1995/1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
All fuels	**PFC**	**-**	**T**	**1,551.7**	**(0.13%)**	**134.6**	**(0.01%)**	**-91.32%**
All fuels	CO_2	-	-	1,011.9	(0.08%)	550.6	(0.06%)	-45.59%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	Tier 3	AS	CS
CH_4	-	-	NE
PFC	Tier 3	AS	CS
NO_X	-	-	NE
CO, SO_2		AS	CS

The source category *Primary aluminium production* is a key category of PFC emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-91.32 %), and thus an extremely low emissions level has been attained (in 2010, emissions amounted to 3.85 % of the contribution of the smallest key category identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

In Germany, aluminium is produced at four foundries, in electrolytic furnaces with pre-burnt anodes. The principal emission sources are the waste gases from the electrolytic furnaces and fugitive emissions via the hall roofs. The climate-relevant substances and air pollutants that are emitted especially include CO, CO_2, SO_2, CF_4 and C_2F_6.

Production of primary aluminium continues to be the largest source of PFC emissions in Germany, in spite of the considerable reductions that have been achieved since 1990. Thanks to extensive modernisation measures in German aluminium foundries, and to decommissioning of production capacities, absolute emissions from this sector fell by 91 % between 1995 and 2010. As to the future development of PFC emissions, stagnation at a low level can be expected.

4.4.3.2 Methodological issues (2.C.3)

The production figures for the year 2010 were taken from the monitoring report by the aluminium industry for the year 2010 (GDA, 2010). The average anode consumption is 430 kg of petrol coke per tonne of aluminium. Table 112 shows the process-related emission factors.

The total quantity of waste gas incurred per tonne of aluminium during the production of primary aluminium was multiplied by an average concentration value formed from several individual figures, from various different plants, with appropriate weighting. The emission factors also make allowance for fugitive emission sources, such as emissions via hall roofs. The emission figures used for CO are the results of emission measurements within the context of investment projects.

The emission factors for SO_2 and CO_2 were calculated from the specific anode consumption. The anodes consist of petrol coke; this material has specific sulphur concentrations of about 1.2 %, from which an SO_2 emission factor of 10.4 kg/t Al can be calculated. The CO_2-emission factor is calculated on the basis of the specific carbon content of petrol coke, 857 kg per t. (cf. Chapter 18.6.2). By multiplying the average anode consumption by the mean carbon content and carrying out stoichiometric conversion to CO_2, one obtains a CO_2-emission factor of 1367 kg/t aluminium. Theoretically, the CO_2-emission factor must be reduced by the proportion resulting from a CO component of 180 kg/t Al, since CO can also form only via consumption of anodes. The CO_2 factor listed below does not take this into account.

The emission factors shown in Table 112 were compared with the emission data in Best Available Techniques Reference Documents (BREF)[41] and other sources (such as VDI Guideline 2286 sheet 1).

Table 112: Activity rates and process-related emission factors for primary aluminium production in 2010

	AR		Emission factors				
	Number of smelters	Production [t]	CO_2 [kg/t]	NO_X [kg/t]	SO_2 [kg/t]	C total [kg/t]	CO [kg/t]
Primary aluminium	4	402,756	1367	N. e.	10.4	N. e.	180

Emission data is available for PFC emissions from primary aluminium smelters, thanks to a voluntary commitment on the part of the aluminium industry. Since 1997, the aluminium industry has reported annually on the development of PFC emissions from this sector. The

[41] cf. http://www.bvt.umweltbundesamt.de/kurzue.htm

measurement data are not published, but they are made available to the Federal Environment Agency.

The measurements conducted in all German smelters in the years 1996 and 2001 form the basis for calculation of CF_4 emissions. In this context, specific CF_4 emission figures per anode effect[42] were calculated, in keeping with the technologies used. The number of anode effects is recorded and documented in the foundries. The total CF_4 emissions were calculated by multiplying the total anode effects for the year by the specific CF_4 emissions per anode effect determined in 2001. The total emission factor for CF_4 is obtained by adding the CF_4 emissions of the smelters and then dividing the sum by the total aluminium production of the smelters. C_2F_6 and CF_4 occur in a constant ratio of about 1:10. The above-described method was applied to the entire time series, and the emissions for the years 1990 to 1996 were filled in via recalculations.

4.4.3.3 Uncertainties and time-series consistency (2.C.3)

The figures for PFC, CO, CO_2 and SO_2 emissions are in keeping with the Tier 3b approach and thus are considered very accurate. The time series for CO, CO_2 and SO_2 are consistent.

On the other hand, in the framework of voluntary commitments no survey of the plant-specific number of anode effects in 1991, 1992, 1993 and 1995 was conducted, and no calculation was carried out for those years (cf. 4.4.3.6).

In addition, the years 1991 through 1994 were years of deep crisis for the German aluminium industry, due to sharp drops in the world-market prices for primary aluminium. For this reason, a number of plants were decommissioned. While all smelter types were affected, smelters that had recently been modernised, with point-feeder technology, were most strongly affected. Their capacity decreased by 43%, with regard to the relevant levels in 1990. This also explains the sudden increase and stagnation in the implied emission factor for CF_4 in these years. In absolute terms, the primary smelters emitted only 26 tonnes of CF_4 in 2007, while they emitted 45 tonnes in 2005. This drop was due to a decrease in production. With regard to 2006, production increased slightly, however, because partial shutdowns of furnaces in the Stade plant were more than offset by production increases at the Hamburg production site. In 2009, drastic reductions of production took place at the Rheinwerk Neuss site. As a result of the difficult economic situation at other German smelters, process instabilities repeatedly occurred that were caused by frequent start-up and shutdown processes. Those instabilities led to higher numbers of anode effects and, thus, to higher PFC emissions. The economic situation restabilised in 2010. That made it possible to run continuous, stable processes. As a result, the numbers of anode effects decreased to such a degree that absolute PFC emissions decreased, by comparison to their level in 2009, in spite of the production increases.

42 “...Organic fluorides occur only under certain conditions, and such conditions occur in the furnace repeatedly, at intervals of hours to severals days. These conditions are referred to as the "anode effect". ... The gas at the anode changes in composition from CO_2 to CO and 5 to 20 % CF_4...." (ÖKO-RECHERCHE 1996)

4.4.3.4 Source-specific quality assurance / control and verification (2.C.3)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The industry conducts annual surveys of activity data and reports such data to (inter alia) the Federal Statistical Office and the Federal Office of Economics and Export Control. The relevant time series seems plausible and shows no inconsistencies. It is assumed that such data collection conforms to quality assurance criteria.

Specific PFC emissions during anode effects were determined via industry measurements carried out in 1996 and 2001 at all plants in Germany that produce primary aluminium. In each case, the amount of PFCs produced depends on the duration and frequency of the relevant anode effects. In recent years, the duration and frequency of anode effects have been considerably reduced via computer-aided process control. In 2010, the German emission factor for CF_4, resulting from anode effects, was 0.044 kg/t aluminium. That factor is thus of the same magnitude as the average international factor, as reported by the International Aluminium Institute (IAI), of 0.034 kg/t for point-feeder systems. Therefore, the emission factor has been verified.

4.4.3.5 Source-specific recalculations (2.C.3)

PFC emissions for 2009 were recalculated, since last year the emission figure for 2008 was used for that year. As a result, C_2F_6 emissions in 2009 decreased from 30.69 Gg CO_2 equivalents to 26.04 Gg CO_2 equivalents (-15.2%). CF_4 emissions in 2009 decreased from 216.52 Gg CO_2 equivalents to 151.71 Gg CO_2 equivalents (-29.9%).

4.4.3.6 Planned improvements (source-specific) (2.C.3)

No improvements are planned at present.

4.4.4 Metal production: SF_6 used in aluminium and magnesium foundries (2.C.4)

4.4.4.1 Source category description (2.C.4)

CRF 2.C.4c	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
SF_6 used in aluminium and magnesium foundries	SF_6	-	-	197.1	(0.02%)	106.5	(0.01%)	-45.94%

Gas	Method used	Source for the activity data	Emission factors used
SF_6	D/CS	PS/NS	D/CS

The source category *SF_6 used in aluminium and magnesium foundries* is not a key category.

Aluminium production:

Generally speaking, inert gases without additives are sufficient for rinsing secondary molten aluminium. A purification system of inert gases, with added SF_6 at a concentration of 1 or 2.5 %, has been used in the past, however, in a few – usually smaller – aluminium foundries and in laboratories. Such purification systems were last used in 1999 (no sales have taken place in Germany since 2000). From 1990 to 1999, SF_6 consumption remained relatively constant, at 0.5 t/a.

In isolated cases, pure SF_6 has been used again as a purification gas since 1999.

Magnesium production:

In magnesium casting, since the mid-1970s, SF_6 has been used as a protective gas over molten magnesium to prevent the magnesium's oxidation and ignition. The amount of SF_6 used per tonne of magnesium (specific SF_6 coefficient) has decreased sharply since 1995, since HFC-134a is increasingly being used as a substitute. SF_6 is used in both a) the sand-casting process, for production of prototypes, individual parts and small series, and b) the pressure-casting process, in which it serves as a protective gas.

4.4.4.2 Methodological issues (2.C.4)

Use of SF6 as a purification and protective gas in magnesium production is an open use, i.e. all of the SF_6 used in the process is emitted into the atmosphere. The practice of assuming the equivalence between consumption (AR) and emissions conforms to the method in the IPCC Guidelines (IPCC, 1996a: page 2.34).

For aluminium foundries, the relevant emission factor has been established more reliably, via plant-specific measurements carried out in 2010. As a result, the relevant emissions figures have been established more reliably as well.

Reports and archived survey records from 1996 have been used as a basis for the reporting years 1990 through 1994.

Emission factors

Until now, an emission factor of 100% has been assumed for aluminium foundries, because information relative to the extent to which SF_6 breaks down was lacking.

On the basis of confidential measurement records certified by the pertinent permit authority, the emission factor for the period 1999 through 2008 has been reduced to 3 %. Via structural conversions, the emission factor has been further reduced, to 1.5%, as of 2009.

For magnesium foundries, EF_{use} = 100% is assumed, due to a continuing lack of more precise decomposition-level data that would support a more precise estimate.

Activity data for aluminium production

SF_6-consumption data are obtained via surveys of gas sellers. At the same time, the survey for the 2000 reporting year revealed that there have been no sales of this gas mixture since 2000.

Data on the SF_6 used in pure form since 1999 have been obtained via direct surveys of users and have been compared with relevant data of gas sellers.

Since the 2007 reporting year, the data have been obtained by the *Federal Statistical Office* via surveys of gas sellers with regard to SF_6-sales figures.

Activity data for magnesium production

In 1996, a survey was carried out, under commission to the Federal Environment Agency, of all domestic magnesium foundries that use SF_6. That survey determined the amounts consumed in the years 1990 to 1995.

Until the 2007 reporting year, data on the amounts used were obtained directly from users. Since the 2006 reporting year, the data have been obtained via surveys of gas sellers with regard to SF_6-sales figures. In the 2006 reporting year, the two methods were compared.

Since the 2007 reporting year, data of the *Federal Statistical Office* have been used.

4.4.4.3 Uncertainties and time-series consistency (2.C.4)

As studies have shown, part of the SF_6 used in aluminium and magnesium production is broken down during such use. For this reason, the assumption that amounts used in magnesium production are emitted to a degree of 100 % probably overstates the emissions considerably. Without more precise measurements, for magnesium production, that would make it possible to determine an average degree of decomposition in the process, the uncertainties for the emission factors cannot be quantified.

For the aluminium industry, the emission factor has been applied to the highest measured emissions level, and an uncertainty of 50% has been assumed for lower levels, since measurements have shown that emissions are frequently considerably lower than the maximum levels.

4.4.4.4 Source-specific quality assurance / control and verification (2.C.4)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Quality assurance / control for amounts consumed in Mg foundries was carried out via a one-time comparison of findings from foundry surveys with producers' total SF_6 sales figures – and with data of gas sellers. For reported year 2007, additional findings resulting from a technical discussion held in December 2007 have been taken into account.

As to amounts consumed by Al foundries, for the 2002 reporting year, sales figures were compared for the first time with amounts used by industry, and this comparison revealed a discrepancy. That discrepancy has since been corrected. Sales figures and industrial usage quantities were compared for reporting year 2004 and showed good agreement.

4.4.4.5 Source-specific recalculations (2.C.4)

No recalculations are required.

4.4.4.6 Planned improvements (source-specific) (2.C.4)

No improvements are planned at present.

4.4.5 Metal production: Other (2.C.5)

CRF 2.C.5	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
	HFC 134a	-	-	C	C	C	C	C

Gas	Method used	Source for the activity data	Emission factors used
HFC	D	PS/NS	D

For this source category, only emissions from use of HFC-134a in magnesium foundries are reported.

4.4.5.1 Source category description (2.C.5)

Since 2003, HFC-134a has increasingly been used, instead of SF_6, as a protective gas over molten baths.

4.4.5.2 Methodological issues (2.C.5)

For use of HFC-134a, the calculation method, emission factor used and figures for activity data in magnesium production are identical with the comparable figures for use of SF_6 in magnesium production (2.C.4). For this reason, they are described in Chapter 4.4.4.2.

4.4.5.3 Uncertainties and time-series consistency (2.C.5)

The relevant uncertainties have been quantified.

4.4.5.4 Source-specific recalculations (2.C.5)

No recalculations are required.

4.4.5.5 Source-specific planned improvements (2.C.5)

No improvements are planned at present.

4.4.5.6 Source-specific quality assurance / control and verification (2.C.5)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.5 Other production (2.D)

In the CSE, process-related emissions from production of particle board and from pulp production are reported under 2.D.1 Pulp and paper.

Process-related emissions from production of alcoholic beverages, and from production of bread and other foods, are listed under 2.D.2 Food and drink.

4.5.1 *Other production: Pulp and paper (2.D.1)*

4.5.1.1 Source category description (2.D.1)

CRF 2.D.1	Gas	Key category	1990 Total emissions (Gg) & percentage (%)	2010 Total emissions (Gg) & percentage (%)	Trend

Gas	Method used	Source for the activity data	Emission factors used
NO_X, CO			CS
NMVOC, SO_2			D

The source category *Other production – pulp and paper* is not a source of greenhouse-gas emissions and is thus not a key category.

All emissions of climate-relevant gases from the pulp and paper industry, and from particle-board production, in Germany result from combustion of fuels; for this reason, they are reported in Chapter 3.2 as energy-related emissions. The pulp and paper industry does not produce any process-related emissions of climate-relevant gases within the meaning of the *IPCC Good Practice Guidance* (2000).

Two of the six pulping plants in Germany carry out sulphate-process **pulp production** via caustification. For these plants, fuel-related CO_2 emissions in lime ovens are already taken into account, as energy-related emissions, via the pertinent fuel statistics. The remaining four plants use the sulphite process.

No attempt was made to take account of country-specific CO emission factors in energy-related emissions from pulp production, since that would have required conversion of product-based emission factors into fuel-based emission factors. Such conversion is an extremely involved process. Compared to the relevant CO emissions from paper mills, the CO emissions from the six pulping plants are of insignificant quantities.

The sulphate and sulphite pulp-production processes can both be a source of SO_2 emissions. In sulphate pulp production, NO_X, CO and NMVOC emissions are also released from recovery boilers, lime ovens, bark boilers and auxiliary boilers.

A detailed description of the relevant processes – in the present example, fibre production (including wood-pulp production) and paper and carton production – and supplementary information about auxiliary boilers are provided in Annex 3, Chapter 19.2.4.1.

Particle board is produced from wood chips, with added binders, in a process that applies heat and pressure. The main source of NMVOC emissions in such production are the wood chips used, which release NMVOC during drying via heating. NMVOC can also be emitted from wood and binders during the pressing process.

Particle board is produced in a total of 16 plants in Germany. Some 6,000 employees work in particle-board plants nation-wide. The particle-board industry tends to be dominated by larger companies.

4.5.1.2 Methodological issues (2.D.1)

The **pulp and paper industry** produces no process-related emissions of climate-relevant gases within the meaning of the *IPCC Good Practice Guidance* (IPCC, 2000). For indirect greenhouse gases, the IPCC-Guidelines emission factors listed in Table 113 were used until the reported year 2004.

Table 113: IPCC default emission factors for SO_2, NO_x, CO and NMVOC from pulp production

	NO_X	CO	NMVOC	SO_2
		[kg / t ADt*]		
Sulphate pulp	1.5	5.6	3.7	7
Sulphite pulp				30

* ADt = Air-dried tonne

As of reported year 2005, plant operators have provided updated emission factors.

Table 114: Real emission factors, for German plants, from pulp production. (German contribution to revision of the BAT reference (BREF) document for the pulp and paper industry, 2007)

	NO_X	CO	NMVOC	SO_2
		[kg / t ADt*]		
Sulphate pulp	1.75	0.16	3.7	0.05
Sulphite pulp	2.8			2

In 2010 the following quantities were produced, in a total of 138 plants:

Table 115: Pulp and paper production, produced quantities

Product	Quantities produced in 2010	
Production of paper, cardboard and carton (PCC):	23.20	million t
Raw-material production:		
Paper pulp	1,514,790	t
of this, sulphite pulp	590,610	t
of this, sulphate pulp	924,180	t
Wood pulp	1,239,305	t
Recycled paper	13,633,000	t
Quantity of recycled paper used for this purpose	(16,308,204	t)

Source: Verband Deutscher Papierfabriken, Leistungsbericht 2010 (VDP, various years)

These figures can be traced back to the base year, 1990.

Particle board

Emission factors

The emission factors have been determined on the basis of experts' assessments.

Activity data

The activity data were obtained from national statistics (STATISTISCHES BUNDESAMT: Fachserie 4, Reihe 3.1).

Table 116: Updated activity data for the particle-board industry (2.D.3)

Year	2005	2006	2007	2008	2009	2010
Activity rate for the particle-board industry [in t]	6,575,000	6,502,000	6,460,000	5,300,000	4,575,000	4,561,000

Source: Federal Statistical Office (Statistisches Bundesamt), Fachserie 4, Reihe 3.1.4

4.5.1.3 Uncertainties and time-series consistency (2.D.1)

Pulp and paper

Until reported year 2004, the IPCC default values (IPCC, 1996b) were used for emissions calculation. As of reported year 2005, updated, Germany-specific emission factors were entered into the CSE emissions database, following consultation with German plant operators. Such updating was required because German sulphate pulp plants had undertaken considerable modernisation measures, in the previous five years, that had led to sharp emissions reductions. The updating was completed as of 2005. In sulphite pulp plants, continual improvements led to considerable SO_2-emissions reductions with respect to corresponding emissions levels in 1990.

The uncertainties in the activity rates are estimated to amount to 5-10 %. The uncertainties in the emission factors are estimated to amount to 20 %.

Particle board

The uncertainties in the activity rates for the particle-board industry ±5 % (expert's assessment).

4.5.1.4 Source-specific quality assurance / control and verification (2.D.1)

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors.

4.5.1.5 Source-specific recalculations (2.D.1)

The available data relative to **production of particle board** have been improved via use of the activity rates since 2004. As of 2004, data that have been carried forward from previous years will be replaced with data of the Federal Statistical Office (STATISTISCHES BUNDESAMT: Fachserie 4 Reihe 3.1).

4.5.1.6 Source-specific planned improvements (2.D.1)

Since plant operators have confirmed the emission factors from the international guidelines, no further inventory improvements for this source category are planned at present.

The CO_2 emissions from caustification in sulphate pulp production are of biogenic origin; thus, they do not have to be reported. In future, CO_2 of biogenic origin may also be reported, in the interest of enhancing transparency.

4.5.2 Other production: Food and drink (2.D.2)

4.5.2.1 Source category description (2.D.2)

CRF 2.D.2	Gas	Key category	1990 Total emissions (Gg) & percentage (%)	2010 Total emissions (Gg) & percentage (%)	Trend
		- -			

Gas	Method used	Source for the activity data	Emission factors used
CO_2	IE	IE	IE
NMVOC	CS	NS	CS/D

The source category *Other production – food and drink* is not a source of greenhouse-gas emissions and is thus not a key category.

The food and beverage industry's emissions of direct climate gases in Germany result from fuel combustion; for this reason, they are reported under CRF 1.A.2. The food and beverage industry's important process-related emissions include non-methane volatile organic compounds (NMVOC) (IPCC 1996c: p. 2.41). Carbon dioxide emissions from food inputs that occur during certain production processes are not reported in CRF 2.D.2., since they result from use of biological carbon and do not contribute to net CO_2 emissions. Solvent emissions related to production of margarine and vegetable oils are reported in source category 3.D. Animal fats are thus included in the source category "Margarine and solid and hardened fats". CO_2 used in sugar production, which is obtained from burning of limestone, is bound during the production process. Therefore, that process is not emissions-relevant (cf. UFOPLAN research project FKZ 205 41 217/02).

Emissions of the food and drink industry are reported, in summary form, in the inventory in "Table2(I)s2" of the sectoral report for industrial processes. In the table "Background data of the sectoral report for industrial processes" ("Hintergrunddaten des sektoralen Reports für Industrielle Prozesse"), "Table2(I).A-G", the IEF is listed as NE, since the pertinent CO_2 emissions are reported under CRF 1.A.2.

With revenue of EUR 149.5 billion in 2010, the food industry is one of Germany's most important economic sectors. In that same year, 544,000 people were employed in a total of 5,890 food-industry companies (BVE 2011, p. 8). The German food industry includes an especially large number of small and medium-sized enterprises (SMEs); nearly 80 percent of its companies have fewer than 100 employees, and only 3 percent have more than 500 employees (BpB 2002: p.51).

Pursuant to the IPCC, emissions reporting for the food and drink source category covers the following products:

Alcoholic beverages

- Wine
- Beer
- Spirits

Bread and other foods

- Meat, fish and poultry
- Sugar

- Margarine and solid and hardened fats
- Cake, cookies and breakfast cereals
- Bread
- Animal feedstuffs
- Coffee roasting

Default emission factors for NMVOC emissions relative to these products are listed (IPCC, 1996c: p. 2.41f).

4.5.2.2 Methodological issues (2.D.2)

For emissions calculations, national emission factors were used where available. Otherwise, the emission factors recommended by IPCC and CORINAIR were used. The basis for selection of emission factors consists of the research report "Emissions from the food industry" ("Emissionen aus der Nahrungsmittelindustrie") (FKZ 206 42 101/01; IER, 2008).

The Central System of Emissions (CSE) lists activity rates (produced amounts) and emission factors for NMVOC emissions for the relevant sectors. The activity rates for the various products / product groups, with the exception of that for feedstuffs, were obtained from the *FEDERAL STATISTICAL OFFICE* (STATISTISCHES BUNDESAMT: Fachserie 4, Reihe 3.1 and Fachserie 3, Reihe 3.2.2). The activity rates for feedstuffs were obtained from the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) (Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten). Because of its greater precision, the distilled-spirit tax (Branntweinsteuerstatistik) of the *Federal Statistical Office* was used to determine the activity rate for spirits production.

Table 117 shows the activity rates determined, emission factors used and the relevant NMVOC emissions calculated for the year 2010.

Table 117: NMVOC emissions from the food industry (2.D.2)

Product	Activity rates		Emission factors		Emissions [t]
Bread					
- Industrial bakeries	3rd 765,421	t	0.3	kg/t	1,129.6
- Craft bakeries	925,675	t	3.0	kg/t	2,777.0
Cake, cookies and breakfast cereals	1,590,683	t	0.1	kg/t	159.1
Sugar	3,540,109	t	0.9	kg/t	3,186.1
Meat, poultry, fish	1,535,447	t	0.03	kg/t	46.1
- Meat/fish, smoked	2,272,325	t	0.0023	kg/t	5.2
Animal fats	381,754	t	1	kg/t	381.8
Coffee roasting	532,551	t	0.069	kg/t	36.7
Feedstuffs	20,275,885	t	0.1	kg/t	2,027.6
Beer	88,985,000	hl	0.002	kg/hl	178.0
Wine					
- Red wine	2,643,766	hl	0.08	kg/hl	511.5
- White wine	3,776,756	hl	0.035	kg/hl	132.2
- Other wines	865,843	hl	0.058	kg/hl	50.2
Spirits	1,120,738	hl	2.93	kg/hl	3,283.8

* With reduction measures taken into account

A total of 13.6 Gg of NMVOC emissions result for source category 2.D.2.

4.5.2.3 Uncertainties and time-series consistency (2.D.2)

The uncertainties in the activity rates are estimated to amount to 5-20 %. A research project was carried out (IER, 2008), in the UFOPLAN framework for 2006-2008, with the aim of improving the database and facilitating maximally realistic estimation of emissions from the *food industry*. That research project was able to determine national emission factors for a number of source areas (sugar production, spirits production, coffee roasting, smoking of meat and fish), to obtain more-detailed information with regard to the nature and scope of emissions-reduction measures in the various sectors and to improve the database for determination of activity rates. Where no national emission factors were available, emission factors from the *IPCC Workbook* (1996a, 2.41f) and the *Emission Inventory Guidebook* (EMEP, 2009) were used. For determination of emissions from production of other wines (fruit wines), the average of the emission factors for red-wine and white-wine production was used.

4.5.2.4 Source-specific quality assurance / control and verification (2.D.2)

Due to resources limitations, and to the area's minimal relevance, no QC/QA is carried out for reporting relative to precursors.

Other countries' reports contain very little information about 2.D.2, and thus no comparisons are possible at present. No comparison with ETS data is possible, since no emissions subject to emissions trading occur in 2.D.2.

4.5.2.5 Source-specific recalculations (2.D.2)

Source-specific recalculations were carried out in the source categories spirits and feedstuffs, since it proved possible to improve some of the data for those categories via activity rates.

4.5.2.6 Source-specific planned improvements (2.D.2)

No improvements are planned at present.

4.6 Production of halocarbons and SF_6 (2.E)

CRF 2.E	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
	HFC	**L**	**T**	**4,218.5**	**(0.35%)**	**165.6**	**(0.02%)**	**-96.07%**
	SF_6	-	-	167.3	(0.01%)	90.4	(0.01%)	-45.94%
	PFC	-	-	0.0	(0.00%)	0.0	(0.00%)	-

Gas	Method used	Source for the activity data	Emission factors used
HFC	Tier 3	PS	PS
SF_6	Tier 3	PS	PS

The source category *Production of halocarbons* is a key category of HFC emissions in terms of emissions level and trend. It is subdivided into 2.E.1 By-product emissions and 2.E.2 Fugitive emissions.

4.6.1 By-product emissions (2.E.1)

4.6.1.1 Source category description (2.E.1)

For process-related reasons, production of HCFC-22 produces up to 3 % HFC-23 as a by-product. For technical reasons, even when the HFC-23 is subjected to further processing (for example, to produce refrigerants) or is collected and then broken down into other substances, some HFC-23 is always released into the atmosphere.

Germany still has two production plants for HCFC-22. Those two plants, which are operated by a single company, are located in Frankfurt and Bad Wimpfen. In 1995, a CFC-cracking plant went into operation in Frankfurt that cracks, at high temperature, excess HFC-23 produced during production of HCFC-22 and that recovers hydrofluoric acid; i.e. no significant emissions are produced. HFC-23 produced at the second German production facility is captured in large amounts at the production system itself; the substance is then sold as a refrigerant or – following further distillative purification – as an etching gas for the semiconductor industry. Since 1999, the excess amount that cannot be sold has been delivered to the cracking facility in Frankfurt. That measure has substantially reduced emissions. The emissions level of 0.5 % of CFC production, the level estimated by the operator for 2002, has been further reduced, sharply, via improved collection equipment.

4.6.1.2 Methodological issues (2.E.1)

In keeping with manufacturer information from 1996, HFC-23 emissions are assumed to have remained constant in the years 1990 to 1994.

Since 1995, the producer has calculated emissions, via a mass-balance procedure, on the basis of HCFC-22 production, HFC-23 concentrations in exhaust gas (as measured annually), sales of HFC-23 and quantities of HFC-23 delivered to the cracking plant. For reporting year 1995, emissions-reduction measures (the cracking plant) for the first production plant were assumed to have been in place since mid-year.

HCFC-22 production was terminated in mid-2010. HFC-23 emissions stopped occurring as of 2011.

Emission factors

Since produced quantities of HCFC are not reported, no emission factor can be determined and compared with the IPCC standard emission factor.

Activity data

The producer reports emissions of HFC-23.

Since there are fewer than three producers in Germany, the pertinent emissions data are confidential. Data for SF_6 are reported in aggregation with other confidential data in 2.G. Data for the other F-gases are reported in 2.E as an "unspecified mix" that is an aggregate of 2.E.1 and 2.E.2.

4.6.1.3 Uncertainties and time-series consistency (2.E.1)

The production figures used as a basis for emissions calculation may be considered highly accurate, since they come directly from the producer's internal records.

4.6.1.4 Source-specific quality assurance / control and verification (2.E.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.6.1.5 Source-specific recalculations (2.E.1)

No recalculations are required.

4.6.1.6 Source-specific planned improvements (2.E.1)

No improvements are planned at present.

4.6.2 Production-related emissions (2.E.2)

4.6.2.1 Source category description (2.E.2)

In Germany, one company produces these gases; its HFC und SF_6 production takes place at two locations. Emissions trends are tied to trends in amounts produced. While SF_6 and HFC-134a are produced in Germany, until 2008 no complete synthesis of HFC-227ea was carried out in Germany. Part of the HFC-227ea produced in Tarragona, Spain, undergoes subsequent distillation, in Germany, to pharmaceutical purity (use in dosing aerosols). That process produces emissions as a result of minor gas losses.

HFC-134a has been produced since 1994, while HFC-227ea has been produced since 1996.

4.6.2.2 Methodological issues (2.E.2)

Emission factors

It is possible to calculate an emission factor from the emissions and production quantities reported by the producer. The resulting factor is not published, however, because the underlying data are confidential.

Activity data

Because the HFC producer in Germany is the country's sole producer, that company's data are confidential. Emissions and production quantities are reported to the Federal Environment Agency, but only in a form aggregated with emissions from CRF source category 2.E.1.

4.6.2.3 Uncertainties and time-series consistency (2.E.2)

The production figures used as a basis for emissions calculation may be considered highly accurate, since they come directly from the producer's internal records.

4.6.2.4 Source-specific quality assurance / control and verification (2.E.2)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

4.6.2.5 Source-specific recalculations (2.E.2)

No recalculations are required.

4.6.2.6 Source-specific planned improvements (2.E.2)

No improvements are planned at present.

4.6.3 Other (2.E.3)

No other sources of relevant greenhouse-gas emissions are known.

4.7 Consumption of halocarbons and SF_6 (2.F)

CRF 2.F	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Consumption of halocarbons and SF_6	**SF_6**	**L**	**T**	**6,414.8**	**(0.52%)**	**3,052.5**	**(0.32%)**	**-52.41%**
Consumption of halocarbons and SF_6	**HFC**	**L-**	**T**	**C**	**C**	**C**	**C**	**C**
Consumption of halocarbons and SF_6	PFC			220.9	(0.02%)	173.7	(0.02%)	-21.35%

Gas	Method used	Source for the activity data	Emission factors used
HFC, PFC, SF_6		cf. Table 118	

The source category *Consumption of halocarbons and SF_6* is a key category of SF_6 und HFC emissions in terms of emissions level and trend.

Source category 2.F includes Refrigeration and air conditioning systems (2.F.1), Foam production (2.F.2), Fire extinguishing agents (2.F.3), Aerosols (2.F.4), Solvents (2.F.5), Semiconductor production (2.F.7), Electrical operating equipment (2.F.8) and Other applications (2.F.9). In the interest of more precise data collection, these sub-source categories are broken down further, as described in the following sub-chapters.

Use of relevant substances as refrigerants in stationary and mobile refrigeration applications, which accounts for over three-fourths of relevant emissions, is the largest source of HFC emissions in source category 2.F from use of fluorinated greenhouse gases. The remaining emissions are distributed among the sources "foams" and "aerosols" and, in small amounts, "fire extinguishers", "solvents" and "semiconductor production".

Some two-thirds of PFC emissions come from the semiconductor industry (which includes circuit boards; due to its insignificance in this context, that category is not reported separately), and one-third come from air-conditioning and refrigeration systems. Small quantities are emitted from shoes and from production of photovoltaic modules (PV modules).

About half of the SF_6 emissions come from soundproof windows, with emissions in that area occurring primarily in disposal of soundproof windows. About one-fourth of the emissions originate from electrical equipments. As to the remaining emissions, production of PV modules is the predominant source, followed by production of optical glass fibres. Small amounts originate in the semiconductor industry, from automobile tyres and from trace gases. No information can be provided regarding quantities for the emissions sources "shoes", "AWACS" and "welding", since the relevant data are confidential.

Table 118: Overview of methods and emission factors used for the current reporting year, in source category 2.F - *Consumption of HFCs, PFCs and SF_6*.

		Method	Gas			Emission factor (dimensionsless)		
			HFC	**PFC**	**SF_6**	**Production**	**Application**	**Waste management**
1. Air-conditioning and refrigeration systems	**2.F.1**							
Domestic refrigeration	2.F.1a					NO	0.003 (D)	0.3 (D)
Commercial refrigeration	2.F.1b			PFC		0.002 (CS)	0.015 - 0.15 (D)	0.3-0.5 (CS)
Transport refrigeration (vehicles and containers)	2.F.1c			PFC		5 g / unit (CS, D)	0.1 - 0.3 (CS, D)	0.3 (D)
Industrial refrigeration	2.F.1d			PFC		0.0015 (CS)	0.07 (D)	0.3 (CS)
Stationary air conditioning systems								
Large air conditioning systems	2.F.1e					0.01 (D)	0.06 (D)	0.3 (CS)
Heat pumps						2 g / unit (D, CS)	0.02 - 0.025 (D)	0.3 (D)
Room air conditioners		Tier 2a	HFC			0.025 (CS)	0.025 (D)	0.3 (D)
Mobile air conditioning systems								
- Trucks						2 g/system (CS)	0.10 - 0.15 (D)	
- Automobiles						2 g/system (CS)	0.1 (D)	
- Busses	2.F.1f					5 g/system (CS)	0.15 (D)	
- Ships						0.01 (CS)	0.1 – 0.3 (CS)	0.3 (CS)
- Railway vehicles						0.002 (CS)	0.06 (CS)	
- Agricultural machines						5 g/system (CS)	0.15 - 0.25 (CS)	
2. Foam production	**2.F.2**							
Hard foam with 134a						0.1 (D)	0.005 (D)	
Hard foam with 365mfc/245fa/227ea						0.15 (CS)	0.01 (CS)	
Integral foam						1 (CS)	NO	
PUR foam (134a)	2.F.2a	Tier 2a	HFC			0.5 g/can (CS)	1 (CS)	NO
PUR foam (152a)						0.5 g/can (CS)	1 (CS)	
XPS foam (134a)						C	0,0066 (CS)	
XPS foam (152a)						1 (CS)	NO	
3. Fire extinguishers	**2.F.3**	CS	HFC			0.001 (CS)	0.01 – 0.08 (CS) 0.04 (D)	1.0 (D)
4. Aerosols	**2.F.4**							
Metered dose inhalers	2.F.4a	CS				0.01 (CS)	1 (CS)	
Other aerosols / novelties	2.F.4b/c	Tier 2				0.015 (CS)	1 (D)	
5. Solvents	**2.F.5**	Tier 2	HFC			NO	1 (D)	
6. Other applications that use ODS substitutes	**2.F.6**					NO	NO	NO
7. Semiconductor production	**2.F.7**	Tier 2a		PFC	SF_6	C (CS)	NO	
8. Electrical equipments	**2.F.8**							
Switchgear and controlgear	2.F.8a	Tier 3a			SF_6	0.02 (CS)	0.001 – 0.01 (CS)	0.015 (CS)
Other	2.F.8b	CS				0.15 – 1 (CS)	0.006 – 0.003 (CS)	NO
9. Other	**2.F.9**							
Insulated glass windows	2.F.9a	Equ. 3.24 ff				0.33 (D)	0.01 (D)	1 (D)
Car tyres	2.F.9b	Equ. 3.23			SF_6	NO	NO	1 (D)
Sports shoes	2.F.9c	Equ. 3.23		PFC		NO	NO	1 (D)
Trace gas	2.F.9d	Equ. 3.22				NO	1 (D)	NO
AWACS maintenance	2.F.9e	CS				NO	C	NO
Welding	2.F.9f	CS				NO	1 (CS)	NO
Optical glass fibre	2.F.9g	CS				0,7 (CS)	NO	NO
Photovoltaics	2.F.9h	CS				0,058 (CS)	NO	NO

Equ. = Equation from the IPCC GPG (2000)

Halocarbons and SF_6 are used in a number of different applications. Whereas in some, so-called "open" applications, consumed quantities are emitted completely, in the same year in question, in other applications large quantities are stored (stocks). The substances then are emitted, either partially or completely, from such "stocks" throughout the entire usage phase and in relevant waste management. It is thus neither possible nor useful to provide a mean emission factor. Most of the EF used are country-specific (CS), although some are also IPCC default (D).

The "current emissions (A)", as listed in Table 2(II)s2 of the inventory tables, consist of the quantities of HFCs, PFCs and SF_6 that, during a reporting year, slowly escape from "stocks" and are emitted in production and waste management.

On the other hand, the potential emissions of gases listed in Table 2 (II) s2 correspond to the production quantities in the country, with import quantities added and export quantities deducted. The pertinent quantities are determined via evaluation of statistical surveys and experts' assessments (for example, for fill quantities).

In general, the emissions data collected for the various product groups comprise emissions from production, use and waste disposal. Except where indicated otherwise in connection with the pertinent methods, these emissions are calculated as follows:

1. Production emissions are determined via new domestic consumption, as an activity rate:

Equation 1:

$$EM_{production} = EF_{production} * \text{new domestic consumption}$$

2. Application emissions are based on the average annual stock of relevant pollutants (the activity rate), and they are calculated via the following formula:

Equation 2:

$$EM_{application} = EF_{application} * \text{average stocks}$$

These average stocks are obtained as half of the sum of the final stocks of the previous year (n-1) and of the current year (n); summation is carried out from the first year of application on. The result consists of the accumulated average pollutant stocks for year n.

The final stocks for the current year are calculated by summing annual new additions, from the first reporting year to the current one. The new additions for a given year consist of the new domestic consumption for that year, minus production emissions and losses from removals. The calculation thus requires consideration of foreign trade.

3. Disposal emissions refer to new additions for the year that is x years (depends on product lifetime) prior to the current reporting year n:

Equation 3:

$$EM_{disposal} = EF_{disposal} * \text{new additions (n-x)}$$

In this chapter, the sections *Uncertainties and time-series consistency, Source-specific quality assurance / control and verification, Source-specific recalculations and Planned improvements* vary in their reference – some refer to the entire relevant source category, some to the sub - source category in question and some to only a part of a sub - source category. In each case, the reference involved is apparent from the CRF number in the section heading.

4.7.1 Refrigeration and air conditioning systems (2.F.1)

4.7.1.1 Source category description (2.F.1)

This category is divided into the sub-categories of household refrigeration, commercial refrigeration, transport refrigeration, industrial refrigeration, stationary air-conditioning systems, and mobile air-conditioning systems (cf. Table 118).

In Germany, the leading pure-HFC refrigerants, far and away, are HFC-134a and the mixtures R404A, R407C and R507A.

For calculation of HFC emissions from the sub-categories of refrigeration and stationary air conditioning systems, individual data are collected, or refrigerant models are used. Any refrigerant models used are described in connection with the relevant method.

The emission factors used are the result of surveys of experts. Disposal emissions in this source category first occurred in 2002, in sub-source category 2.F.1.f (automobile air conditioners).

4.7.1.2 Methodological issues (2.F.1)

4.7.1.2.1 Domestic refrigeration (2.F.1.a)

In 1994, producers of domestic refrigerators and freezers made a changeover from CFC-12 to HFC-134a. A short time later, they then switched to isobutane. Small numbers of devices containing HFC-134a, representing a small share of all relevant appliances, have been imported since 1993.

Equation 2 is used to calculate annual HFC emissions on the basis of average stocks. To that end, annual HFC additions since 1993 are determined and aggregated.

Production losses and new consumption for domestic purposes do not have to be determined, since filling takes place only abroad.

Emission factors

Current HFC emissions from household refrigerators and freezers are estimated at 0.3 %, which is within the value range given by IPCC–GPG (2000) in Table 3.22, 0.1 to 0.5 %

The emission factor for disposal, at a value of 30 %, is in keeping with the value given by IPCC–GPG (2000) in Table 3.22.

Activity data

The annual additions figure of 1 % of new appliances is an estimate of leading refrigerator manufacturers.

The appliances in question are considered to have an average lifetime of 15 years. That value lies within the upper section of the value range given by IPCC–GPG (2000) in Table 3.22, 12 to 15 years.

4.7.1.2.2 Commercial refrigeration (2.F.1.b)

Commercial refrigeration is the largest and most diverse area of HFC application. It is roughly divided into general food retail and other commercial refrigeration. The great diversity of refrigeration systems involved, with regard to model, size, type of refrigerant and emissions-tightness, results from the fact that most relevant systems are customised systems. This is true to a lesser extent in the retail food sector. In light of the extremely large number of companies specialising in refrigeration, detailed statistical surveys of refrigerant stocks are not practicable. Therefore, a different calculation method is used.

Use of HFCs as refrigerants grew only gradually. For example, HFC-134a was not used on any significant scale until mid-1993. The refrigerant mixture R404A was also not used until 1993. The refrigerant mixture R508B has been in use since 1996, and R407C has been in use only since 1997.

Today, the mixture R404A is the most important HFC refrigerant for stationary refrigeration systems, ranking ahead of even HFC-134a in this category. The mixtures R407C and R508B are also of some significance.

In its basic characteristics, the following refrigeration model also holds for industrial refrigeration systems. Pertinent differences between the two areas are described in the present section.

- Foreign trade with locally installed refrigeration systems plays a negligible role, and thus annual HFC consumption for new systems is the same as new HFC additions in new systems. First, the refrigerant stocks are estimated for the target state in which all existing refrigeration systems contain only HFCs (no HCFCs).
- To this end, the entire *commercial refrigeration* sub-category is divided into numerous different device categories, in accordance with the criteria of application area / type of shop (for example, small supermarket) and system type (for example, central system). Due to the large differences between the refrigeration systems involved, a distinction is also made between target stocks for the category "food sales" and those for the category "other commercial refrigeration".
- The entire sub-category of *industrial refrigeration* is divided into numerous applications. Divisions are defined by industrial sector and pertinent refrigeration area (normal refrigeration, low-temperature refrigeration and freezing). In the area of the food and drink industry, divisions based on individual product groups are also defined.
- The type of refrigerant and numbers of relevant systems involved are determined for each system/device category and application. In addition, the installed refrigeration output, in kW per system, and the specific refrigerant quantity, in "kg per installed kW", are established and assumed to be constant. The product "Number of systems * installed refrigeration output * specific refrigerant quantity" is the total amount of refrigerant in question.
- In the area of *commercial refrigeration* for general food sales, refrigerant quantities are first determined separately for normal and low-temperature refrigeration and then summed. The resulting sum is then divided between R404A and HFC-134a in accordance with a ratio of 80 to 20. Then, the data are combined into the categories of central systems (high emissions) and reciprocating compressors (low emissions).
- In the category of *other commercial refrigeration*, the data are combined into the categories of plug-in ready single appliances and installed stationary systems.

- The target stocks, in connection with the average service lifetimes (10 years) for industrial and commercial refrigeration systems, can then be used to calculate how much refrigerant must be filled annually into new systems (new additions) in order to maintain stocks in the face of removals of old systems (1/10 of stocks). The "average yearly stocks" can also be determined for both areas.
- Since HFCs did not completely supplant chlorine-containing refrigerants in new systems as of a certain date, to obtain annual consumption of HFC refrigerants, one must weight the calculated additions for new systems with the relevant HFC share.
- In the area of *commercial refrigeration*, replacement of CFCs in old systems is considered separately, without any distinction between food sales and other commercial refrigeration.
- The production emissions and emissions from stocks are calculated with Equation 1 and Equation 2. Production normally takes place at the relevant sites.
- In the area of *commercial and industrial refrigeration*, disposal emissions occurred for the first time in 2003. They are calculated by means of Equation 3.

Emission factors

Except for $EF_{disposal}$, the emission factors used are the result of surveys of experts and of evaluations of the literature.

As a rule, filling of refrigeration systems produces only small quantities of emissions. For "initial emission", in Table 3.22 IPCC-GPG gives a figure of 0.5 to 3 percent of the initial filling quantity. The country-specific $EF_{production}$, at 0.2 %, is thus much lower than that figure.

Ongoing (H)FC emissions from stationary refrigeration systems in the *commercial refrigeration* category vary widely in keeping with the type of system concerned. Refrigerant losses range from 1.5 % for individual appliances (except for those in food sales) to 15 % for old devices. Those values lie within the lower value ranges given in Table 3.22 of IPCC-GPG (2000), 1 to 10 % for individual appliances and 10 to 30 % for commercial refrigeration systems.

The emission factor for disposal of refrigerated transport systems, at 30 %, lies at the upper boundary of the range given in Table 3.22 of IPCC-GPG (2000) commercial refrigeration systems, 10 to 30 percent. For converted CFC-12 systems only, a disposal emission factor of 50 % is assumed, in keeping with the fact that smaller quantities of refrigerant can be recovered from old systems at the time of disposal.

Activity data

The pertinent number of equipment operators, and the types of refrigeration equipment (i.e. as sets) commonly involved, have been generally assessed by experts who have carried out direct surveys of equipment suppliers and users. The specification "average refrigeration fill, in kg per kW of refrigeration output" has been determined semi-empirically by experts, with the help of technical literature.

4.7.1.2.3 Transport refrigeration (refrigerated vehicles and containers) (2.F.1.c)

HFCs have been used as refrigerants in *refrigerated vehicles* since 1993. Today, the refrigerants most commonly used in refrigerated vehicles are HFC-134a and the refrigerant mixtures R404A and R410A. The sizes and refrigerant fill quantities of refrigeration systems vary in keeping with the load volumes of the refrigerated vehicles in question.

Refrigerated containers are used primarily for transports of perishable goods by ocean-going ships. Since their emissions take place primarily in international waters, their refrigerant emissions are divided, in each case, in keeping with the relevant country's share of world trade. Germany is assigned 10% of global emissions from refrigerated containers. Since 1993, the most commonly used refrigerant has been HFC-134a. Since 1997, R404A has also been used.

The following refrigeration model is applied to *refrigerated vehicles*:

- The entire sub-category of *transport refrigeration* is divided into four size classes of refrigerated vehicles: 2-5 t, 5-9 t, 9-22 t and > 22 t of gross vehicle weight.
- Refrigerant types, and specific refrigerant fill amounts, are assigned to the various size classes. Each refrigerant is also assigned a percentage share of each size class. In some cases, the refrigerant breakdown used may have to be modified. Since the 2006 reporting year, the refrigerant R404A has been used in half of the small systems of up to 5 t gross vehicle weight. Until 2005, only HFC-134a was used. Since 1993, relevant filling has consisted of 50 % HFC-134a and 50% R404A in the size class 5-9 t gross vehicle weight, while HFC-134a, R404A and R410A have been used in the size classes 9-22 t and > 22 t.
- The number of newly licensed refrigerated vehicles, and the number of refrigerated vehicles filled within the country (broken down by refrigerants), are determined for each year. The annual new additions of refrigerants result from the numbers of newly licensed refrigerated vehicles and the above assumptions.
- When one knows the final stocks from the previous year, one can calculate the average yearly stocks and the year-end stocks.
- In conformance with the Ordinance on CFC-halon prohibition (FCKW-Halon-Verbotsordnung), HFCs were substituted for CFC-12 in a certain number of old systems. These amounts have to be included in the annual new additions.
- Production emissions are calculated with Equation 1, since they must be seen in connection with new consumption. No use is made of the possibility of calculating emissions on the basis of numbers of newly filled vehicle refrigeration systems, and of the filling loss per system. Emissions from stocks are calculated with Equation 2.
- The service lifetime used for old systems, 7 years, lies within the value range recommended by the IPCC. The service lifetime used for new systems, 10 years, is somewhat higher than the range given by the IPCC-GPG in Table 3.22, 6 to 9 years. Disposal emissions occurred in connection with refrigerated vehicles for the first time in 2003. They are calculated by means of Equation 3.

The "bottom-up" approach described in IPCC-GPG (2000) refers only to refrigerated vehicles on roads.

For *refrigerated containers*, the following refrigerant model is used:

- The number of refrigerated containers produced worldwide is determined for each year.
- The worldwide HFC additions for refrigerated containers are determined on the basis of annual unit figures from global production, in combination with the relevant fill quantities and fill percentages for the various relevant refrigerants.

- Germany's HFC additions are determined from worldwide additions, in keeping with Germany's share of global trade, which amounts to 10 %.
- When one knows the final stocks from the previous year, one can calculate the average yearly stocks and the year-end stocks.
- Emissions from stocks are calculated with Equation 2.
- Since refrigerated containers are produced only outside of Germany, no emissions from filling occur in Germany.
- Refrigerated containers have an average lifetime of 14 years, and disposal emissions from such containers occurred for the first time in 2007. They are calculated by means of Equation 3.

Emission factors

The emission factors on which the emissions data are based are listed in Table 118. The emission factors used lie within the ranges recommended in the IPCC-GPG (2000); they are thus *default values*. The only exception is the emission factor for emissions from stocks in refrigeration units of refrigerated containers; at 10 %, it lies below the range given in Table 3.22 of the IPCC-GPG (2000), 15 to 50 %.

Ongoing HFC emissions from new refrigeration units of refrigerated vehicles in the range 5-22 t gross vehicle weight are estimated to amount to 15 %. For units in vehicles up to 5 t gross vehicle weight, the emission factor is 30 %.

For old units in refrigerated vehicles, the emission factor for emissions from stocks is estimated to average 25 %, for all unit size classes. "Old systems" are understood to be converted CFC-12 systems. The emission factors for refrigerated vehicles thus lie at the lower end of the range given in IPCC-GPG (2000), 15 to 50 %.

Filling losses are small by comparison to ongoing emissions from stocks. Filling losses of refrigerant, in filling of refrigerated vehicles, are placed at 5 grams per system, regardless of system size. That is a standard value for hose losses during on-site filling. When emissions from filling are calculatorily considered in relation to new consumption, emission factors between 0.06 and 0.25 % result. The great majority of the resulting values lie below the range given by the IPCC-GPG in Table 3.22, 0.2 to 1 percent.

No emissions from filling of refrigerated containers occur in Germany.

The emission factor for disposal of refrigerated transport systems, at 30 %, lies at the upper boundary of the range given in IPCC-GPG (2000), 20 to 30 percent.

Activity data

Until 2008, the registration figures for refrigerated vehicles, broken down by weight classes, were taken from statistical reports of the Federal Motor Transport Authority (KBA). Since in 2009 the Federal Motor Transport Authority stopped carrying out separate surveys of refrigerated vehicles, the numbers of new refrigerated vehicles since 2009 are determined via extrapolation from the registration figures for utility vehicles as determined by the KBA. Fill quantities in refrigeration systems, information on refrigerants used, and details on CFC-12 replacement were provided by experts of the leading providers of vehicle refrigeration units.

New additions of refrigerants in the area of refrigerated containers are determined via a refrigerant model based on the numbers of refrigerated containers produced worldwide, with the numbers provided by the "World Cargo News" information service for the industry. A 10 % share is allocated to Germany.

4.7.1.2.4 Industrial refrigeration (2.F.1.d)

The industrial refrigeration included in this sector refers to refrigeration for production of products – mostly food and drink – that are refrigerated or frozen.

Refrigeration systems in this category, as in the category of *commercial refrigeration*, are usually not purchased directly from series production. They tend to be customised systems, and thus the refrigeration model for this category is similar to that for *commercial refrigeration*. On the other hand, use of fluorine-based refrigerants has not become standard practice in industrial applications. In addition, natural refrigerants – primarily ammonia – are used much more frequently, especially in the food industry.

The predominating refrigerants used in industrial refrigeration are R404A, HFC-134a and R407C. HFC-23 und PFC-116 are also used in low-temperature systems, while HFC-227ea is used in higher-temperature systems.

The refrigeration model used is similar to that used for *commercial refrigeration*. It is thus described in the section for commercial refrigeration.

Emission factors

The emission factors on which the emissions data are based are listed in Table 118.

The emission factors used are the result of surveys of experts and literature evaluations.

As a rule, filling of industrial refrigeration systems produces only small quantities of emissions. For "initial emission", in Table 3.22 IPCC-GPG (2000) gives a figure of 0.5 to 3 percent of the initial filling quantity. The country-specific $EF_{production}$, at 0.15 %, is lower than that figure.

Current HFC emissions from industrial refrigeration systems are estimated at 7 %, which is in the lower segment of the value range given by IPCC-GPG (2000) in Table 3.22, 7 to 25 %.

The emission factor for disposal of industrial refrigeration systems, at 30 %, is higher than the range given in IPCC-GPG (2000), 10 to 20 percent.

4.7.1.2.5 Stationary air-conditioning systems (2.F.1.e)

The category of *stationary air conditioning systems* includes room air conditioners, large air conditioning systems for cooling entire buildings or large halls and heat-pump systems.

4.7.1.2.5.1 Room air conditioners

Room air conditioners are used to cool the interiors of individual rooms or even of entire floors. Their performance levels tend to be lower than those of large air conditioning systems. The refrigerants used include the HFC mixture R407C (since 1998) and the mixture R410A (since 2000).

There is no domestic production of room air conditioners. Room air conditioners are normally already filled when imported. "VRF multi-split" units, with 7 internal units, and multi-split units with power ratings of up to 15 kW, and with 3 internal units, are an exception. In 1998, the first devices with R407C appeared on the market, while the first devices with R410A appeared in 2000. Prior to that time, only devices with HCFC-22 had been available.

The following refrigeration model is used in this category:

- *Room air-conditioners* are divided into the following five categories, and annual sales in each category are determined via surveys of sellers: mobile units, single-split units, multi-split units with power ratings of 12 kW and of 15 kW, and VRF multi-split systems.
- The pertinent fill amounts and refrigerant mixtures are determined for each category. The annual new consumption, which is identical with annual new additions of refrigerants, is obtained from sales statistics and the above assumptions. When one knows the existing stocks, one can calculate the average yearly stocks and the year-end stocks.
- No production emissions occur. Losses in installation of stationary single-split units are not taken into account, because they represent only very small quantities within the model. The situation is different with regard to multi-split units and VRF multi-split systems. According to surveys of experts, the installation losses amount to 5 g per indoor unit, which translates into an emission factor of 2.5% per indoor unit.
- Emissions from stocks are calculated with Equation 2.
- Disposal emissions occurred for the first time in 2008, following an average-lifetime period of 10 years. They are calculated with Equation 3. The estimated lifetime is at the lower end of the range given in IPCC-GPG (2000), 10 to 15 years.

Emission factors

Ongoing HFC emissions from room air conditioners are estimated to be 2.5%, for all unit types (mobile, single-split, multi-split (12 KW), multi-split (15 KW), and VRF multi-split), unit sizes and refrigerant types. The emission factor for use thus lies within the middle of the range proposed in Table 3.22 of IPCC-GPG (2000), 1 to 5 %.

The emission factor for disposal, $EF_{disposal}$ = 30 %, lies in the upper part of the range proposed in IPCC-GPG (2000), 20 to 30 %.

The country-specific emission factor for production, $EF_{production}$ = 2.5 %, lies above the value range proposed in IPCC-GPG (2000), 0.2 to 1 %, since it includes installation losses per indoor unit.

The emission factors used are the result of surveys of experts.

4.7.1.2.5.2 Large air conditioning systems

In turbocompressor systems, only HFC-134a has been used since 1993. In the years 1995 through 1998, HFC-134a was also used for conversions of CFC-12 turbocompressor systems. In screw compressor systems, HFC-134a has been used since 1993. Since 1997, the refrigerant mixture R407C has been increasingly used as well. From 1995, through 2004, scroll and piston compressor systems used HFC-134a. Since 1997, the refrigerant mixture R407C has been used in such systems; since 2005, R410A has been used as well.

The following refrigeration model is applied:

- Stationary air conditioning systems are divided into three categories. The number of new systems in each of the following categories is determined each year via surveys of experts: turbocompressor systems for the upper performance range, screw compressors for the middle performance range and scroll and piston compressors for the lower performance range (to 20 kW). In cases in which less cooling power is required, room air conditioners are normally used.
- An average fill amount and specific refrigerant composition are determined for each category.
- Figures for annual consumption of refrigerant are obtained from the new additions of systems, in connection with the above assumptions. Consumption for CFC replacements in old systems has to be taken into account. HFC additions to domestic stocks are then obtained by subtracting production emissions, which tend to be low in general for refrigeration systems.
- When one knows the existing stocks, one can calculate the average yearly stocks and the year-end stocks.
- Production emissions are calculated by multiplying the quantities consumed in filling by the $EF_{production}$.
- Emissions from stocks are calculated with Equation 2.
- Disposal emissions occurred for the first time in 2005. They are calculated with Equation 3.

IPCC-GPG (2000), Table 3.22, gives a service lifetime of 10 to 30 years for liquid chiller systems. The values used in the present case lie within that range: 12 years for systems with piston and scroll compressors, 20 years for systems with screw compressors and 25 years for turbocompressor systems. The average lifetime of converted CFC-12 turbocompressor systems is estimated at 10 years.

Emission factors

The emission factors used are the result of surveys of experts.

Ongoing HFC emissions are placed at 6%, for all refrigeration-performance classes, compressor types, age classes and refrigerant types. That emissions figure lies within the lower range of the relevant proposal in IPCC-GPG (2000), 2 to 15 percent.

The filling loss, at 1 %, lies within the upper section of value range given by IPCC-GPG (2000), 0.2 to 1 %.

The country-specific emission factor used for disposal, $EF_{disposal}$ = 30 %, lies above the range proposed in IPCC-GPG (2000), 5 to 20 %.

Activity data

Due to a lack of publicly accessible statistics on annual HFC consumption for stationary air conditioning systems, of various types, all data for this application must be obtained via surveys of experts, covering the full spectrum from the global market leader to regional firms specialising in air conditioning systems.

4.7.1.2.5.3 Heat-pump systems

Via a refrigeration cycle, heat pumps draw heat from the air, ground or groundwater and make it available for heating or cooling indoor areas or for heating water. Since 1995, the refrigerant HFC-134a and the HFC mixtures R404A and R407C have been used; since 1998, R410A has been used as well.

A pertinent refrigerant model, developed with the help of experts, assigns mean HFC fill quantities, and percentage shares of the various HFC types, to the four heat-pump categories of "air", "groundwater", "ground" and "hot water". It also includes service-life and emissions-rate figures. The Bundesverband Wärmepumpe (BWP) national heat-pump industry association publishes annual statistics on the number of new pump units installed within the country. Those data provide the basis for emissions calculation.

Heat pumps with HFCs have been produced and sold since 1995. Since the units have an average service life of 15 years, disposal-related emissions begin occurring in 2010.

Emission factors

The emission factors used are the result of surveys of experts.

The current HFC emissions for heating-system heat pumps (air, groundwater and ground systems) are estimated at 2.5 %, while the emissions for water-heating heat pumps are placed at 2 %. The EF_{use} used thus lie within the range proposed by IPCC-GPG (2000), 1 to 5 %.

The filling losses amount to 2 g / heat pump. For the four types of heat pumps involved, with fill quantities ranging from 0.8 kg (water-heating heat pump) to 3 kg (heating-system heat pump working with air), the losses thus range from 0.07 to 0.25 %. Consequently, the $EF_{production}$ lies below, or lies within the lower part of, the range given in Table 3.22 of IPCC-GPG (2000), 0.2 to 1 %.

The emission factor for disposal, $EF_{disposal}$ = 30 %, lies in the upper part of the range proposed in IPCC-GPG (2000), 20 to 30 %.

Activity data

Each year, the Bundesverband Wärmepumpe (BWP) national heat-pump association publishes the numbers of new domestic installations of heat pumps. Those figures serve as the basis for the relevant emissions calculation.

4.7.1.2.6 Mobile air-conditioning systems (2.F.1)

"Mobile air conditioning systems" comprises vehicle air conditioning systems in passenger cars, trucks and utility vehicles, busses, agricultural machinery, rail vehicles and ships. Hydrofluorocarbons (HFCs) have been used in mobile air conditioning systems since 1993. In German-produced automobiles, they have been used since 1991. HFC-134a is the only HFC-based refrigerant used in such systems. Since the 2002 reporting year, less significant sources (such as agricultural machinery) have been included for the first time.

The time series show a significant emissions increase since 1995. This increase, which has occurred in spite of decreases in fill amounts, is a direct result of increased use of mobile air conditioning systems in vehicles.

We have applied our own refrigeration model, which is as follows:

- Determination of annual numbers of newly licensed vehicles, for the classes automobiles, trucks / utility vehicles, busses and agricultural machines.

- Determination of the average rates of installation of air conditioners in automobiles, trucks / utility vehicles, busses and agricultural machines. For automobiles, the average rate is based on figures for each vehicle type; these are supplemented as appropriate with figures of industry experts.
- Determination of the average fill amounts (refrigerant), from figures for each vehicle type and from figures provided by industry experts.
- Determination of numbers of air conditioning systems newly installed each year on ships (on the basis of statistics on new ship construction for the German fleet) and in railway vehicles (on the basis of new procurements by German Railways / Deutsche Bahn), and determination of the relevant fill amounts involved.
- Determination of annual new additions of HFC-134a for each area, using the above information, and determination of the final stocks and average stocks for each area.
- Emissions from stocks are obtained by multiplying the "average yearly stocks", for each area, by the relevant EF_{use}. Determination of domestic consumption of HFC-134a for production of mobile air conditioning systems.
- Production emissions are computed with Equation 1.
- Disposal emissions occurred for the first time in 2002. These are calculated via Equation 3.

Emission factors

The emission factors used were obtained from the literature (e.g. CLODIC & BEN YAHIA, 1997; FISCHER, 1997; ÖKO-RECHERCHE, 2001; ÖKO-RECHERCHE / ECOFYS 2003; PREISEGGER, 1999; SIEGL et al., 2002), as well as from measurements (automobiles), evaluations of workshop documentation and comprehensive surveys of experts. In addition to regular emissions during operation, emissions also arise as a result of accidents and other external influences.

Current HFC emissions are estimated at 10 %, for automobiles; at 10-15 % for utility vehicles; at 15 % for busses; at 6 % for railway vehicles; at 15 - 25 % for agricultural machinery; and 10 - 30 % for ships. The EF_{use} used thus lie largely within the range proposed in IPCC-GPG (2000), 10 to 20 % for air-conditioning systems in automobiles, utility vehicles, busses and railway vehicles. No proposals have been provided for agricultural machinery and ships.

The EF for filling of systems in automobiles, utility vehicles, busses and railway vehicles (cf. Table 118) lie below the value given in IPCC-GPG (2000: p. 3.110), 0.5 %. The Guidelines provide no values for agricultural machinery and ships.

The emission factor for disposal of HFC from mobile air conditioners is 30 %. It thus lies below the standard value in the IPCC-GPG (2000: p. 3.110), 40 %.

Activity data

The Federal Motor Transport Authority reports new registrations of automobiles, utility vehicles, busses and agricultural tractors. The sources for production figures include the German Association of the Automotive Industry (VDA), the German Engineering Federation (VDMA), other statistics and surveys of manufacturers.

Fill amounts for automobile air conditioners are determined via direct surveys of automobile companies. In addition, they are obtained by combining official statistics, information from surveys of automakers and experts' assessments (ÖKO-RECHERCHE, 2005).

4.7.1.3 Uncertainties and time-series consistency (2.F.1 all)

The emission factors are subject to considerable uncertainties. The broad range of emission factors found in the literature (see the refrigeration models) for identical applications is only partly a consequence of technical modifications, of how well systems are sealed or of national differences. To a large extent, it also results from real uncertainties, since too little solid empirical study of such factors has been carried out (ÖKO-RECHERCHE, 2007).

As a result of the aforementioned uncertainty with regard to emission factors, and to the large number of individual applications (systems) involved, the emissions data are considered to be too imprecise. In order to improve the reliability of data provided, the data were compared with manufacturers' (substance-oriented) sales data.

Until the 2001 reporting year, Germany reported only aggregated emissions, covering all sub-source categories. Within the context of emissions surveys for the years 1999 to 2001, and the emissions survey for the 2002 reporting year, the emissions for the reporting years 1995 to 1998 were reviewed and updated on the basis of new findings on input quantities and emission factors. All data are thus being improved on an ongoing basis.

The quality of the data on emissions from mobile air conditioning systems is good. The reason for this is that annual HFC consumption can be precisely determined via statistics on new registrations, and on production, imports and exports, of automobiles, which account for the largest part of this sector, as well as via annual model-specific figures on installation rates and the pertinent fill amounts. Only in the area of commercial vehicles are the data subject to major uncertainties.

The emission factors previously assumed have been confirmed via the results of an expert report by the Federal Environment Agency (UBA) (ÖKO-RECHERCHE, 2001) and an EU study on leakage rates from mobile air conditioning systems (ÖKO-RECHERCHE / ECOFYS, 2003). Overall, the EF are considered to be accurate.

The uncertainties for the entire sub-source category of refrigeration and air conditioning systems have been quantified for the 2012 report.

4.7.1.4 Source-specific recalculations (2.F.1 all)

The production and registration statistics for refrigerated vehicles (sub-source category 2.F.1.c) for the year 2009 had to be corrected to take account of new findings. Those corrections led to the changes listed in Table 119 in activity rates (AR) and emissions (EM) from production and use of HFC-125, HFC-134a, HFC-143a and HFC-32.

Table 119: Overview of recalculation-related changes in activity rates (AR) and emissions (EM) for production and use of HFC-125, HFC-134a, HFC-143a and HFC-32 in refrigerated vehicles in sub-source category 2.F.1.c.

	Units	2009
AR production, HFC-125		
Submission 2011	t	6.854
Submission 2012	t	9.096
Difference	**t**	**± 2.242**
AR production, HFC-134a		
Submission 2011	t	4.914
Submission 2012	t	5.943
Difference	**t**	**± 1.028**
AR production, HFC-143a		
Submission 2011	t	6.164
Submission 2012	t	8.153
Difference	**t**	**± 1.990**
AR production, HFC-32		
Submission 2011	t	1.639
Submission 2012	t	2.197
Difference	**t**	**± 0.559**
EM production, HFC-125		
Submission 2011	t	0.0067
Submission 2012	t	0.0083
Difference	**t**	**± 0.0016**
EM production, HFC-134a		
Submission 2011	t	0.0086
Submission 2012	t	0.0104
Difference	**t**	**± 0.0018**
EM production, HFC-143a		
Submission 2011	t	0.0066
Submission 2012	t	0.0081
Difference	**t**	**± 0.0016**
EM production, HFC-32		
Submission 2011	t	0.0011
Submission 2012	t	0.0014
Difference	**t**	**± 0.0003**
AR use, HFC-125		
Submission 2011	t	161.842
Submission 2012	t	163.805
Difference	**t**	**± 1.963**
AR use, HFC-134a		
Submission 2011	t	100.787
Submission 2012	t	101.378
Difference	**t**	**± 0.591**
AR use, HFC-143a		
Submission 2011	t	164.399
Submission 2012	t	166.389
Difference	**t**	**± 1.990**
AR use, HFC-32		
Submission 2011	t	22.735
Submission 2012	t	23.014
Difference	**t**	**± 0.279**
EM use, HFC-125		
Submission 2011	t	25.063
Submission 2012	t	25.382
Difference	**t**	**± 0.320**
EM use, HFC-134a		
Submission 2011	t	23.112
Submission 2012	t	23.260
Difference	**t**	**± 0.148**
EM use, HFC-143a		
Submission 2011	t	25.589
Submission 2012	t	25.917
Difference	**t**	**± 0.328**
EM use, HFC-32		
Submission 2011	t	3.410
Submission 2012	t	3.452
Difference	**t**	**± 0.042**

In keeping with recent publications of the Federal Motor Transport Authority, in the utility vehicles category (sub-source category 2.F.1.f) the number of newly registered utility vehicles with a gross vehicle weight exceeding 7.5 t had to be increased for 2009, retroactively, from 37,239 to 39,326 units. This made it necessary to recalculate the values for use of utility vehicles with a gross vehicle weight exceeding 7.5 t, and the recalculations raised the activity rate for such use from 521.91 t to 522.87 t (+ 0.96 t) of HFC-134a, and the use emissions from 78.29 t to 78.43 t (+ 0.14 t) of HFC-134a, in 2009.

An erroneously entered figure for the activity rate for production of railway vehicles (sub-source category 2.F.1.f) in 2009 was corrected; this reduced the relevant figure from 8.40 t to 7.56 t (- 0.84 t). As a result, the emissions from filling of HFC-134a in 2009 decreased from 0.017 t to 0.015 t (- 0.002 t). The activity rate for use decreased from 232.58 t to 232.16 t (-0.42 t), and the use emissions decreased from 14.0 t to 13.9 t (- 0.1 t).

4.7.1.5 Planned improvements (2.F.1)

The refrigerant models being used are to be reviewed for currentness.

4.7.2 Foam blowing (2.F.2)

Since 1993, hydrofluorocarbons (HFCs) have also been used in foam blowing as substitutes for ozone-depleting, climate-damaging CFCs and HCFCs.

No HFC blowing agents are needed in soft-foam production, and thus soft foams are not taken into account in the report.

The four categories of hard foam for which HFCs are used as blowing agents include PUR hard foam, PUR integral foam, PUR foam sealant (one-component foam – OCF) and XPS insulation foam.

4.7.2.1 PUR foam products (2.F.2)

4.7.2.1.1 Source category description (2.F.2)

The group of PUR foam products includes hard-foam and integral-foam products. Hard foams are used in many different types of products, including household appliances, insulation boards, sandwich elements and insulating foams produced in small series. Integral foams are used in shoes for sports and recreation and in various automobile parts. From 1996 to 1997, HFCs were used only in integral foams. Since 1998, they have also been used as blowing agents in PUR hard-foam products. HFCs have been giving way to hydrocarbons such as pentane.

The time series, which does not begin until 1996, shows a small increase in emissions until 2001. A larger increase occurred from 2002 to 2004. These results agree with the historical development of HFC use in this application area, an area which arose only slowly, as a result of the long period of utilisation of HCFCs. Emissions from PUR foam products decreased slightly as of 2005.

Along with HFC-134a, since 2002 HFC-365mfc (with small quantities of added HFC-227ea) has also been used as a blowing agent. Since 2004, HFC-245fa has also been used as such an agent. HFC-245ca is not used in Germany.

4.7.2.1.2 Methodological issues (2.F.2)

Emissions are determined by means of Equation 1 und Equation 2. The production emissions consist of the quantity of HFC emitted within no more than one year after production (first-year loss).

Emission factors

The emission factors used are shown in Table 118. In the case of PUR hard foams with HFC-134a, the factors are in line with the standard values given in IPCC-GPG (2000), on page 3.96. The emission factors for all other HFCs have been approved by national experts and adjusted where necessary. For example, the emission factor for production of PUR hard foam with use of 365mfc/227ea was increased from 10 % to 15 %, because that HFC mixture has been used increasingly since 2004 in open on-site applications, especially in spray foams.

The emission factor for HFC-365mfc from stocks was taken from an estimate based on test products.

In the case of integral foams, the entire blowing agent (apart from small residual amounts) escapes during the foaming process. Since the residual amounts in question escape within no more than 2 years (so the domestic experts who were consulted), an emission factor of 100 % for production is considered suitable for Germany, instead of the value given in IPCC-GPG (2000).

Activity data

The figures for new domestic consumption, for each blowing agent and each product group, are based on the amounts of foam products produced in Germany. The data for products in service are based on the amounts of foam products used in Germany (sales in Germany) since the introduction of HFCs. Given a product lifetime of at least 20 years, removals from products in service do not yet play any significant role.

New domestic consumption and domestic sales of foam products are determined annually via surveys of manufacturers, users and blowing-agent suppliers, and via information from the relevant industry association (IVPU – the polyurethane-foam industry association).

4.7.2.2 PUR foam sealants (2.F.2)

4.7.2.2.1 Source category description (2.F.2)

The term "foam sealant" refers to polyurethane foam that is sprayed, on site, from pressurised containers (cans). The blowing agents now used for such foam, following the prohibition of HCFCs, include mixtures of HFCs and propane, butane or dimethyl ether (DME). At the same time, the HFC quantities in such cans have been continually reduced since 1996.

HFC-134a has been used in Germany since 1992, in production of PUR one-component foam (in cans). HFC-152a was used from 2002 to 2004. Imported cans of PUR foam sealant used in Germany contain HFC-134a (since 1992) or HFC-152a (since 1995). Emissions from PUR foam sealants have been decreasing since 1997. Since 4 July 2008, a ban has been in force in the EU, with a few permitted exceptions, on sale of one-component-foam products filled with fluorinated greenhouse gases. For that reason, future emissions can be expected to remain relatively constant, at low levels.

4.7.2.2.2 Methodological issues (2.F.2)

Pursuant to the IPCC Guidelines (1996b: p. 2.58), in each case the emissions for this open use are considered the same as the HFC quantity sold with the can. In contrast to the IPCC method, it is assumed that all emissions occur in the year of sale, however, since use and disposal occur promptly. At the same time, used cans are not completely empty when they go to waste management; they still contain about 8 % of their original foam contents, including the relevant blowing agent. The majority of that blowing agent eventually also enters the atmosphere, after a certain delay.

Filling emissions are calculated from the number of cans filled per year in Germany and the blowing-agent loss per can.

Emissions from use are calculated with Equation 2.

Emission factors

The $EF_{production}$ was determined via surveys of experts and of manufacturers. From 1992 to 2002, it amounted to 1.5 g/can, while as of 2003 it has been only 0.5 g/can, since the total fill quantities in cans have decreased.

Activity data

The following data are required for determination of new domestic HFC consumption for filling and the resulting filling losses (production emissions):

- Number of cans filled annually, in Germany, with HFC-134a or HFC-152a,
- HFC content per can, in grams,
- Specific filling loss.

These data are obtained via surveys of experts.

The following information is required for determination of use emissions per year:

- Number of cans with blowing agent 134a or 152a that are sold annually in Germany,
- HFC content per can, in grams.

These data are provided by the manufacturers themselves.

The pre-1995 data for foam sealants were obtained via discussion, in 2006, with leading foreign OCF sellers and from older publications.

4.7.2.3 XPS hard foam (2.F.2)

4.7.2.3.1 Source category description (2.F.2)

HFC consumption and emissions from production of XPS insulation boards have occurred only since 2001, since HCFCs or $CO_{2/ethanol}$ were used in this area prior to that time. HFC-152a and 134a, either by themselves or in mixtures, are used.

4.7.2.3.2 Methodological issues (2.F.2)

Total emissions from this area are calculated with Equation 1 and Equation 2. For both of the HFCs used, the new inland consumption is reported directly by the European association CEFIC[43] or by its industry group EXIBA[44].

Trials with HFC collection and recovery have been conducted, but to date no relevant systems have been implemented, for both technical and economic reasons.

Use emissions are calculated from the average amount of HFCs in XPS insulating foams in domestic service. This amount increases annually solely through new addition of insulation boards containing 134a. Given a product lifetime of 50 years, removals from products in service do not yet play any significant role. The new HFC additions are not equivalent to annual new consumption, minus production emissions. The reason for this is that, as a result of foreign trade, especially exports of 134a-based XPS, only 25 % (the complementary value for the export rate) of the HFC-134a contained in products amounts to new additions to domestic HFC stocks.

Disposal emissions thus play no significant role to date.

Emission factors

The production emissions (HFC first-year losses) for HFC-152a are practically 100 % ($EF_{production}$ of HFC-152a = 1), since the substance is used solely as a blowing agent in production. With HFC-134a, only part of consumption is emitted upon blowing; most of the substance enters into the product. The $EF_{production}$ for HFC-134a is determined empirically and communicated by the CEFIC[45] association or by its EXIBA[46] industry association.

A representative of the FPX extruded-polystyrene-foam association estimated the annual releases from enclosed HFC-134a cell gas as being less than 1 % in 2002. That figure is based, inter alia, on an internal study of BASF regarding the half-lives of various cell gases, including HFC-134a (WEILBACHER 1987). The EF_{use} from that laboratory study has been used for HFC-134a. Fugitive emissions from boards depend on board thickness, and they can be given only as average values, or as values for specific board thicknesses. The value used, EF_{use} = 0.66 %, is based on average board thickness, and it lies below the value proposed in IPCC-GPG (2000), 3 %.

Activity data

All of the data required for emissions calculation, including new domestic consumption, loss rate in production and the foreign trade balance for HFC-134a-containing insulation boards, are provided by the relevant European industry association (CEFIC or EXIBA).

4.7.2.4 Uncertainties and time-series consistency (2.F.2)

The uncertainties for the "foams" sub-source category have been systematically quantified.

The emissions data for prior years, for PUR foam products, are considered fairly accurate, since the quantities of HFCs used are still rather small at present. In future, however, it will

[43] CEFIC – The European Chemical Industry Council
[44] EXIBA – European Extruded Polystyrene Insulation Board Association
[45] CEFIC – The European Chemical Industry Council
[46] EXIBA – European Extruded Polystyrene Insulation Board Association

become more difficult to obtain a good market overview in view of the anticipated product diversity.

Because it includes only a small number of manufacturers, the German XPS market is not complex. Since the EF and AR were prepared in co-operation with manufacturers, they are considered sufficiently precise.

Since 2001, the relevant industry association has determined the input quantities of HFC-152a and HFC-134a (AR) in production of XPS hard foams. Since only three manufacturers use HFC for XPS blowing, there is little reason to doubt the reliability of the activity data. This also applies to the export rate and the HFC production emissions determined for use of HFC-134a.

The production emissions in use of HFC-152a, 100 %, do not agree with the existing IPCC estimates. Nonetheless, the industry association considers them to be realistic.

The value for the emissions rate from current stocks, as determined by a laboratory study, will be used as long as no reliable measurements with insulation boards in actual service have been carried out; such measurements would be considered more conclusive than laboratory values.

4.7.2.5 Source-specific recalculations (2.F.2)

No recalculations are required.

4.7.2.6 Planned improvements (source-specific) (2.F.2)

No improvements are planned at present.

4.7.3 Fire extinguishers (2.F.3)

4.7.3.1 Source category description (2.F.3)

Halons, which until 1991 were permitted fire extinguishing agents, have since been largely supplanted by ecologically safe substances – especially inert gases, such as nitrogen and argon, for systems for flooding rooms; and by powder, CO_2 and foams in handheld fire extinguishers.

In 1998, HFC-227ea was certified in Germany as a halon substitute. In 2001, HFC 236fa also received such certification. That substance is used solely in the military sector, however. HFC-23, while certified since 2002, did not begin to be used until 2005. Today, certification of fire extinguishing agents is no longer required. Nonetheless, the list of fire extinguishing agents in use has not grown, since all application areas can be covered with halogen-free agents and with the aforementioned HFCs (especially 227ea and 236fa).

HFC-based fire extinguishing agents are imported and filled into fire extinguishing systems in Germany. Virtually no foreign trade with filled systems takes place. The time series do not begin until after 1995.

4.7.3.2 Methodological issues (2.F.3)

The annual new HFC additions in domestic systems are identical with the amounts added to new systems within the country (new HFC consumption).

IPCC-GPG (2000, Chapter 3.7.6) proposes that a "sales-based top-down" approach be used for determining emissions in connection with fire extinguishing agents. A bottom-up Tier-2 approach is considered unsuitable because the activity rates required for that approach are unavailable for many countries. Since activity data are available in Germany for HFC-227ea and 236fa, a bottom-up approach is used. Unlike the top-down approach of the IPCC-GPG (2000), the bottom-up approach takes filling emissions into account.

Due to a lack of pertinent data, the installed quantities of HFC 23 are estimated by the Federal Environment Agency.

Pursuant to the *IPCC Guidelines 2006*, fire extinguishing systems have an average service life of 15 years.

Emission factors

The $EF_{production}$ are based on experts' assessments.

That $EF_{production}$, which is based on experts' assessments, increases for HFC-236a from 1 % to 4 % by the year 2007, in order to take account of the greater probability of leaks in older systems. The 4 % figure conforms to the IPCC Guidelines 2006. The emission factor for use of HFC-23 has also been set at 4 %. With regard to HFC-227ea, concrete figures are available relative to installed and refilled quantities. They were obtained via up-scaling from the pertinent company's market share (as estimated by the company) to the German market as a whole.

For all HFCs, the emission factor for disposal is 100%.

Activity data

The emission figures for HFC 227ea are based on statistical surveys by one company, covering the aspects of input quantities, refill quantities, accidental releases, releases in cases of fire, and flooding tests in Germany (by analogy to Tier 2). Up-scaling was carried out on the basis of the market shares estimated by the company. The data for HFC-236fa are based on company information provided on a voluntary basis. The figures for HFC-23 are based on estimates of the Federal Environment Agency.

4.7.3.3 Uncertainties and time-series consistency (2.F.3)

The uncertainties for the "fire extinguishing agents" sub-source category have been systematically quantified.

4.7.3.4 Source-specific recalculations (2.F.3)

No recalculations are required.

4.7.3.5 Planned improvements (source-specific) (2.F.3)

No improvements are planned at present.

4.7.4 Aerosols (2.F.4)

This area includes metered-dose inhalers (MDI), which are used in medical applications, as well as general-purpose aerosols and so-called "novelty aerosols".

4.7.4.1 Metered-dose inhalers (2.F.4.a)

4.7.4.1.1 Source category description (2.F.4.a)

Metered-dose inhalers are used in the medical sector, primarily for treatment of asthma. Metered-dose inhalers with an HFC propellant first reached the German market in 1996. They contained the propellant HFC-134a. Since then, the number of available preparations has grown continually. Domestic filling of such devices did not begin until 2001. Since 1999, HFC-227ea has also been used, in addition to HFC-134a, as a propellant for metered-dose inhalers.

The time series shows an emissions increase that correlates with increasing use of HFCs as CFC substitutes. A large change occurred in 2001. As of that year, CFCs were prohibited for the largest group of active ingredients, the short-acting betamimetics.

4.7.4.1.2 Methodological issues (2.F.4.a)

With regard to the activity data, the method is equivalent to a bottom-up approach. Since 98 % of the contents of such inhalers consist of propellant, their contents are considered to consist solely of HFCs.

Most inhalers are sold by chemists (pharmacies). An estimated 10 percent are used by hospitals, for their own needs, while 3 percent are samples, "not for sale", for doctors and pharmaceutical representatives. These two categories are taken into account by adding 13 % to sales by chemists/phamarcies.

The time period between pharmacy sales and use is short. The reference figure for emissions – in contrast to IPCC-GPG (2000, equation 3.35) – is thus not the sum of half the purchases (sales) of the previous year and half the purchases (sales) of the current year, but all purchases (sales) for the current year. The IPCC-GPG approach would be a useful choice if the available data covered produced inhalers – rather than sold inhalers – since considerable time, for transport and storage, indeed passes between production and use.

The production emissions are added to the usage emissions. Part of the emissions are collected with cold traps and then incinerated. Without such collection, the emissions would be higher.

Emission factors

The EF_{use} on which production-emissions data are based is itself based on very precise producer determination of filling emissions. These amount to about 1 %, with respect to new consumption for filling. This translates to about 0.15 g per 10 ml inhaler.

In agreement with IPCC specifications (IPCC-GPG (2000), p. 3.85), a 100 % emissions level in use (EF_{use} = 1) is assumed. Inhaled HFCs are not broken down in bronchial passages; they are released into the atmosphere, without undergoing any changes, upon exhalation. The inhalers are assumed to have a lifetime of only one year, however. The emission factor has thus been classified as "country-specific".

Activity data

The emissions data for the period until reporting years 2005 (production) and 2006 (use) are based on sales figures (sales in pharmacies) for metered-dose inhalers in Germany, as obtained via surveys of producers. The total unit numbers, the average fill quantity in ml and the propellant used have all entered into relevant calculations. As of the 2006 reporting year, the activity-rate figures for production are based on experts' estimates. As of the 2007 reporting year, the activity-rate figures for use are based on such estimates. In the category "metered dose inhalers", the results of the *Federal Statistical Office's* annual surveys of certain climate-relevant substances normally do not become available on time for the corresponding current report year. Retroactive data cross-checking is carried out when necessary, however.

4.7.4.2 Other aerosols (2.F.4)

4.7.4.2.1 Source category description (2.F.4.b)

In Germany, six types of general-purpose aerosols (includes neither medical sprays nor novelties) containing HFC are sold:

- Compressed-air sprays,
- Cooling sprays,
- Drain-opener sprays,
- Lubricating sprays,
- Insecticides, and
- Self-defence sprays.

Production and use of general-purpose aerosols with HFC-134a began in 1992; production and use of such aerosols with HFC-152a began in 1995. The HFC quantities filled in Germany remained constant from 1995 to 2005. Since 2006, those quantities have been decreasing slightly.

Other aerosols include "novelty" aerosols (artificial snow, "silly string", etc.). Such products are not produced in Germany, however. Use of novelty sprays with HFC-134a began in 1995, while use of sprays with HFC-152a began in 2000. The relevant emissions have been decreasing sharply since 2003. That trend is the result of a EU ban, in force as of 4 July 2009, on sale of novelty aerosols filled with hydrofluorocarbons (HFCs). Producers were quick to respond by choosing other propellants for their products.

4.7.4.2.2 Methodological issues (2.F.4.b)

Imports and exports are roughly in balance, and thus the domestic market can be considered equivalent to consumption for domestic filling. Domestic consumption refers to spray cans filled in Germany, regardless of where the cans are ultimately used.

Emission factors

In keeping with IPCC specifications (IPCC-GPG (2000), p. 3.85), a 100 % emissions level for use ($EF_{Anwendung}$ = 1) is assumed; this is appropriate and justified. Of the numbers of spray cans sold in Germany, it is assumed that half are used in the same year they are purchased and half are used in the following year. This is in keeping with the pertinent proposal in IPCC-GPG (2000). The emission factor has thus been classified as "default".

The EF_{use} = 1.5 % on which production-emissions data for other aerosols are based is itself based on experts' assessments.

Activity data

The data for the period prior to 1995 are based on estimates of experts. In keeping with a bottom-up approach, all quantity data as of 1995 are provided directly by producers, fillers and operators, as well as by relevant industry associations. Emissions data for general-purpose aerosols also include filling emissions (= production emissions). Estimates are based on EU-wide data.

4.7.4.3 Uncertainties and time-series consistency (2.F.4 all)

The uncertainties for the "aerosols" sub-source category have been systematically quantified.

In the case of metered dose inhalers, the surcharge factor for hospitals and doctors' samples can vary, by ± 3 %, from the above-cited 13%.

In comparison to the emissions data for metered dose inhalers, the data for other aerosols are considered to be not as good, since the large number of products involved makes it difficult to obtain an overview of the market. Large quantities of imports, especially in the area of "novelties", also complicate the situation. The uncertainties are thus considerably higher (more than 20 %).

Since the shift from CFCs to chlorine-free propellants had already been completed by the beginning of the 1990s, the time series for the period 1995-2005 showed virtually no changes. Slight emissions decreases have been seen since 2006.

4.7.4.3.1 Source-specific recalculations (2.F.4 all)

No recalculations are required.

4.7.4.3.2 Source-specific planned improvements (2.F.4 all)

No improvements are planned at present.

4.7.5 Solvents (2.F.5)

4.7.5.1 Source category description (2.F.5)

Use of HFCs as solvents was banned in Germany until the year 2001 (2nd Ordinance on the Implementation of the Federal Immission Control Act – 2. BimSchV) and remains heavily restricted to this day. Individual applications must be submitted for each form of use, and such applications are approved only in special cases.

4.7.5.2 Methodological issues (2.F.5)

Emissions are calculated in keeping with Tier 2 as described in IPCC-GPG 2000 (Equation 3.36).

Emission factors

Emissions in use are assumed to be completed within 2 years.

Activity data

The emissions data are based on sales data of the authorised vendor, and they apply solely to HFC-43-10mee. Since the data are confidential, they are reported under CRF 2.G.

4.7.5.3 Uncertainties and time-series consistency (2.F.5)

All of the uncertainties for the sub-source category *solvents* have been identified.

4.7.5.4 Source-specific recalculations (2.F.5)

No recalculations are required.

4.7.5.5 Source-specific planned improvements (2.F.5)

No improvements are planned at present.

4.7.6 Other applications that use ODS substitutes (2.F.6)

Germany reports no emissions in this source category.

4.7.7 Semiconductor manufacturing (2.F.7)

4.7.7.1 Source category description (2.F.7)

The semiconductor industry currently emits PFCs (CF_4, C_2F_6, C_3F_8, c-C_4F_8), HFCs (CHF_3), nitrogen trifluoride (NF_3) and SF_6 from production processes. These gases are used for etching structures on thin layers and for cleaning reaction chambers following chemical vapour deposition (CVD). In the production process, some of the PFCs fed into plasma chambers are converted partly into CF_4.

The semiconductor industry's emissions depend partly on the degree to which the industry uses waste-gas-scrubbing equipment. They also depend directly on semiconductor-production levels (in the present case, annual levels). As a result of these dependencies, emissions tend to fluctuate rather strongly from year to year.

4.7.7.2 Methodological issues (2.F.7)

The emissions cannot be determined solely on the basis of input quantities (sales by gas vendors), because the difference between consumption and emissions depends on a number of factors, including only-partial chemical transformation in plasma reactors and the effects of downstream waste-gas-scrubbing systems.

Emission factors

During the etching process, only about 15 % of the added CF_4 reacts chemically. The emission factor, an inverse reaction quota, thus amounts to 85 % of the CF_4 consumption.

Activity data

Reliable emissions data are available for 1990 and 1995. Linear interpolation was carried out for the years 1991 to 1994.

Until the 2000 report year, emissions data were based on surveys carried out by the EECA-ESIA (European Electronic Component Manufacturers Association – European

Semiconductor Industry Association). National manufacturers were queried regarding production capacities, amounts of substances used and waste-gas treatment equipment.

As the result of a voluntary commitment by the semiconductor industry, emissions figures are available for this sub-source category, for all individual substances, from the year 2001 onwards. In keeping with a standardised calculation formula (Tier 2c approach), the emissions data are calculated for each production site, from annual consumption, aggregated and then reported by the German Electrical and Electronic Manufacturers Association (Zentralverband Elektrotechnik- und Elektroindustrie eV. - ZVEI, electronic components and systems) to the Federal Environment Agency.

4.7.7.3 Source-specific recalculations (2.F.7)

The association (ZVEI) has carried out moderate recalculations for period 1995 until (no later than) 1999.

		Units	1995	1996	1997	1998	1999
Submission 2011	C_2F_6 emissions	t	11.31	13.90	17.40	17.34	18.80
Submission 2012			13.32	14.62	18.13	18.48	18.32
Difference			**2.00**	**0.72**	**0.72**	**1.14**	**-0.48**
Submission 2011	CF_4 emissions		11.19	12.71	12.89	11.69	17.10
Submission 2012			11.89	13.25	13.43	12.71	17.15
Difference			**0.70**	**0.54**	**0.54**	**1.02**	**0.05**
Submission 2011	CHF_3 emissions		1.06	1.25	1.33	1.00	1.05
Submission 2012			1.16	1.30	1.38	1.05	1.06
Difference			**0.10**	**0.05**	**0.05**	**0.05**	**0.01**
Submission 2011	SF_6 emissions		2.04	1.75	2.22	2.44	2.19
Submission 2012			2.07	1.75	2.22	2.44	2.19
Difference			**0.04**	**0.00**	**0.00**	**0.00**	**0.00**

4.7.7.4 Source-specific planned improvements (2.F.7)

No improvements are planned at present.

4.7.8 Electrical equipments (2.F.8)

This source category consists primarily of use of electrical equipments (2.F.8.a), which is further sub-divided into high-voltage (HS – Hochspannungs-), medium-voltage (MS – Mittelspannungs-) and other electrical equipments. The area of particle accelerators is reported under 2.F.8.b.

4.7.8.1 Use of electrical equipments (2.F.8.a)

4.7.8.1.1 Source category description (2.F.8.a)

In electricity transmission and distribution, SF_6 is used primarily in switchgear and controlgear and equipment in high-voltage (52-380 kV) and, increasingly, medium-voltage (10-52 kV) networks. It serves as an arc-extinguishing and insulation medium (in the latter function, in place of air). In addition, it is used in production of components installed in gas-insulated indoor switchgear and controlgear (instrument transformers, bushings) or supplied directly to operators (high-voltage instrument transformers for outdoor installations).

As a result of first-time inclusion, in the 2002 reporting year, of additional SF_6 applications, the time series shows a marked jump in emissions in 2002. In report year 2005, new companies were included in reporting, especially in the new category "Other electrical equipments". For reasons having to do with the economy as a whole, more systems were sold in 2005 and 2006. Nonetheless, absolute emissions are falling overall, due to considerable reductions in the area of "other" equipments and as a result of again-lower emissions rates in switchgear and controlgear. In 1996, industry, represented by producers' and operators' associations and the SF_6 producer, committed itself to reducing emissions in life cycles of switchgear and controlgear and to provide annual progress reports. In 2005, this voluntary commitment was extended, in co-operation with the Federal Environment Agency and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), to include additional energy-transmission and energy-distribution installations above the 1 kV level. In addition, specific reduction targets were added to the commitment. The scope of voluntary reporting was enlarged and refined accordingly. In 2006, manufacturers and the gas producer made further investments in reduction measures. Substitutes for SF_6 foams were introduced in some sub-areas of bushings. This brought about further reductions in specific emissions rates and absolute emissions, even though production continued to increase.

4.7.8.1.2 Methodological issues (2.F.8.a)

The emissions figures are based largely on a mass balance. Increasingly, they are also being combined with emission factors for sub-areas in which the technical measurement limits for mass-balancing have been reached or in which mass-balancing would necessitate unreasonably high costs.

The methods used are based on the new "2006 IPCC Guidelines for National Greenhouse Gas Inventories; Volume 3", Chapter 8. For further information, the reader is referred to "Tier 3, Hybrid Life-Cycle Approach" in sub-chapter 8.2.

Usage emissions

Ongoing emissions from products in service include the amount of SF_6 in service, as accumulated since 1970 via annual additions of switchgear and controlgear; they are given as the average for year n.

The final amount of SF_6 in all electrical equipments for a given year n changes annually by the balance of new additions and removals. Some removals (high voltage) have been registered since 1997; large-scale removals of first-generation high-voltage switchgear and controlgear and equipment cannot be expected until after 2010, in light of the products' estimated service lifetime of at least 40 years.

Three special aspects must be taken into account in reporting relative to switchgear and controlgear:

- Calculation of the final stocks for a given year n is based on the final stocks for the previous year (n-1); this does not extend back to the first year of service, however. Such backward extension, an otherwise customary procedure, is not used for switchgear and controlgear, because operators/manufacturers estimated the SF_6 stocks in service for 1995. Their estimate was broken down into high-voltage and medium-voltage categories (770 t and 157.6 t, respectively).

- In the area of high-voltage switchgear and controlgear, stocks and emissions are determined via direct surveys of the some 100 operators. In such surveys, the operators are asked to provide data on their current stocks of SF_6 in electrical equipments (gas-insulated HV switchgear (GIS), circuit breakers, outdoor instrument transformers). Emission factors determined on the basis of reference systems are then applied to such stocks data.
- The group of operators of medium-voltage switchgear is very numerous and highly diverse. It is thus not feasible to conduct direct surveys. Manufacturers of medium-voltage switchgear have themselves taken responsibility for updating their domestic stock data on the basis of their sales data. The emissions can be determined in that the systems are practically maintenance-free and, by definition (IEC 62271-1), require no refilling throughout their entire lifetimes. The emissions are minimal (usually, they occur only as a result of external influences), and they can be accounted for via a lump-sum emission factor (resulting from survey of experts): the emissions rate has been set at a constant 0.1 % since 1998, since virtually all of the systems added to domestic stocks since the mid-1990s are systems that are "sealed for life" (hermetically sealed pressurised systems pursuant to IEC). In their voluntary commitment of 2005, the operators also promised to use only such systems. As a result, the impact of the few older systems that have emissions rates greater than 0.1 % has diminished. Stocks are calculated, in each case, by adding new additions to the previous year's stock level and deducting decommissioned units. To date, for reasons of practicality, the resulting calculatory, marginal, emissions-based reductions of stocks have not been taken into account.

Disposal emissions

Because switchgear and controlgear have long service lifetimes (40 years), and because the first use of SF_6 dates from the late 1960s, disposal emissions are just now beginning to occur, on a small scale. The quantities of SF_6 (AR), in old switchgear and controlgear (high-voltage and medium-voltage), that now need to be disposed of thus simply have been roughly estimated to date (at a constant 3 t/a). As of the 2005 report year, amounts for disposal from systems removal are being determined precisely for the first time, by the relevant associations. This also applies to emissions from disposal, which prior to 2005 were estimated at 0.06 t.

Activity data

In the framework of manufacturers' voluntary commitment, annual consumption by manufacturers of electrical equipments, and stocks of medium-voltage switchgear and controlgear, are reported to the Federal Environment Agency by the German Electrical and Electronic Manufacturers' Association (ZVEI), while stocks of high-voltage switchgear and controlgear, outdoor-mounted instrument transformers, gas-insulated lines and transformers are reported by the Forum network technology / network operation (FNN) in the Association for Electrical, Electronic & Information Technologies (VDE) and, since 2004, by the Association of the Energy and Power Generation Industry (VIK). Participants in the voluntary commitment jointly determine quantities of decommissioned units.

Table 120 shows the inventory data for the current year, broken down by sub-source categories and with explanatory remarks. The sum total for electrical equipments for energy transmission and distribution agrees with the data in Table 2 (II)F, Sheet 2, source category 2.F.8 in the CRF.

Table 120: 2010 inventory data for source category 2.F.8, including relevant sub-source categories

Source category 2.F.7 – electrical equipments for energy transmission and distribution, with sub-source categories – 2009 inventory	Activity data			Emissions	
	Annual consumption, production	Stocks	Decommissioned	Production	Operation
			(tonnes of SF_6)		
Electrical equipments for energy transmission and distribution 2.F.8 (Total), including:	942.6	2033	15	10.5	7.1
MV switchgear and controlgear and equipment (in hermetically sealed pressurised systems)*	153.1	860.0	0.12	0.6	0.9
HV switchgear and controlgear and equipment (in hermetically sealed pressurised systems)**	726.3	988.2	14.9	3.7	5.7
Other electrical equipments ***	63.1	185.0	IE	6.2	0.5

IE= included in "HV switchgear and controlgear…"; marginal

Explanatory remarks:

* Hermetically sealed pressurised systems pursuant to IEC 62271-1 for the range 1kV through 52 kV; also known as "sealed for life" systems

** Sealed pressurised systems pursuant to IEC 62271-1 for the range above 52 kV

*** Gas-insulated transformers: marginal residual stocks in the network; (no production emissions) + high-voltage instrument transformers for outdoor installation (all emissions categories) + gas-insulated lines (GIL) (all emissions categories) + high-voltage bushings (only production emissions) + medium-voltage cast-resin instrument transformers (only production emissions) + testing of medium-voltage components (only production emissions) + 1000V capacitors (only production emissions)

4.7.8.1.3 Uncertainties and time-series consistency (2.F.8.a)

Since there are only about ten different manufacturers of electrical equipments (including bushings and instrument transformers), the consumption data, and the new-additions and decommissioned-units figures, are highly reliable. This holds all the more in that such data and figures are based on internal accounting, and that fill amounts are determined with great precision and then noted on devices' name plates. The pertinent uncertainty is in the area of ± 5 %.

Determination of emissions is more difficult, since the plants typically concerned have several different emissions sources, each quite small. Gas losses occur in filling of devices, in testing, in opening of products that fail to pass quality inspections, in product development, etc.. On the other hand, all domestic plants proceed in accordance with a standardised questionnaire that lists all possible emissions sources and that is checked for correctness during surveys. For this reason, and because there are few manufacturers (see above), the precision of data collection ultimately depends on the precision of the relevant measurements. The resulting figures lie within ±10 % of estimates.

Emissions from operation in the high-voltage sector are determined by operators, via annual refilling, which is carried out by operators' own personnel or by manufacturers' service networks. (Refilling is carried out when the fill level drops below 90 % of the desired fill level; normally, devices are equipped to show any need for refilling.) This method can be considered very reliable, i.e. the deviations from the actual value are about ±5 %. All surveys to date have produced similar results for emissions rates; all results are within a range from 0.75 to 0.88 %. The one-time emissions-rate peak for high-voltage switchgear and controlgear that occurred in 2004 is the result of special events. In the main, it was due to simultaneous refilling of old, older-model systems that were less well-sealed.

In the year 2000, a decrease with respect to the previous year occurred in high-voltage in-service stocks and, thus, in emissions, both of which had been increasing since 1995. For in-service stocks, the decrease amounted to over 25 t, while for emissions it amounted to 0.85 t. That decrease, which was due to trends in gas-insulated HV switchgear (GIS) (600 to 567 t), cannot be explained as the result of decommissioning removals, since the role of such removals is still insignificant. According to the VDN, which carries out the surveys, the underlying problem is both statistical and organisational in nature. At the end of the 1990s, electricity-market liberalisation led to profound operator regrouping (through mergers and changes in ownership of various parts of companies). Along with those changes, personnel assignments relative to electrical equipments in service were repeatedly changed. As a result, it is possible that double-counting occurred in 1999, and that some operating equipment was not counted in 2000. In light of experience gained in recent years, the uncertainty today can be assumed to lie in the range of ± 5 % for high-voltage stocks.

The emissions rate of 0.1 % in the medium-voltage sector may be considered acceptable for stocks in recent years.

4.7.8.1.4 Source-specific recalculations (2.F.8.a)

No recalculations are required.

4.7.8.1.5 Source-specific planned improvements (2.F.8.a)

No improvements are planned at present.

4.7.8.2 Use in particle accelerators (2.F.8.b)

4.7.8.2.1 Source category description (2.F.8.b)

SF_6 is used in elementary particle accelerators as an insulating gas. High-voltage accelerator systems (0.3 to more than 23 MV) are used by university institutes, research groups and industry. In industry, low-voltage devices with less than 0.3 MV are also used. Yet another relevant category consists of radiation-therapy devices in medical facilities.

4.7.8.2.2 Methodological issues (2.F.8.b)

In early 2004, Öko-Recherche, working under commission to the Federal Environment Agency, carried out a complete survey of particle accelerators within the country, with the aim of updating pertinent data, some of which date from 1996. In the process, both users and producers of the devices/systems were queried. The questions posed had to do with the quantities of SF_6 in their devices and with refills of SF_6 carried out during the last seven years.

The CSE assumes responsibility for structuring the survey. For all five relevant categories, it contains annual data on SF_6 stocks and on replacements to compensate for emissions. The emissions in question include both ongoing emissions and minor filling and disposal losses.

4.7.8.2.3 Uncertainties and time-series consistency (2.F.8.b)

The uncertainties for this source category have been systematically quantified.

4.7.8.2.4 Source-specific recalculations (2.F.8.b)

No recalculations are required.

4.7.8.2.5 Source-specific planned improvements (2.F.8.b)

No improvements are planned at present.

4.7.9 Other (2.F.9)

This source category comprises the uses *Sound-proof glazing* (2.F.9.a), *Automobile tyres* (2.F.9.b), *Sport shoes* (2.F.9.c), *Trace gas* (2.F.9.d), *AWACS maintenance* (2.F.9.e), *Welding* (2.F.9.f), *Optical glass fibres* (2.F.9.g) and *Photovoltaics* (2.F.9.h).

4.7.9.1 Sound-proof glazing (2.F.9.a)

4.7.9.1.1 Source category description (2.F.9.a)

Since 1975, SF_6 has been used to enhance the soundproofing properties of multi-pane windows. In such use, the gas is inserted into the spaces between the panes. The disadvantages of such use are that it reduces windows' thermal-insulation performance and that SF_6 is a powerfully acting greenhouse gas. The higher priority given to thermal insulation – e.g. by the Thermal Insulation Ordinance (Wärmeschutzverordnung) – along with improved SF_6-less window technologies, have led to a reduction in use of SF_6 in this application since the mid-1990s.

In Germany, sound-proof windows have been produced by numerous companies and filled with gas. Exports of assembled windows play no significant role.

Since 4 July 2007, a ban has been in force in the EU on sale of windows, for residential uses, that are filled with fluorinated greenhouse gases. As of 4 July 2008, that ban also applies to other windows. Current and future emissions in this source category thus come primarily from open waste management of old windows, which is assumed to occur an average of 25 years after the windows were filled. For this reason, total emissions are expected to continue growing until the year 2020.

4.7.9.1.2 Methodological issues (2.F.9.a)

Emissions occur during filling of spaces between panes, as a result of overfilling (production emissions), during use (use emissions) and in disposal (disposal emissions). Emissions are calculated in keeping with with equations 3.24 – 3.26 of IPCC-GPG (2000) on the basis of new domestic consumption, average annual stocks and remaining stocks 25 years ago.

The time series for sound-proof glazing begin in 1975, since the filling quantities of the year 1975 are of relevance for emissions from stocks in 1995. These data, which were reconstructed with the help of industry experts in 1996, were published in 2004 for the first time.

Emission factors

According to expert-level information from manufacturers of windowpanes and gas-filling equipment, provided to industry experts and to a scientific institute, one-third of the SF_6 used in the process of pumping SF_6 into spaces between windowpanes escapes. The $EF_{production}$ is thus 33 %, with respect to new annual consumption.

This emission factor is obtained in the following manner: In use of both manual filling devices and automatic gas-filling presses, gas-swirling in the space between the panes cannot be avoided. As a result, the escaping gas consists not only of the air originally between the panes, it also includes an air-SF_6 mixture. More and more mixed gases escape as the filling process progresses. The gas loss, the "overfill", ranges from 20 to 60 % of the amount filled. The smaller the window concerned, the greater the overfill's relative importance. On average, i.e. throughout the entire spectrum of filled windows, of all shapes and sizes, the overfill level amounts to 50 % of the amount actually contained between the panes. This corresponds to one-third (33 %) of the relevant consumed amounts. This emission factor continues to be used, since neither filling technologies nor the range of window geometries have changed.

A DIN standard (DIN EN 1279-3, DIN 2003) specifies an upper limit of 10 per mil for annual losses of filled gas from panes' peripheral seals. This value also takes account of gas losses resulting from glass breakage in transport, installation and use, as well as from age-related increasing leakage from peripheral seals. The result is an emission factor EF_{use} of 1 % with respect to the average SF_6 stocks that have accumulated since 1975 and that are in place in year n.

Finally, disposal losses are incurred at the end of windows’ service lifetimes (utilisation periods), or an average of 25 years after the windows were filled. For this reason, emissions from disposal do not have to be taken into account until the year 2000.

Since each year a window loses 1 % of its gas, with respect to the previous year's value, only part of a window's original quantity of gas is emitted when the window undergoes disposal. Since no gas collection upon disposal takes place, however, the emissions level is 100% ($EF_{disposal}$ = 1).

Activity data

The new annual consumption is determined via top-down survey (domestic sales by the gas industry).

4.7.9.2 Automobile tyres (2.F.9.b)

4.7.9.2.1 Source category description (2.F.9.b)

Beginning in 1984, automobile tyres were filled with SF_6 for reasons of image (the resulting improved pressure constancy is not relevant in practice). The peak consumption year was 1995. In that year, over 500 of the some 3,500 tyre-sales outlets in Germany had equipment for filling tyres with SF_6 gas. Because SF_6 is a powerfully acting greenhouse gas, many tyre dealers began filling tyres with nitrogen instead. This practice led to a considerable reduction in use of SF_6. Since 4 July 2007, a ban has been in force in the EU on sale of new automobile tyres filled with fluorinated greenhouse gases. The bulk of today’s emissions originates from gas in older filled tyres.

4.7.9.2.2 Methodological issues (2.F.9.b)

For the sake of simplicity, gas emissions during tyres' service lifetimes are not taken into account; as a result, emissions occur only when tyres are dismantled. Given an intended service lifetime of about 3 years, and the fact that there is no foreign trade with filled types, emissions follow domestic consumption for filling with a three-year time lag (ÖKO-RECHERCHE, 1996). The emissions are calculated using equation 3.23 of IPCC-GPG (2000).

Emission factors

The very small losses incurred in filling of tyres are not taken into account. Since SF_6 escapes completely when tyres are dismantled, $EF_{disposal}$ = 1.

Activity data

Annual sales are determined via surveys, carried out by the Federal Statistical Office, of gas suppliers, regarding their domestic sales to tyre dealers and automobile service centres.

4.7.9.3 Sport shoes (2.F.9.c)

4.7.9.3.1 Source category description (2.F.9.c)

SF_6 was inserted into the soles of sport shoes in order to enhance cushioning. 2003 was the last year in which this practice occurred anywhere in Europe. As of 2004, PFC-218 (C_3F_8) was used in this application. Use of that gas was then discontinued in 2006. Today, nitrogen is usually used for this purpose. Sale of footwear produced with fluorinated greenhouse gases has been prohibited in the EU since 4 July 2006. Current emissions occur only in disposal of sport shoes.

4.7.9.3.2 Methodological issues (2.F.9.c)

The emissions are calculated using equation 3.23 of IPCC-GPG (2000).

Production emissions occur only in foreign countries. Current emissions from stocks are not determined.

In keeping with a commitment to maintain confidentiality, data relative to sport-shoe soles are reported under CRF 2.G.

Emission factors

Manufacturers do not report production emissions.

It is assumed that no emissions occur during use.

In disposal, emissions may be equated with input quantities ($EF_{disposal}$ = 1). In addition, in a procedure similar to the IPCC method for automobile tyres, a time lag of three years is assumed.

Activity data

The filled quantities are based on manufacturers' European-wide sales figures. These figures are broken down, on the basis of Germany's population, to obtain figures for Germany. While such data have been available to the Federal Environment Agency since the 2001 report year, they are published only in aggregate form, for reasons of confidentiality.

4.7.9.4 Trace gas (2.F.9.d)

4.7.9.4.1 Source category description (2.F.9.d)

SF_6, as a stable and readily detectable trace gas, even at extremely low concentrations, is used by research institutions to investigate a) ground-level and atmospheric airflows and gas dispersions and b) water currents.

As of report year 2007, use of SF_6 as a trace gas decreased considerably with respect to earlier years.

4.7.9.4.2 Methodological issues (2.F.9.d)

In contrast to the procedure followed for equation 3.22 in IPCC GPG (2000), the quantities used are determined via experts' assessments, and not via gas-sellers' sales figures. New consumption for this open use is listed in CRF Table 2(II).Fs2 under "amount of fluid filled in new manufactured products", because this description covers the manner in which the gas is actually used in this application.

Emission factors

An "open use" is assumed, i.e. annual new inputs are completely emitted in the same year and are treated as consumption for production ($EF_{production}$ = 1). No recovery takes place.

Activity data

In 1996, total domestic use was estimated by experts of all relevant research institutions. Since then, use levels have been estimated by one expert at three-year intervals. These assessments indicate that the quantities used vary only slightly.

4.7.9.5 AWACS (Airborne Warning and Control System) maintenance (2.F.9.e)

4.7.9.5.1 Source category description (2.F.9.e)

SF_6 is used as an insulating medium for radar in Boeing E-3A (NAEWF; formerly, AWACS) aircraft, which are large military surveillance aircraft. It is used to prevent electrical arcing, towards the antenna, in waveguides with high voltages in excess of 135 kV. Ongoing emissions are relatively high, since SF_6 is released to equalize pressure as aircraft climb.

4.7.9.5.2 Methodological issues (2.F.9.e)

Activity data

The emissions figures are based on reported purchased quantities for filling and refilling of NATO's NAEWF fleet. Reported sales figures are double-checked against gas-sellers' statistics. The emissions data for report years until 2001 are based on estimates that are themselves based on a survey from the year 1996. For this reason, the emissions data for the years 1997 to 2001 are imprecise. For report year 2002, a new survey of consumed quantities was carried out. This showed a significant increase over relevant quantities in report year 2001.

Experts consider the annual SF_6 requirements for the NAEWF fleet to be constant.

Data on AWACS maintenance are reported under CRF 2.G, since the data are confidential.

4.7.9.6 Welding (2.F.9.f)

4.7.9.6.1 Source category description (2.F.9.f)

According to gas suppliers, use of SF_6 in welding began in 2001. SF_6 is used as a protective gas in welding of metal. Since there is only one user in Germany, the pertinent data are subject to confidentiality protection.

4.7.9.6.2 Methodological issues (2.F.9.f)

Because they are confidential, data on consumption and emissions in connection with welding are reported under CRF 2.G.

Emission factors

No reliable data are available on SF_6 decomposition during use. Experts presume that the entire relevant input SF_6 quantities are emitted completely into the atmosphere during use. For this reason, consumption and emissions are considered equal for welding applications. The emission factor for welding is specified as $EF_{use} = 1$.

Activity data

The annual amounts consumed are determined via enquiry of the company that uses SF_6 for welding purposes.

4.7.9.7 Optical glass fibre (2.F.9.g)

4.7.9.7.1 Source category description (2.F.9.g)

Use of SF_6 in production of optical glass fibre began in 2002. In such production, SF_6 is used for fluorine doping. Numerous production operations are in place in Germany.

4.7.9.7.2 Methodological issues (2.F.9.g)

Emissions occur in production of optical glass fibre cable.

Emission factors

The 2006 IPCC Guidelines[47] contain no information on use of SF_6 in production of optical glass fibre. According to experts, 70 % of the input SF_6 quantities escape. For this reason, an emission factor of $EF_{production} = 0.7$ is used.

Activity data

The annual consumption figures are obtained via surveys, carried out by the Federal Statistical Office, of gas suppliers, with regard to their domestic sales.

4.7.9.8 Photovoltaics (2.F.9.h)

4.7.9.8.1 Source category description (2.F.9.h)

In wafer production in Germany, SF_6 and other fluorine compounds are used for structure etching and for cleaning of reaction chambers during production processes. Since the purity

[47] IPCC GL 2006, Vol. 6, Chapter 6: Electronics Industry

of the process gas is lower than that of the gas used in the similar production process in the semiconductor industry, use for *photovoltaics* is reported separately. In Germany, use of SF_6 in solar technology began in 2002.

The time series shows a continuous emissions increase between 2002 and 2006; this is due to increases in production. A large jump occurred in 2007 and 2008, when quantities of produced wafers and, thus, the quantities of SF_6 used, increased sharply. In 2009, the opposite effect occurred.

Since 2008, NF_3 has substituted for SF_6 in all new production lines for production of Si thin-film cells.

In addition, in 2002/2003 the hydrocarbon CF_4 was introduced for "edge insulation" of crystalline solar cells. The procedure using that substance was soon supplanted by a different procedure that is easier to handle, however. Consumption of CF_4, which peaked in 2004, has been decreasing sharply since then.

4.7.9.8.2 Methodological issues (2.F.9.h)

Like emissions in the semiconductor industry, emissions in photovoltaics occur during production. The relevant production emissions cannot be determined solely on the basis of the quantities used (sales by the gas trade). The differences between consumption and emissions result from a) the fact that chemical conversion in plasma reactors is only partial and b) the effects of downstream waste-gas-scrubbing systems.

Emission factors

In 2009, only one producer in Germany did not have a waste-gas-scrubbing system. For this reason, the IPCC emission factor of 40% is used only for the first year of pertinent use, 2003. Thereafter, the emission factor decreases, as the percentage of wafer production connected to downstream waste-gas-scrubbing systems increases. In 2010, it was just less than 6%.

Activity data

The annual consumption figures are obtained via surveys, carried out by the Federal Statistical Office, of gas suppliers, with regard to their domestic sales. In addition, the data were checked in a separate study entitled "SF_6 and NF_3 in the German photovoltaic industry" ("SF_6 und NF_3 in der deutschen Photovoltaik-Industrie") (ÖKO-RECHERCHE, 2009: FKZ 360 16 027).

4.7.9.9 Uncertainties and time-series consistency (2.F.9 all)

In the case of sound-proof glazing, since 2006 data from the top-down survey of annual new consumption, carried out on the basis of commercial sales data, have been compared with data from the *Federal Statistical Office's* pertinent annual surveys. This procedure, which may be considered reliable and complete, has increased data reliability. Due to the wide range of influencing factors, the $EF_{production}$ cannot be measured reliably. Estimates resulting from a survey of ten industry experts, conducted in 1996 and 1999 (the experts represented window manufacturers, suppliers of filling devices and one scientific institute) indicate, virtually conclusively, that the mean filling loss ranges between 30 % and 40 %. A 1 % rate is considered realistic for ongoing gas losses.

With regard to sport shoes, in spite of the good quality of the data for the EU, the filled-quantities breakdown, by Member States, is subject to considerable uncertainties.

4.7.9.10 Source-specific recalculations (2.F.9 all)

No source-specific recalculations were required.

4.7.9.11 Source-specific planned improvements (2.F.9 all)

No improvements are planned at present.

4.7.10 Source-specific QA/QC and verification (2.F)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data for the 2003 report year, like the data for most of the previous years, were collected by an external expert working in the framework of a research project under commission to the Federal Environment Agency.

For the most part, quality assurance was carried out by an external expert. In addition, the data are checked by the relevant Federal Environment Agency specialist upon receipt.

The collected data on the size of source-category-specific HFC stocks, on composition of those stocks with regard to various HFC refrigerants, on EF, etc. are subject to continual quality assurance / control and verification, although this process has not yet been standardised. On a regular basis, various sources (environmental statistics[48], production and sales figures[49], etc.) are consulted, and experts (users, refrigerant manufacturers, suppliers, etc.) are consulted to determine the sources' reliability.

The data for electrical equipments and semiconductor production have undergone an internal association process of quality assurance / control and verification.

Due to the large number of manufacturers involved (nearly 400), no double-checking via bottom-up survey (manufacturers' purchase data) is carried out for sound-proof glazing. From 2006 through 2009, data for annual new consumption were checked against the *Federal Statistical Office's* pertinent annual surveys.

The entire sector of F-gas emissions was subjected to voluntary trilateral review. Experts from England, Germany and Austria reviewed the F-gas inventories of the other countries involved. The review produced the positive result that Germany has a good F-gas inventory. Consequently, no recommendations for improvements of the German F-gas inventory were made.

[48] Surveys pursuant to Art. 11 of the Environmental Statistics Act (UstatG).
[49] Surveys pursuant to the Foreign Trade Statistics Act (AHStatGes) and production statistics.

4.8 Other areas (2.G.)

CRF 2.G	Gas	Key category		1995 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Consumption of hHalocarbons and SF_6	SF_6	-	-	442.2	(0.04%)	163.3	(0.02%)	-63.07%

Gas	Method used	Source for the activity data	Emission factors used
SF_6		s. Table 118	

Emissions of SF_6 from use in *sport shoes* (2.F.9.c Other – sport shoes), use in connection with *AWACS maintenance* (2.F.9.e Other – AWACS maintenance) and use in *welding* (2.F.9.f Other – welding) are reported under 2.G, for reasons of confidentiality.

Emissions of HFCs from uses as solvents (2.F.5 Solvents) are reported under 2.G, for reasons of confidentiality.

PFC emissions from use in sport shoes (2.F.9.c Other – sport shoes) and in photovoltaics (2.F.9.h) are reported under 2.G, for reasons of confidentiality.

In keeping with a recommendation of the Expert Review Team, all information relative to the emissions reported under 2.G, in the areas of "source category description", "methodological issues", "uncertainties and time-series consistency", "source-specific recalculations and verification" and "planned improvements", is provided in the relevant category chapters.
No other sources of relevant greenhouse-gas emissions are known.

5 SOLVENTS AND OTHER PRODUCT USE (CRF SECTOR 3)

5.1 Overview (CRF Sector 3)

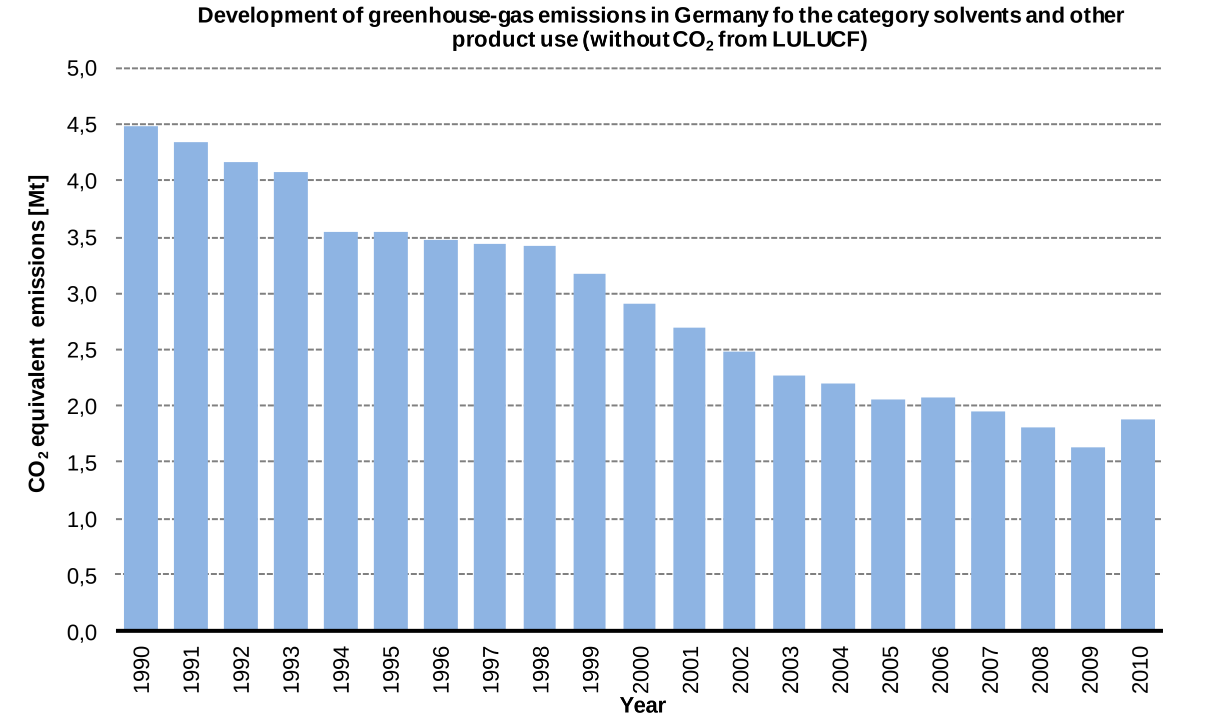


Figure 43: Overview of greenhouse-gas emissions in CRF Sector 3

This source category comprises emissions from the use of chemical products. Currently, the source category includes information on solvent emissions from applications in the industry, commercial/institutional and residential sectors, as well as detailed information about release of N_2O during its use.

Source category 3, *Solvents and other product use*, is divided into the sub-source categories *Paint application* (3.A), *Degreasing and dry cleaning* (3.B), *Chemical products, manufacture and processing* (3.C) and *Other product use* (3.D). *Other product use* (3.D) includes emissions of laughing gas (cf. Chapter 5.3), emissions from selective catalytic reduction (SCR) systems and the above-detailed other solvent uses that cannot be allocated to source categories 3.A through 3.C.

The N_2O emissions from source category 3.D *Other product use* are reported separately from other emissions categories, in Chapter 5.3.

5.2 Solvents - NMVOC (3.A-3.C & 3.D)

5.2.1 Source category description (3.A-3.C & 3.D)

CRF 3.A-3.C, 3.D (NMVOC)	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Total Solvent and Other Product Use	CO_2	-	-	2,552.0	(0.21%)	1,583.3	(0.17%)	-37.96%

Gas	Method used	Source for the activity data	Emission factors used
CO_2	RA	NS	D
NMVOC	Tier 2	NS	CS

The source category NMVOC emissions from the area of *Solvents and other product use* (CRF 3.A-3.C and 3.D) is not a key category.

The NMVOC emissions released through use of solvents and solvent-containing products all belong to sub-categories of this source category.

The four reporting categories of this source category vary widely in structure. To take account of this variation, inventory data were calculated in keeping with the UNECE/EMEP sub-structures based on the CORINAIR97 (CORINAIR: COordination d' INformation Environmentale; sub-project AIR) SNAP system[50].

Source category 3.D *Other product use* includes the following uses and activities:

- Treatment of glass and rock wool
- Printing industry (printing applications)
- Extraction of oils and fats
- Use of glues and adhesives
- Use of wood preservatives
- Undersealing and wax treatments for automobiles
- Household use of solvents (not including paints and lacquers)
- Automobile-wax stripping
- Manufacturing of pharmaceutical products
- Household use of pharmaceutical products
- Other

"NMVOC" is defined in keeping with the VOC definition found in the EC solvents directive[51]. For purposes of the definition of solvents, the term "solvent use" is also defined in keeping with the EC solvents directive[52].

It is important to note that some volatile organic compounds are used both as solvents and as chemical reactants – for example, toluene, which is used as a solvent in lacquers and glues and as a reactant for production of toluenediisocyanate (TDI), and methyl ethyl ketone (butanone), which is used as a solvent in printing inks and as a base material for synthesis of methyl ethyl ketone peroxide. Consequently, VOC (either substances or fractions of

50 In the present area, this involves "SNAP Level 3" detailing.

51 In this definition, volatile organic compounds (VOC) include all organic compounds that are volatile at 293.15 K, at a vapour pressure of at least 0.01 kPa or under the usual conditions for their use.

52 In this definition, an organic solvent is a volatile organic compound that, either by itself or in combination with other raw materials, products or waste substances, and without changing chemically, either dissolves or is used as a cleanser for dissolving dirt accumulations, as a solvent, as a dispersing agent, as an agent for adjusting viscosity or surface tension, or as a softener or preservative.

substances or products) used as chemical reaction components are not included in this source category.

Delimitation of this source category as outlined above takes a highly diverse range of emissions-causing processes into account. The factors considered with regard to such processes include:

- Concentrations and volatility of VOC used.
  The relevant spectrum includes use of volatile individual substances as solvents – for example, in cleansing; use of products with solvent mixtures – for example, in paints and lacquers; and applications in which only small parts of mixtures used (also) have solvent properties (as is the case, for example, in polystyrene-foam production).
- The great differences in emissions conditions.

Solvent uses can be open to the environment – as is the case in use of cosmetics – or largely closed to the environment – as in extraction of essential oils or cleaning in chemical dry-cleaning systems.

5.2.2 Methodological aspects (3.A-3.C & 3.D)

NMVOC emissions are calculated via an approach oriented to product consumption. In this approach, the NMVOC input quantities allocated to these source categories, via solvents or solvent-containing products, are determined and then the relevant NMVOC emissions (for each source category) are calculated from those quantities via specific emission factors. This method is explicitly listed, under "consumption-based emissions estimating", as one of two methods that are to be used for emissions calculation for this source category.

Use of this method is possible only with valid input figures – differentiated by source categories – in the following areas:

- Quantities of VOC-containing (pre-) products and agents used in the report year,
- The VOC concentrations in these products (substances and preparations),
- The relevant application and emission conditions (or the resulting specific emission factor).

To take account of the highly diverse structures throughout this source category, these input figures are determined on the level of 37 differentiated source categories (in a manner similar to that used for CORINAIR SNAP Level 3), and the calculated NMVOC emissions are then aggregated. The product / substance quantities used are determined at the product-group level with the help of production and foreign-trade statistics. Where possible, the so-determined domestic-consumption quantities are then further verified via cross-checking with industry statistics.

The values used for the average VOC concentrations of the input substances, and the emission factors used, are based on experts' assessments (expert opinions and industry dialog) relative to the various source categories and source-category areas. Not all of the necessary basic statistical data required for calculation of NMVOC emissions for the most current relevant year are available in final form; as a result, the data determined for the previous year are used as a basis for a forecast for the current report. The forecast for NMVOC emissions from solvent use for the relevant most current year is calculated on the basis of specific activity trends. As soon as the relevant basic statistical data are available for the relevant most current year, in their final form, the inventory data for NMVOC emissions from solvent use are recalculated.

Since 1990, NMVOC emissions from use of solvents and solvent-containing products have decreased by about 42 %. The greatest part of this emissions reduction has occurred in the years since 1999. This successful reduction has occurred especially as a result of regulatory provisions such as the *Ordinance, under chemicals law, for limiting emissions of volatile organic compounds (VOC) through limitations on the placing on the market of solvent-containing paints and varnishes (Chemikalienrechtliche Verordnung zur Begrenzung der Emissionen flüchtiger organischer Verbindungen (VOC) durch Beschränkung des Inverkehrbringens lösemittelhaltiger Farben und Lacke (Lösemittelhaltige Farben- und Lack-Verordnung - ChemVOCFarbV*), the 31st Ordinance on the execution of the Federal Immissions Control Act *(Ordinance on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain facilities – 31. BImSchV)*, the 2nd such ordinance *(Ordinance on the limitation of emissions of highly volatile halogenated organic compounds* – 2. *BImSchV)* and the Technical Instructions on Air Quality Control (TA Luft). The German "Blauer Engel" ("Blue Angel") environmental quality seal, which is used to certify a range of products, including paints, lacquers and glues with low solvent concentrations, has also played an important role in this development.

While product sales increased in some areas – even over periods of several years – thereby adding to emissions, the above-described measures have largely offset this trend. These successes, which have occurred especially in recent years, are reflected in the updated emissions calculations – which, thanks to methods optimisation, now feature greater differentiation of VOC concentrations and emission factors.

For the 2009 report, indirect CO_2 emissions from NMVOC were calculated for the first time. The following relationship was used for pertinent conversion:

$$EM_{Indirect\ CO2} = EM_{NMVOC} * \text{molar mass } CO_2 / \text{molar mass C} * 75\ \%$$

Since compatibility with EU greenhouse-gas reporting is the primary methodological backdrop for conversion of NMVOC emissions into indirect CO_2 emissions, for the current report we have used the Reference Approach proposed in *Chapter 7 Precursors and Indirect Emissions* of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories:

$$EM_{Indirect\ CO2} = EM_{NMVOC} * \text{molar mass } CO_2 / \text{molar mass C} * 60\ \%$$

5.2.3 Uncertainties and time-series consistency (3.A-3.C & 3.D)

At the time of the report, errors had been estimated for NMVOC emissions; this was carried out using the error-propagation method and on the basis of experts' assessments for all input figures (in all 37 differentiated source categories). The main source of current uncertainties consists of inadequate precision in separation of basic statistics (production and foreign-trade statistics), with regard to categorisation in VOC-containing and VOC-free products, and with regard to use in different source categories with highly differing emissions conditions.

5.2.4 Source-specific quality assurance / control and verification (3.A-3.C & 3.D)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

5.2.5 Source-specific recalculations (3.A-3.C & 3.D)

The data used in the emissions inventory for the NMVOC emissions of the previous year (2009) were subjected to routine source-specific recalculations. That procedure, which is grounded in the methodology for the product-consumption approach, is required because the relevant final data from foreign-trade statistics do not become available until after the report for the pertinent reported year has been completed.

Table 121: Source-specific recalculations, in 3.A-D, for NMVOC emissions from solvents

Source category	Status	Gas	Units	2009	2010
3 A, Paint application	Submission 2011	NMVOC	Gg	268	
3 A, Paint application	Submission 2012	NMVOC	Gg	224	260
	Difference	**NMVOC**	**Gg**	**-44**	
3 B, Degreasing and dry cleaning	Submission 2011	NMVOC	Gg	46	
3 B, Degreasing and dry cleaning	Submission 2012	NMVOC	Gg	37	37
	Difference	**NMVOC**	**Gg**	**-9**	
3 C, Chemical products, manufacture and processing	Submission 2011	NMVOC	Gg	54	
3 C, Chemical products, manufacture and processing	Submission 2012	NMVOC	Gg	48	56
	Difference	**NMVOC**	**Gg**	**-6**	
3 D, Other product use	Submission 2011	NMVOC	Gg	301	
3 D, Other product use	Submission 2012	NMVOC	Gg	286	366
	Difference	**NMVOC**	**Gg**	**-15**	

Table 122: Source-specific recalculations, in 3.A-D, of solvent emissions, in CO_2 equivalents

Source category	Status	Gas	Units	2009	2010
3 A, Paint application	Submission 2011	CO_2	Gg	589	
3 A, Paint application	Submission 2012	CO_2	Gg	493	573
	Difference	**CO_2**	**Gg**	**-97**	
3 B, Degreasing and dry cleaning	Submission 2011	CO_2	Gg	101	
3 B, Degreasing and dry cleaning	Submission 2012	CO_2	Gg	82	82
	Difference	**CO_2**	**Gg**	**-19**	
3 C, Chemical products, manufacture and processing	Submission 2011	CO_2	Gg	119	
3 C, Chemical products, manufacture and processing	Submission 2012	CO_2	Gg	106	123
	Difference	**CO_2**	**Gg**	**-13**	
3 D, Other product use	Submission 2011	CO_2	Gg	663	
3 D, Other product use	Submission 2012	CO_2	Gg	630	805
	Difference	**CO_2**	**Gg**	**-33**	

5.2.6 Planned improvements (source-specific) (3.A-3.C & 3.D)

No further source-category-specific improvements are planned at present.

5.3 Other – use of N_2O (3.D)

CRF 3.D (N_2O)	Gas	Key category (source)		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Total Solvent and Other Product Use	**N_2O**	**-**	**T**	**1,924.6**	**(0.16%)**	**299.2**	**(0.03%)**	**-84.45%**

Gas	Method used	Source for the activity data	Emission factors used
N_2O	CS	AS/Q	CS

The source category *Solvents and other product use* is a key category for N_2O emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-84.45 %), and thus an extremely low emissions level has been attained (in 2010, emissions amounted to 8.5 % of the contribution of the smallest key category identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

5.3.1 Source category description (3.D.1)

The German nitrous oxide market is dominated by Air Liquide, Linde AG and Westfalen AG, all of which are leading producers as well as importers. No nitrous oxide emissions occur in nitrous oxide production and in filling of the gas into gas bottles. Emissions occur solely in use of the gas. Medical applications represent the most important N_2O-emissions source. Other emissions sources include use of laughing gas as a propellant in whipped-cream aerosol cans and use in the semiconductor industry. N_2O is also released, in small amounts, in blasting.

Medicine – anaesthesia

In medicine, nitrous oxide, a gas with analgesic properties, is used for narcotic purposes. In such applications, nitrous oxide is mixed with pure oxygen, to produce an active gas mixture consisting of 70 % nitrous oxide and 30 % oxygen. In modern anaesthesia, the effects of nitrous oxide are enhanced through addition of other narcotics. While medical use of N_2O is not prohibited, there is strong resistence – especially in the German medical sector – against widespread, general use of the substance. Medical use of laughing gas has thus been decreasing continuously since 1990.

Food industry – whipped-cream aerosol cans

In the food industry, nitrous oxide is used as an additive known as "E 942". Foods sold in pressurised containers are extracted from such containers with the help of propellants. As it exits such a container, a food takes on either a foamy or a creamy consistency, depending on what type of food it is. Examples of relevant foods with added N_2O include whipped cream (from spray cans), quark, and various desserts such as ready-to-eat puddings (DIE VERBRAUCHER INITIATIVE E.V, 2005; LINDE GAS GMBH, 2005).

Semiconductor manufacturing

A wide range of different chemicals and gases is used in semiconductor production. Argon, ultra-pure oxygen, hydrogen, ultra-pure helium and nitrogen account for the lion's share of the gases used. Special process gases, such as nitrous oxide (dinitrogen monoxide), ammonia and hexafluorethane, are used only in relatively small amounts, and the amounts involved have remained nearly constant over the past few years (AMD Saxony LLC&Co. KG, Dresden, Umweltbericht (environmental report) 2002/2003, page 16).

Explosives

Explosives are used in both military and industrial contexts. Civil and commercial explosives are used in mining, in construction in rocky terrain, in demolition, in geology and in fireworks.

Nitrous oxide emissions occur primarily in detonation of explosives that contain ammonium nitrate, such as ANFO (ammonium nitrate / fuel oil) and emulsion explosives. In general, commercial / civil explosives consist to some 60 to 80 % of ammonium nitrate (AN). By contrast, Andex, an ANFO explosive, contains up to 94 % ammonium nitrate.

In Germany, two companies produce explosives for civil use: Orica Mining (formerly Dynamit Nobel) and Westpreng GmbH (Wasag Chemie).

While no nitrous oxide emissions occur in manufacturing of explosives, nitrous oxide can form in thermal decomposition of explosives. The reason for this is that ammonium nitrate (AN) forms nitrous oxide (laughing gas) and water as it decomposes thermally.

Under careful warming to a temperature above the melting temperature, the reaction is as follows:

$$NH_4NO_3 \longrightarrow N_2O + 2H_2O$$

But in a fast, detonative reaction of an AN-containing explosive, the reaction occurs as follows:

$$NH_4NO_3 \longrightarrow 2H_2O + N_2 + 0.5O_2$$

This means that under high pressure and temperature AN primarily forms nitrogen, oxygen and water as it reacts. Only a small concentration of primarily formed N_2O remains intact in the detonation process. For example, detonation clouds of amatols[53], which contain some 80 % AN, have only 0.1 mole N_2O per mole of ammonium nitrate. From this figure, a theoretical maximum of about 68 g (this figure was provided by an explosives expert; the stoichiometric value would be 44 g/mole amatol (80%-AN)) per kilogramme AN can be calculated (ORELLAS, D.L., 1982; VOLK, F,, 1997, page 74). According to experts, this AN-content figure can be used as a basis for assumptions regarding N_2O emissions for other explosives.

N_2O in automobile tuning

In automotive technology, nitrous oxide is used to improve combustion in gasoline / petrol engines, via so-called "laughing-gas injection". In the process, laughing gas is broken down into nitrogen and oxygen. The nitrogen cools the combustion process, and the oxygen increases combustion power. This "tuning" tactic can quickly increase engine performance. To date, one company in Germany offers such tuning measures. Research has shown that the technology used for such tuning is designed to consume the input laughing gas completely, without producing significant emissions.

[53] Amatol x/y : military explosives – pourable mixtures, generally consisting of x % TNT and y % ammonium nitrate

5.3.2 Methodological issues (3.D.1)

Anaesthesia

The 1990 figure for N_2O emissions from medical applications is based on an extrapolation of a statistical plant survey conducted in 1990 in the territory of the former GDR. At the time, it was ascertained that one plant for the production of N_2O for narcotic purposes had existed in the former GDR. Also at the time in question, the plant had not yet been operational for long (it was constructed in 1988). The annual production capacity was approximately 1,200 t. Research indicated that there were no exports or imports of this substance, and thus it was assumed that all of the substance was used for domestic consumption. Via the per-capita emissions calculated from this for the former GDR, and assuming identical conditions, N_2O emissions of 6,200 t were estimated, as a rough approximation, for Germany in 1990. The N_2O figure for 2001 was obtained via a written memorandum, dating from 2002, of the Industriegaseverband e.V. (IGV) industrial-gas association. That figure was tied to a range of 3,000 ~ 3,500 t/a. The mean value from that range (3,250 t/a) was then used for generation of an N_2O-emissions time series.

Since 2005, the Industriegaseverband (IGV) industrial-gas association has carried out surveys of N_2O sales for all applications in Germany. In addition, the IGV has made the data from those surveys available to the Federal Environment Agency for reporting purposes. In 2010, the IGV entered into a voluntary agreement, with the Federal Ministry of Economics and Technology (BMWi), regarding annual provision of N_2O-sales data for purposes of emissions reporting.

The gaps in the data relative to uses in anaesthesia are closed via interpolation and extrapolation.

The pertinent emission factor is 100%.

Whipped-cream aerosol cans

Use of N_2O in aerosol cans for whipped cream, in Germany, has to be carefully differentiated. In Germany, there is one maker of aerosol cans for whipped cream. That maker also fills the cans in Germany. In emissions calculations, it is assumed, on the basis of the above-described research, that that company accounts for a share of about 3 % of the laughing-gas sales of the IGV industrial-gas association. Most of the companies who deal with such aerosol cans have them filled abroad and then import them into Germany. The relevant sales of such companies are thus not included in the data of the IGV industrial-gas association. The MIV dairy-industry association has reported to the Federal Environment Agency the results of a one-time survey that showed that 50.2 million units of whipped-cream aerosol cans were sold in 2008. At the same time, the MIV association reported that the units involved vary in size, and that it is not possible to break the figures down by can sizes. Internet research showed that pressurized cartridges for this area are sold in Germany: cartridges with 8g of N_2O, for 0.5l (whipped-cream) cans, and cartridges with 16g of N_2O, for 1.0l cans. Comparison calculations have shown that 8g of N_2O is a safe approximation, for purposes of calculation, for the amount of laughing gas contained per sold unit (whipped-cream aerosol can). That, in turn, leads to an input figure of 401.6 t N_2O for whipped-cream aerosol cans in 2008 in Germany. Since no pertinent data are available for the years prior to 2008, that value is assumed to be constant.

The emission factor for whipped-cream aerosol cans is assumed to be 100%.

Semiconductor manufacturing

On a one-time basis, the German Electrical and Electronic Manufacturers' Association (ZVEI) has provided information on quantities of laughing gas sold in the years 1990, 1995, 2000, 2001 and 2008. Values between those points are obtained via interpolation.

In addition, the ZVEI estimated the emission factor for 2008 to be about 40 %, in keeping with conversion of laughing gas within the pertinent process and with downstream treatment processes. The ZVEI was unable to provide any figures for 1990. But since it can be assumed that levels of waste-gas treatment in 1990 were not nearly as high as they were in 2008, an emission factor of 100 % is used as a conservative estimate for 1990. The emission factor for the period between 1990 and 2008 was obtained via interpolation.

Explosives

In 2003, a total of 59 kt of explosives was produced in Germany. Of that figure, 13 kt were exported abroad, and 5.8 kt were imported into Germany[54]. Those figures, in turn, yield a figure of 51.8 kt for the amount of explosives used in Germany. Of that amount, ANFO accounts for a share of 60 %, emulsion explosives account for 25 % and dynamite explosives account for 15 %. ANFO explosives consist of 94 % ammonium nitrate and 6 % fuels. The corresponding relationship for emulsion explosives is 80 % to 20 %; for dynamite explosives, it is 50 % to 50 %.

At present, nitrous oxide amounts in detonation clouds are not determined, while amounts of NO and NO_2 are determined.

Normally, N_2O formation plays a significant role only in explosives that contain ammonium nitrate (AN). That said, no precise analyses of detonation clouds of ANFO explosives have been carried out. For this reason, it must be assumed that the N_2O concentrations formed upon detonation of ANFO are similar, with regard to AN content, to those formed upon detonation of amatols and ammonites[55], for which analyses have been carried out that support relevant estimates. The following result has been obtained: upon detonation, amatoles and ammonites form about 0.1 mole N_2O per mole of ammonium nitrate (AN).

According to the *Federal Office for Material Research and Testing* (BAM), levels of explosives use in Germany remained constant from 1990 to 2005.

The emission factor for use of explosives is 0.1036 kg N_2O/t explosives. That emission factor was determined, via measurement, by the BAM in February 2010. As a result, the emission factor has been corrected downward, considerably, with respect to the Submission 2010.

For whipped-cream aerosol cans and the semiconductor industry, the pertinent emissions are reported in aggregation with confidential emissions data from N-dodecandiacid production (2.B.5).

[54] Personal communication: Federal Office for Material Research and Testing (BAM).

[55] Ammonite: Composition: 70-88 % ammonium nitrate, with 5-20 % nitroaromates, 1-6 % vegetable flour and, in some cases, 4 %
nitroglycerine, aluminium powder and potassium perchlorate

5.3.3 Uncertainties and time-series consistency (3.D.1)

Since 2005, activity data for narcotic / anaesthetic uses have been obtained from association information. For that reason, the uncertainty is estimated to be 20 %. The data on consumption for whipped-cream aerosol cans are subject to a very high level of uncertainty (75 %), since the relevant calculation is based on several assumptions and since a definite figure is available only for 2008. The uncertainty of the activity data for the semiconductor industry is estimated at 10 %, since the data have been obtained from facility operators themselves.

The uncertainty in the emission factors for anaesthesia and whipped-cream aerosol cans is set as 0 %, since at present it is assumed that N_2O undergoes no transformation in use, and that the gas thus escapes completely into the atmosphere following its use. The emission factor for use in semiconductor manufacturing is estimated to have an uncertainty of 15 %, since the data have been obtained from facility operators themselves. The emission factor for explosives is estimated to have an uncertainty of 5 %, since the emission factor has been determined via an official measurement.

With these results, the time series can be considered to show a normal distribution (distribution type).

5.3.4 Source-specific quality assurance / control and verification (3.D.1)

Due to a lack of relevant specialised staff, it has not yet been possible to have quality control and quality assurance carried out by source-category experts. Quality assurance was carried out by the Single National Entity. Data were taken from previous years or determined on the basis of existing calculation routines.

5.3.5 Source-specific recalculations (3.D.1)

No recalculations are required.

5.3.6 Source-specific planned improvements (3.D.1)

No improvements are planned at present.

6 AGRICULTURE (CRF SECTOR 4)

6.1 Overview (CRF Sector 4)

6.1.1 Source categories and total emissions, 1990 - 2010

In Germany, source category 4, "Agriculture", includes Enteric fermentation (4.A), Manure management (4.B) and Agricultural soils (4.D).

Emissions from rice cultivation (4.C) do not occur in Germany, while clearance of land by prescribed burning (4.E) is not practiced in Germany (NO). Field burning of agricultural residues (4.F) is prohibited in Germany, although it must be noted that some exemptions are permitted, and these do not lend themselves to surveys. Such exceptions are considered to be irrelevant (NO).

For the present NIR 2012, Figure 1 provides an overview of the development of greenhouse-gas emissions, over time, in the areas 4.A, 4.B and 4.D. The pertinent data were calculated with the GAS-EM model described in chapters below (cf. Chapter 6.1.2).

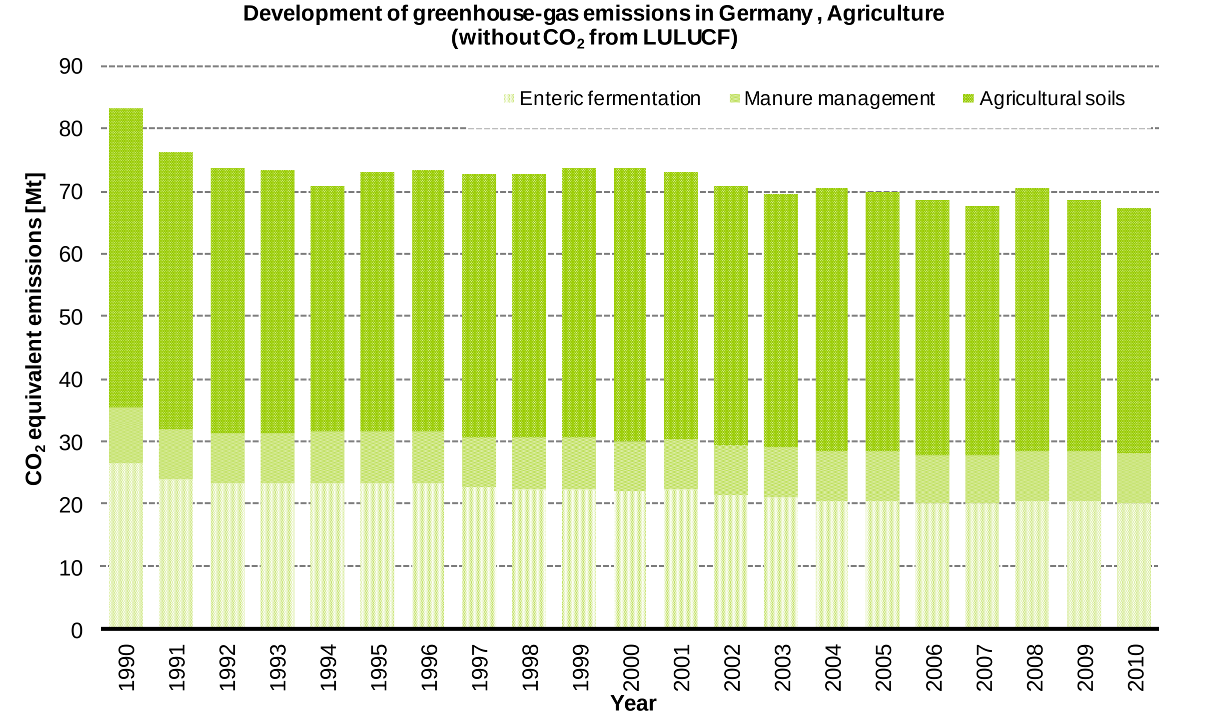


Figure 44: Overview of greenhouse-gas emissions in CRF Sector 4

6.1.2 The GAS-EM emissions-inventory model

The German emissions calculations for the gases methane (CH_4), ammonia (NH_3), nitrous oxide (N_2O) and nitrogen monoxide (NO) from agricultural sources were carried out with the GAS-EM (Gaseous Emissions) inventory model.

6.1.2.1 Guidelines applied, and detailed report

The GAS-EM emissions-inventory model is based on implementation of the relevant sets of guidelines (UN ECE: EMEP, 2003; EMEP, 2006; EMEP, 2009; IPCC Guidelines: IPCC, 1996b; IPCC 2006, IPCC Good Practice Guidance and Uncertainty Management: IPCC, 2000).

Over the past few years, many of the methods described in the guidelines have been refined for purposes of GAS-EM. A comprehensive description of the GAS-EM inventory model, including listings of relevant additional sources, is presented in the pertinent detailed report (HAENEL et al., 2012). The following remarks summarise the detailed report with regard to the aims for the NIR 2012.[56].

The following chapters on the methods used in 4.A (Chapter 6.2.2.1), 4.B (Chapters 6.3.2.2.1 and 6.3.4.2.1) and 4.D (Chapter 6.5.2) present an overview of the manner in which GAS-EM functions.

[56] The detailed report is also available in electronic form at: dieter.haenel@vti.bund.de , claus.roesemann@vti.bund.de.

6.1.2.2 Basic structure of the GAS-EM emissions-inventory model

Feed intake serves as the basis for emissions calculations in the animal husbandry sector. It is calculated as a function of basic and yield-related energy requirements, as Figure 45 shows with the example of dairy cows. That approach provides the CH_4 emissions from enteric fermentation (4.A), as well as the carbon and nitrogen excretions data needed to calculate emissions from manure management (4.B). The latter, in turn, enter into calculations of nitrogen discharges into agricultural soils (4.D).

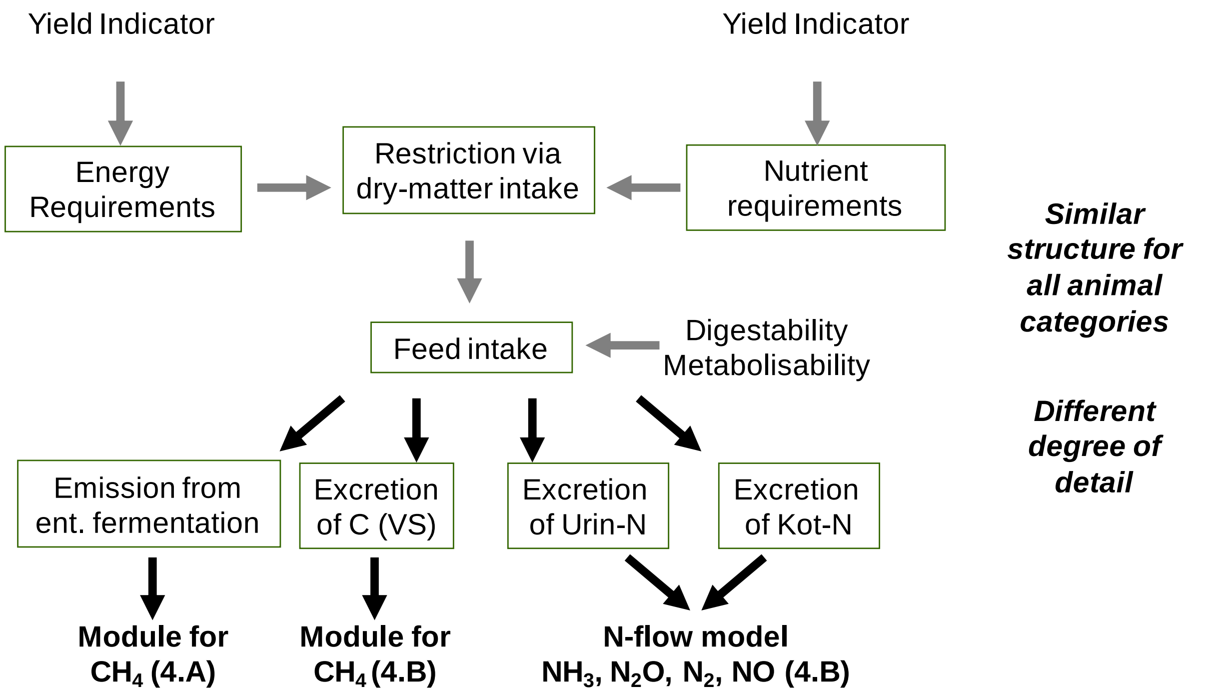


Figure 45: Logical structure of national methods for calculating emissions from animal husbandry, illustrated with the example of dairy cows. ("yield indicator" stands for the sum of basic and yield-related requirements.)

Figure 46 illustrates how, and on what spatial level (depending on data availability), the GAS-EM model, for calculation of emissions from source categories 4.A and 4.B, first breaks the sector down by animal categories and sub-categories, and then breaks those categories / sub-categories down by stall systems, storage systems and manure-application procedures. CH_4 emissions are calculated separately for each animal sub-category in 4.A and 4.B. For source categories 4.B and 4.D, N_2O emissions are calculated on the basis of an N-flow concept (cf. Chapter 6.1.2.4).

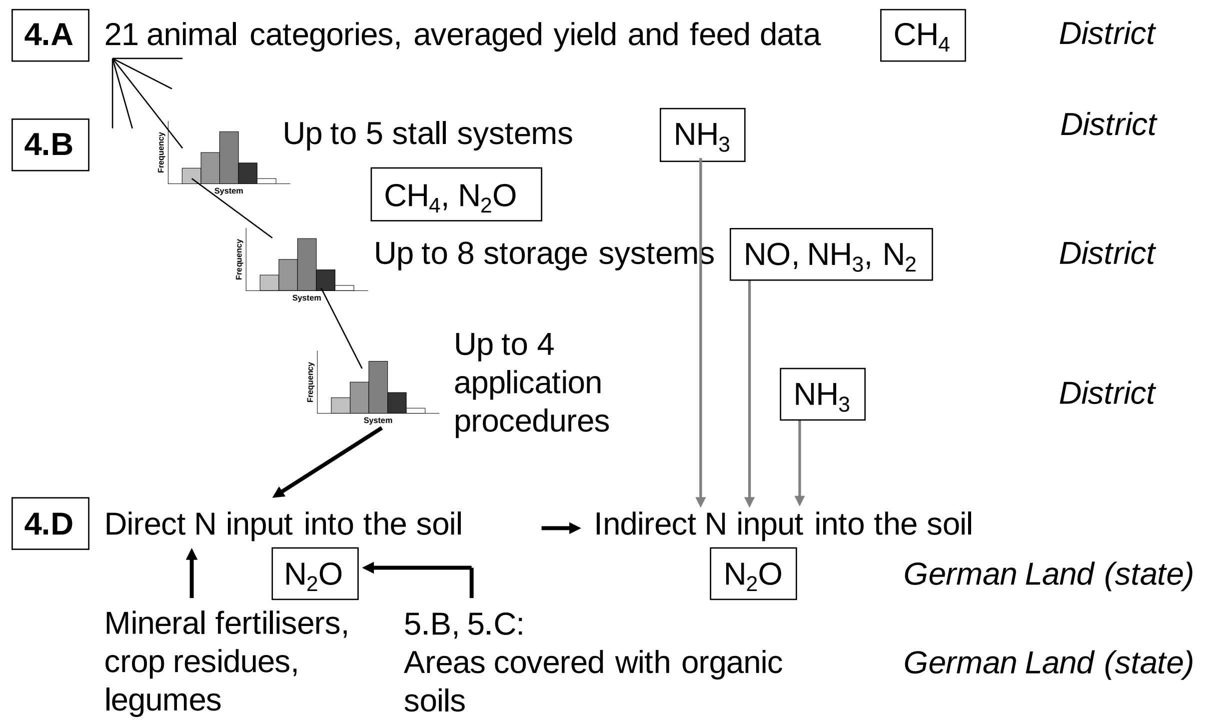


Figure 46: The GAS-EM model: basic concept, thematic content and spatial resolution

6.1.2.3 Treatment of carbon within the emissions inventory

The GAS-EM inventory model is used to calculate CH_4 emissions from enteric fermentation and VS excretions of agricultural livestock (cf. Chapters 6.2, 6.3.2 and 6.3.3), taking account of liquid-manure-based and straw-based systems and their typical forms of storage. In keeping with the IPCC Guidelines, VS contributions from bedding material are not taken into account (cf. Chapter 6.3.1).

6.1.2.4 The nitrogen-flow concept

With the GAS-EM model, N-species emissions are calculated on the basis of the N-flow concept (DÄMMGEN AND HUTCHINGS, 2005).

To make it possible to apply the concept, the N quantities excreted in animal husbandry have to be determined. For dairy cows, heifers, fattening bulls, swine, laying hens, pullets, broilers, ducks and turkey cocks and hens, N excretions are calculated as the difference between ingested N quantities and basic and yield-based N requirements (animal weight, weight gain, annual milk production or egg production (i.e. numbers of eggs) and, if relevant, numbers of young). The N quantity invested with feed is determined on the basis of animal energy requirements and the energy and N content of the feed. For other animals, N-excretion data are taken from the pertinent German literature (cf. the references in HAENEL et al., 2012).

In the case of N excretions, a distinction is made between the two fractions "organic N" and "TAN readily converted into NH_3" ("total ammoniacal nitrogen"). TAN is present in the urine of mammals; in the inventory model, in each case TAN is considered to be equivalent to the N content of urine. Poultry excrete "UAN" (uric acid nitrogen); in the inventory, UAN is treated as TAN. In calculation of N emissions from different stations throughout the spectrum from animal N excretions and N discharges into the soil, two N pools are carried out throughout the calculations: the total N quantity present within the relevant station, and the fraction of that quantity that is present as TAN. As a result of the manner in which the relevant emission factors are defined, NH_3 emissions are calculated in proportion to the available TAN quantity, while N_2O emissions, NO emissions and N_2 emissions (the last of which are also relevant within the N-flow concept) are calculated in proportion to the available N quantity.

The N excretions determined for a given animal category are divided into pasture emissions and stall emissions. The line between the two categories is drawn in accordance with the proportion of time spend in pasture.

In the case of solid-manure systems, N inputs from straw bedding are also taken into account, along with N excretions.

For each animal category category, the quantites of N occurring in stalls are divided in accordance with the relative shares of the animal-housing systems commonly used in Germany, which procedures vary in terms of their emissions behaviour. In stalls, losses of N from excreted quantites of N result, via emissions of NH_3. Following deduction of NH_3 emissions from stalls, the N quantity remaining for all stalls is combined and transferred to the storage-facilities category.

The total quantity of N added to storage facilities is divided among the storage procedures commonly used in Germany, in accordance with the applicable percentage shares for the different procedures. That procedure includes a breakdown by solid and liquid farm manures. NH_3 emissions occur from storage facilities. Emissions of N_2O, NO and N_2 for the stall and storage categories are calculated jointly. The quantity of N remaining in the various storage systems, following deduction of N emissions, is combined and added to the "application" category.

The quantity of N applied is divided among the application procedures commonly used in Germany, in accordance with the applicable percentage shares for the different application procedures and periods required to work manure into the soil; different emission factors apply for different such procedures and periods. This is carried out in accordance with the different application types' relative proportions of the total quantity of farm manure applied. In manure application, N losses occur via NH_3 emissions. Deduction of NH_3 emissions, and of the NO emissions calculated in proportion to applied quantites of N, yields the N quantity available in the soil, the quantity of available N used to calculate N_2O emissions (cf. Chapter 6.5.2).

6.1.3 Characterisation of animal stocks

6.1.3.1 Animal categories (CRF 4.A, 4.B)

For calculation of emissions from animal husbandry in German agriculture, animal stocks are divided into main categories and sub-categories. Division into sub-categories is required to permit adequate description of sub-stocks that are homogeneous with regard to yield and to forms of keeping. The following table compares the German sub-categories and the IPCC proposals.

Table 123: Characterisation of animal stocks pursuant to IPCC, and the pertinent breakdown used for purposes of German emissions reporting

	IPCC main categories	IPCC sub-categories	Germany	
Cattle	Dairy cattle	Subdivision into two or more yield classes	Dairy cattle, yield-/feed-oriented survey for each rural district	
	Adult cattle, "other"	Male/female fattening and additions, pulling power	Suckling cows	
			Stud bulls (mature males)	
	Young animals	Heifers, calves, young male cattle	Calves (to 2 months old)	
			Young female cattle as of 2 months old (heifers)	
			Young male cattle as of 2 months old (fattening bulls)	
Swine	Mature swine	Pregnant sows Farrowing sows	Sows (incl. suckling piglets weighing up to 8.5 kg)	
		Boars	Boars	
	Growing swine	Suckling pigs Fattening pigs Replacement	Weaned piglets	
			Fattening pigs	
Sheep	Ewes	Pregnant ewes Dairy sheep	*CH_4:* Sheep	*N species:* Sheep, not including lambs; lambs
	Sheep >1 year	---		
	Young animals	Male animals, castrated animals, female animals		
Poultry	Chickens	Laying hens in liquid-manure and solid-manure systems Free-range farming, broilers	Laying hens	
			Broilers	
			Pullets	
	Turkeys	Turkeys for breeding Turkeys in stable husbandry Turkeys in free-range husbandry	Male fattening turkeys	
			Female fattening turkeys	
	Ducks	Ducks for breeding Fattening ducks	Fattening ducks	
Other	Other	Horses, goats, donkeys, mules, camels, fur-bearing animals, geese, etc.	Horses (large and small horses), goats, mules and asses, fur-bearing animals, buffalo, geese	

Columns 1 and 2 pursuant to IPCC (2006)

In German reporting, the animal category "cattle" (CRF 4.A.1.A) consists of dairy cows (CRF 4.A.1.a) and "other cattle" (CRF 4.A.1.b). "Other cattle" include calves, heifers, fattening bulls, suckling cows and stud bulls.

The category "swine" (CRF 4.A.8) is divided into sows (including suckling piglets weighing up to 8 kg), weaners, fattening pigs and boars.

For calculation of methane emissions, the category "sheep" (CRF 4.A.3) is not divided into sub-categories. For calculation of emissions of nitrogen species, sheep are divided into the sub-categories of lambs and sheep (not including lambs). The results are reported in aggregated form, for "sheep".

The category "poultry" (CRF 4.A.9) is divided into the categories of laying hens, broilers, pullets, geese, ducks, male turkeys and female turkeys.

For "horses" (CRF 4.A.6), large horses and small horses are considered separately, since the two groups differ in terms of their energy requirements. The results for the two categories are aggregated to form the total results for the category "horses".

Mules and asses (CRF 4.A.7) are treated like light horses.

6.1.3.2 Activity data (CRF 4.A, 4.B)

6.1.3.2.1 Animal head counts (CRF 4.A, 4.B)

The emissions reported by Germany refer to animal places in agricultural facilities that are used year-round for production. An "animal place" within the meaning applied to this context refers to an animal place occupied on a reference date for a relevant official livestock census.

The present inventory has access to livestock-census data for every second year during the periods 1990 to 1996 and 1999 to 2007 (with the exception of 2005) for cattle, swine, sheep, horses and poultry, at the district (Kreis) level. The data were collected by the Federal Statistical Office in the framework of agricultural-structure surveys referenced to 3 May[57]. In 2005, only a representative survey of livestock populations was carried out, and thus no animal-census figures at the district level are available for 2005. In addition to carrying out agricultural-structure surveys, as part of its livestock censuses the Federal Statistical Office carries out surveys of features of cattle and swine populations (twice yearly, referenced to 3 May and 3 November) and of sheep populations (referenced to 3 May; as of 2011, referenced to 3 November). For those animal categories, population information is thus available, at the Länder level, for years between the agricultural-structure surveys. In the interest of time-series consistency, the May-survey figures are always used in the present context for cattle and swine. The agricultural census carried out in 2010, which carried out an exhaustive survey of features of livestock populations, departed from the usual reference date of 3 May; it was referenced to 1 March. Among livestock populations considered for the inventory, only the populations of poultry, goats, sheep and equids are affected by the change in the reference date, since the cattle and swine data for the year 2010 have been obtained largely from the livestock census (referenced to 3 May). While the equid population, which in 2010 was officially surveyed for the first time, includes mules and asses, in the inventory that population is interpreted as a horse head count, since it is not possible to deduct numbers of mules and asses, which are estimated only at the national level (see below), from the relevant numbers of equids at the Länder level. The error this entails (overestimation of numbers of horses) can be neglected, since the number of mules and asses is negligible in comparison to the total number of equids. In the 2010 agricultural census, the goat population was again surveyed, for the first time in decades.

Since 2008 / since the preparation of the NIR 2009, cattle head counts have been taken from a special database ("origin-tracing and information system for animals" HIT - Herkunftssicherungs- und Informationssystem für Tiere; http://www.hi-tier.de) in which every animal is registered. As a result, cattle head counts are available at the district level for the period as of 2008. Via the new survey method, systematically higher animal head counts result for years as of 2008 than result for earlier years in which not all animals were counted, due to the survey thresholds applied. A comparison carried out by the Federal Statistical Office for 2007 reveals that the cattle head counts shown in HIT are 2.9 % higher than those resulting via the conventional survey method (for dairy cows alone, the head counts are 2.8 % higher). Pursuant to the Federal Statistical Office, it is not possible to estimate the

57 The Agricultural-Structure Survey surveys agricultural operations that reach certain survey thresholds (for example, 2 ha of agricultural land, or a minimum number of livestock, such as 8 head of cattle or 8 swine). The applicable survey thresholds were increased in 2010 (inter alia, the size threshold was increased to 5 ha of agricultural land).

discrepancy for earlier years. Consequently, the cattle time series for 1990 to 2007 have not been adjusted. As a result, emissions from keeping of cattle are slightly underestimated for the years 1990 to 2007.

Information on poultry and horse populations is lacking for the years between the agricultural-structure surveys. At the Länder level, those populations have been estimated as follows:

- Lacking figures for poultry for the years 2008 and 2009 were calculated via interpolation between the values for 2007 and 2010. This procedure represents a methodological change from the NIR 2011, in which data lacking for the period as of 2007 were carried forward (and were extrapolated for broilers), since the value for 2010 was not yet known. For the years prior to 2007, the figures used were also interpolated, and were not carried forward from the last available figure. Discrepancies occur as a result between the poultry counts in the NIR 2011 and those in the NIR 2012.
- Data gaps in the time series for horse counts were closed via interpolation; the previous procedure, in which the last available figure was carried forward, was not used. Discrepancies occur as a result between the horse counts in the NIR 2011 and those in the NIR 2012.

For animal categories that are not surveyed, or are seldom surveyed, for purposes of official agricultural statistics, the relevant population counts were obtained as follows:

- The numbers of goats in Germany were not surveyed between the years 1977 and 2010. Until 2004, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) estimated goat populations at the national level. As of 2005, the pertinent time series was continued via estimation by the Federal Statistical Office. In 2010, the total number of goats in Germany was determined in the framework of the 2010 Agricultural Census (Landwirtschaftszählung 2010; LZ 2010). The relevant figure for 2010 is considerably lower than the estimates from the previous years which, by agreement with the Federal Statistical Office, continue to be used nonetheless.
- For mules and asses as well, no figures from official statistics are available for the period in question. Figures published in 2003 by Interessengemeinschaft für Esel und Maultiere (IGEM, interest association for mules and asses; Deutsches Eselstammbuch (German book of donkey pedigrees), 2003) indicate that some 6,000 to 8,000 donkeys, and about 500 mules and hinnies, were being kept in Germany as of that time. More recent figures from Deutsches Eselstammbuch (2009) are considerably lower. On the other hand, those figures are subject to large uncertainties. For that reason, calculations are currently being carried out with a constant figure of 8,500 mules and asses.
- The Federal Statistical Office does not publish buffalo counts. The Deutscher Büffelverband (German buffalo association) has closed this gap by providing such figures for the period as of 2000. In keeping with a recommendation in the final report for the "Initial Review under the Kyoto Protocol and Annual 2006 Review under the Convention", for the years prior to 2000 the time series for the buffalo population at the national level was completed via linear extrapolation. For the years 1990 to 1995, mathematically negative animal head counts result; they are replaced with "zeros".

In the interest of obtaining maximally homogeneous animal categories, some of the animal categories used in official surveys were modified. For this reason, the head-count figures used in the German GAS-EM inventory model for the animal categories calves, heifers, fattening bulls, weaned piglets, fattening pigs, laying hens and pullets diverge from the relevant figures in the official statistics. In the "turkey" category, roosters and hens are considered separately. Horses are divided by size into the two categories "heavy horses" and "light horses" (incl. ponies). The sum totals for all cattle, the sum total for pullets and laying hens, the sum total for turkey roosters and hens and the sum total for heavy horses and light horses all are in keeping with the applicable figures of the Federal Statistical Office. For swine, the total head-count figure used for German emissions reporting is lower, by the number of suckling pigs, than the total figure from official statistics, since the emissions of suckling piglets weighing up to 8 kg animal^{-1} are included with emissions from keeping of sows, and the relevant results are assigned solely to sows. In keeping with the change, with regard to the NIR 2011 (cf. RÖSEMANN et al., 2011), in the calculation procedure applied to the suckling-piglet population (HAENEL et al., 2011b), higher suckling-piglet counts result for the present NIR – and, thus, also a reduction, with regard to the NIR 2011, in the total swine count on which the emissions inventory is based. The revision, described in HAENEL et al. (2011b), of the procedure for calculating animal head counts for the inventory categories weaning piglets and fattening pigs, from the official census figures for piglets weighing up to 20 kg animal^{-1} and young pigs and fattening pigs weighing at least 20 kg animal^{-1}, has no impacts on the total number of swine reported in the emissions inventory.

Table 124 presents a compilation of the animal-place figures on which German reporting is based. With regard to the uncertainties for the animal head counts, cf. Table 133 in Chapter 6.1.4.

Table 124: Animal-place figures used in German reporting (4.A, 4.B), in thousands

[in thousands]	Dairy cattle	Other cattle	Swine	Sheep	Goats	Horses	Mules and asses	Buffalo	Poultry
1990	6,355	13,133	26,502	3,266	90	491	8.5	0.00	113,879
1991	5,632	11,502	22,183	3,250	86	511	8.5	0.00	108,770
1992	5,365	10,843	22,618	2,999	90	531	8.5	0.00	103,662
1993	5,301	10,597	22,238	3,001	92	565	8.5	0.00	106,805
1994	5,273	10,690	21,148	2,882	95	599	8.5	0.00	109,948
1995	5,229	10,661	20,387	2,991	100	626	8.5	0.00	111,228
1996	5,195	10,565	20,809	2,953	105	652	8.5	0.05	112,507
1997	5,026	10,201	21,248	2,885	115	594	8.5	0.17	114,439
1998	4,833	10,110	22,500	2,869	125	535	8.5	0.30	116,371
1999	4,765	10,131	22,138	2,724	135	476	8.5	0.42	118,303
2000	4,570	9,968	21,768	2,743	140	491	8.5	0.63	120,180
2001	4,549	10,055	21,792	2,771	160	506	8.5	0.63	122,056
2002	4,427	9,560	22,110	2,722	160	516	8.5	0.76	122,732
2003	4,371	9,273	22,352	2,697	160	525	8.5	0.89	123,408
2004	4,285	8,911	21,758	2,714	160	512	8.5	1.02	121,984
2005	4,236	8,799	22,743	2,643	170	500	8.5	1.19	120,561
2006	4,082	8,667	22,417	2,561	180	521	8.5	1.32	123,712
2007	4,071	8,615	22,985	2,538	180	542	8.5	1.54	126,863
2008	4,218	8,752	22,677	2,437	190	515	8.5	1.79	127,542
2009	4,205	8,739	23,021	2,350	220	489	8.5	2.11	128,221
2010	4,183	8,626	22,244	2,089	150	462	8.5	2.36	128,900

6.1.3.2.2 Yield, energy and feed data (CRF 4.A, 4.B)

To calculate emissions in accordance with a Tier 2 method, one requires data on animal yield (animal weight, weight gain, milk yield, milk protein content, milk fat content, numbers of births, numbers of eggs and weights of eggs) and on the relevant feed (phase feeding, feed components, protein and energy content, energy metabolisability and digestibility of organic matter). To divide the total numbers of turkeys, as reported by the Federal Statistical Office, into roosters and hens, one must know the applicable sex ratio. For the most part, such data are not available from official statistics. In the present case, such data were obtained from the open literature, from association publications, from regulations for agricultural consulting in Germany and via surveys of experts. Some data for turkeys were provided by hatcheries.

Table 125 shows the mean animal weights for dairy cows, other cattle, swine and poultry. Details on calculation of average animal weights are presented in HAENEL et al. (2012). The average weight for all swine has changed, with regard to the NIR 2011, as a result of changes in animal counts and of updating of average animal weights for sows, weaners and boars. The change in the average weight for poultry, with regard to the NIR 2011, is due a change in the average weight for turkeys (based on updated input data), to interpolation of input data for broilers (male and female) for the period from 2007 to 2010 and to use of interpolation, rather than carry-forwards, to close data gaps.

Table 125: Mean animal weights (4.B)

[kg animal^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	607.9	599.1	619.3	631.1	623.1	621.8	631.9	626.7	636.2	640.4
Other cattle	300.1	299.3	309.5	314.0	312.8	313.7	319.2	319.1	326.3	326.1
Swine	72.8	71.0	71.7	72.0	72.9	74.1	73.7	74.1	73.6	72.9
Poultry	1.76	1.79	1.80	1.72	1.69	1.66	1.63	1.63	1.67	1.63
[kg animal^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	644.3	654.0	648.3	644.6	641.3	645.8	647.4	651.3	645.3	642.0
Other cattle	329.5	334.6	329.4	328.8	327.4	326.4	330.6	333.8	327.7	328.4
Swine	72.4	72.4	72.6	72.9	72.9	72.3	72.6	72.9	72.4	72.5
Poultry	1.82	1.82	1.78	1.90	2.02	2.00	1.96	2.00	1.93	1.90
[kg animal^{-1}]	**2010**									
Dairy cattle	646.8									
Other cattle	330.0									
Swine	70.6									
Poultry	1.89									

For the remaining animal categories, weight does not enter into emissions calculations. Nonetheless, such weights are reported in the CRF tables (on the basis of IPCC default values or German standard values).

Table 126 shows the mean daily milk yield for dairy cows, an important yield parameter. At the time when emissions calculations are carried out, the pertinent data are available only to the penultimate year of the time series. For the last year in the time series, the previous year's value is used.

Table 126: Mean daily milk yield for dairy cows (4.A)

[kg d^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Milk yield	12.9	13.2	13.8	14.4	14.4	14.9	15.1	15.3	15.6	16.2
[kg d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Milk yield	16.6	17.0	17.2	17.9	18.0	18.5	18.8	19.0	18.7	19.1
[kg d^{-1}]	**2010**									
Milk yield	19.1									

The yield-related calculation of gross energy intake (GEI) is based on the assumption that feeding is in accordance with animals' requirements. In that regard, first the relevant animal energy requirements are determined, and then the figure for applicable energy content in the feed is used to determine what quantity of feed must be consumed to meet those energy requirements. The mathematically resulting N content in the feed is checked for consistency with national recommendations on feeding. The total energy content in the feed is used to calculate each relevant animal's total energy intake.

Table 127 shows the daily gross energy intake (GEI) for dairy cows, other cattle and swine. The discrepancies with respect to the NIR 2011 (decrease for cattle; increase for swine) are the result of modifications in the dairy-cow model and in assumptions pertaining to feeding of dairy cows (which have reduced dairy cows' N excretions, which previously were too high, to the level of national standard values); of updating of key index figures for feed for heifers and fattening bulls; and of updating of animal counts and animal weights for swine.

Table 127: Mean daily gross energy intake (GEI) (4.A)

[MJ place^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	257.1	262.0	271.0	276.1	275.7	278.7	282.4	284.2	288.6	291.8
Other cattle	102.4	103.8	107.2	108.0	106.8	107.6	108.2	107.9	108.3	109.2
Swine	27.4	27.9	28.3	28.4	28.7	28.9	29.2	29.2	29.6	29.3
[MJ place^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	295.9	301.1	302.7	306.0	306.8	310.4	312.0	315.0	311.2	314.4
Other cattle	109.5	109.8	108.9	108.8	108.4	108.4	109.0	109.5	108.8	109.0
Swine	29.4	29.8	29.9	29.7	30.0	29.8	30.0	30.1	30.1	30.2
[MJ place^{-1}]	**2010**									
Dairy cattle	315.3									
Other cattle	109.2									
Swine	30.1									

Table 128 through Table 130 show, for dairy cows, other cattle and swine, the input data for the VS calculation on which the calculation of CH_4 emissions from manure management is based. The data include dry-matter intake (DMI), digestibility of organic matter and ash content of feed (cf. also Chapter 6.3.2.2.1). The dry-matter intake is obtained from the feed intake (cf. Chapter 6.3.4.2.1), taking account of the dry-matter content of the various feed components. The digestibility of organic matter, and the ash content of feed, are given as feed index figures (BEYER et al., 2004; information from producers); where the data are not available, suitable substitute values are used (cf. HAENEL et al., 2012).

Table 128: Daily dry-matter intake (DMI) (4.B(a)s1)

[kg $^{-1}$ place^{-1} d^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	14.00	14.25	14.72	14.98	14.95	15.10	15.29	15.38	15.61	15.77
Other cattle	5.54	5.62	5.79	5.83	5.77	5.81	5.84	5.83	5.86	5.90
Swine	1.73	1.75	1.78	1.79	1.81	1.82	1.84	1.84	1.87	1.85
[kg $^{-1}$ place^{-1} d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	15.98	16.24	16.32	16.49	16.53	16.72	16.80	16.96	16.76	16.92
Other cattle	5.92	5.94	5.89	5.88	5.86	5.85	5.88	5.91	5.87	5.88
Swine	1.86	1.89	1.89	1.88	1.90	1.89	1.90	1.91	1.91	1.91
[kg $^{-1}$ place^{-1} d^{-1}]	**2010**									
Dairy cattle	17.0									
Other cattle	5.89									
Swine	1.90									

Table 129: Digestibility of organic matter in feed (4.B(a)s1)

[kg $^{-1}$ place^{-1} d^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	0.728	0.729	0.731	0.733	0.733	0.733	0.734	0.735	0.736	0.737
Other cattle	0.726	0.726	0.726	0.725	0.725	0.725	0.725	0.725	0.725	0.725
Swine	0.852	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.851	0.852
[kg $^{-1}$ place^{-1} d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	0.738	0.739	0.740	0.741	0.741	0.742	0.742	0.743	0.742	0.743
Other cattle	0.725	0.725	0.725	0.726	0.726	0.726	0.726	0.726	0.726	0.726
Swine	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852	0.852
[kg $^{-1}$ place^{-1} d^{-1}]	**2010**									
Dairy cattle	0.743									
Other cattle	0.726									
Swine	0.852									

Table 130: Ash content of feed

[kg $^{-1}$ place^{-1} d^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	0.096	0.096	0.095	0.094	0.093	0.093	0.092	0.092	0.091	0.091
Other cattle	0.090	0.090	0.090	0.090	0.091	0.091	0.091	0.091	0.091	0.091
Swine	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
[kg $^{-1}$ place^{-1} d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	0.091	0.090	0.090	0.089	0.089	0.089	0.088	0.088	0.088	0.088
Other cattle	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091
Swine	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
[kg $^{-1}$ place^{-1} d^{-1}]	**2010**									
Dairy cattle	0.088									
Other cattle	0.091									
Swine	0.057									

The following chapters present further information relative to animal husbandry – for example, excretion data (VS, N).

Mean percentages of pregnant animals do not enter into any of the animal models used. They are reported in CRF Table 4.A, however, in the interest of completeness.

6.1.3.2.3 N excretions (CRF 4.B)

For dairy cows, heifers, fattening bulls, swine, laying hens, pullets, broilers, ducks and turkey cocks and turkey hens, N excretions are calculated as a function of yield. For other animals, N-excretion data are taken from the pertinent German literature (cf. the references in HAENEL et al., 2012).

The method for calculating N excretions as a function of yield is based on the assumption that feeding is in accordance with requirements (cf. Chapter 6.1.3.2.2). The N content in the feed is used to calculate each relevant animal's N intake. The figure that then remains, following deduction of growth-related N retention, N release via products (milk/eggs) and N losses via pregnancy/young, is the N-excretions figure.

- For the animal category "dairy cows", N excretions are calculated as a function of milk yield, milk-protein levels, weight, number of births per year and feed composition.
- For the animal categories "heifers" and "fattening bulls", N excretions are calculated as a function of weight gain, final weight and feed characteristics.
- For all sub-categories of swine, N excretions are determined from animal yields (for sows: number of piglets per year; for weaned piglets and fattening pigs: weight gain) as well as animal weights and fodder composition.
- For laying hens, pullets, broilers, ducks, turkey cocks and turkey hens, excretions are calculated as a function of weight gain, final weight and feed characteristics. For laying hens, laying yields are also taken into account.

For animal categories with pasturing, calculated N excretions per animal place and year are broken down into in-pasture and in-stall excretions, since only in-stall excretions can enter into calculation of N_2O emissions in 4.B. Excrements are divided into in-stall and in-pasture categories in keeping with the relative time proportions for time in stall and time in pasture.

Table 131 shows the N-excretion data per animal place and year for the present NIR 2012 and in comparison to the corresponding values on which the NIR 2011 was based. The results arise via the changes in the animal models; cf. Chapter 6.1.3.3. For the following animal categories, N excretions are considered constant over time and thus are the same in the NIR 2011 and the NIR 2012: goats (11.0 kg place^{-1} a^{-1}), mules and asses (33.4 kg place^{-1} a^{-1}) and buffalo (82.0 kg place^{-1} a^{-1}).

Table 131: N excretions per animal place and year (4.B(b)), as reported in 2012 and as reported in 2011

[kg place^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2012	95.1	98.4	101.8	103.9	101.3	102.2	103.4	103.8	105.4	106.4
Dairy cattle, 2011	106.3	110.1	114.3	117.0	114.4	115.8	117.5	118.3	120.4	121.8
Other cattle, 2012	40.3	41.3	42.6	43.1	42.9	43.4	43.7	43.7	44.0	44.3
Other cattle, 2011	37.1	38.1	39.3	39.8	39.6	40.3	40.7	40.8	40.9	41.2
Swine, 2012	11.8	12.0	12.2	12.2	12.3	12.4	12.5	12.5	12.6	12.5
Swine, 2011	11.7	11.9	11.9	11.9	12.0	12.1	12.1	12.2	12.2	12.1
Sheep, 2012	7.7	7.6	7.6	7.8	7.7	7.7	7.8	7.7	7.7	7.9
Sheep, 2011	7.4	7.2	7.3	7.4	7.4	7.3	7.4	7.4	7.3	7.5
Horses, 2012	48.4	48.4	48.5	48.4	48.4	48.3	48.3	48.6	49.0	49.4
Horses, 2011	48.4	48.4	48.5	48.5	48.4	48.4	48.3	48.3	48.3	49.4
Poultry, 2012	0.68	0.68	0.69	0.66	0.65	0.64	0.64	0.64	0.65	0.63
Poultry, 2011	0.68	0.68	0.68	0.68	0.67	0.66	0.66	0.66	0.67	0.65
[kg place^{-1} a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2012	107.7	109.8	109.8	110.7	111.1	112.4	113.0	114.2	112.4	113.7
Dairy cattle, 2011	123.8	126.6	127.2	128.8	129.4	131.1	131.9	133.4	131.5	131.5
Other cattle, 2012	44.5	44.5	44.2	44.2	44.2	44.2	44.3	44.5	44.2	44.3
Other cattle, 2011	41.4	41.3	41.0	41.0	41.0	41.0	41.0	41.1	40.8	40.8
Swine, 2012	12.4	12.6	12.6	12.5	12.5	12.4	12.4	12.3	12.2	12.1
Swine, 2011	12.1	12.1	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.1
Sheep, 2012	7.8	7.8	7.8	7.9	7.8	7.8	7.8	7.7	7.7	7.8
Sheep, 2011	7.5	7.5	7.4	7.6	7.5	7.5	7.4	7.4	7.4	7.4
Horses, 2012	49.2	49.0	49.1	49.1	49.1	49.1	49.0	49.0	49.0	49.0
Horses, 2011	49.4	49.0	49.0	49.1	49.1	49.1	49.1	49.0	49.0	49.0
Poultry, 2012	0.66	0.67	0.66	0.68	0.73	0.74	0.72	0.74	0.73	0.73
Poultry, 2011	0.67	0.68	0.67	0.68	0.74	0.74	0.72	0.75	0.76	0.78
[kg place^{-1} a^{-1}]	**2010**									
Dairy cattle, 2012	114.1									
Other cattle, 2012	44.4									
Swine, 2012	11.9									
Sheep, 2012	8.2									
Horses, 2012	49.0									
Poultry, 2012	0.73									

As a result of the model improvements described in Chapter 6.1.3.3, the following changes have resulted relative to the comparison of N-excretions data between the NIR 2011 and the NIR 2012: In the dairy cows category, N excretions decreased considerably from the NIR 2011 to the NIR 2012, while N excretions for other cattle increased; for swine and sheep, N excretions increased slightly; for horses, both increases and decreases occurred; for poultry, the NIR 2012 shows slightly lower N excretions for the entire report period. Owing to the predominating influence of dairy cows in this regard, total N excretions of all animals are lower, in the NIR 2012, than they are in the NIR 2011; cf. Table 132.

Table 132: Comparison of total N excretions of all animals, as calculated in 2012 and as calculated in 2011

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N excretions, 2012	1574.8	1421.5	1404.5	1401.4	1378.3	1377.3	1388.5	1359.7	1364.2	1353.4
N excretions, 2011	1603.5	1452.5	1432.8	1431.1	1410.1	1411.1	1425.3	1402.7	1405.6	1393.4
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
N excretions, 2012	1334.6	1352.7	1319.1	1307.8	1280.8	1283.1	1259.2	1273.9	1277.7	1283.3
N excretions, 2011	1370.7	1389.5	1354.5	1349.7	1324.9	1329.9	1300.7	1321.2	1333.1	1341.1

6.1.3.2.4 Housing, storage and application procedures, and pasturing periods (CRF 4.A, 4.B, 4.D)

The data consist of frequency distributions for feeding in various housing systems (proportions for pasturing / stall housing; proportions for different stalling systems), storage systems and manure-application techniques and time in pasture, by animal sub-categories (Table 123).

For years through 1999, the pertinent data were obtained with the help of the RAUMIS agricultural sector model (Regionalisiertes Agrar- und UmweltInformationsSystem für Deutschland; Regionalised agricultural and environmental information system for Germany)[58]. The data that entered into RAUMIS included specialised national statistics at the sectoral and district levels, standardisation data of the Association for Technology and Structures in Agriculture (KTBL-Normdaten) relative to description of production processes, data from the Economic Accounts for Agriculture (EAA), special evaluations of the Federal Ministry of Food, Agriculture and Consumer Protection (herd-size-class distribution) and survey data. Where relevant statistical data were missing, models were formulated with the aid of experts.

Updating of the aforementioned RAUMIS data was no longer possible after 1999. In the NIR 2011, those data were still used for years through 2009.

For the NIR 2012, current data for the 2010 are now available for purposes of emissions reporting – from the 2010 agricultural census (LZ 2010), from the survey of agricultural production methods carried out together with the LZ, and from a survey on farm-manure application carried out in calendar year 2010. For the categories cattle, swine and sheep, those data deviate from RAUMIS data used previously.

[58] RAUMIS is operated by the Institute for Rural Studies of the Johann Heinrich von Thünen Institute (vTI; until 2008: Federal Agricultural Research Institute (FAL). For a pertinent introduction, cf. WEINGARTEN (1995); a detailed description is provided in HENRICHSMEYER et al. (1996).

In most cases, gaps between the data from the LZ 2010 and the RAUMIS data of 1999 have been closed via linear interpolation. In some cases, however, LZ 2010 data were used in the inventory for the period beginning in 1990, in replacement of comparatively uncertain RAUMIS data or comparatively uncertain assumptions. For example, the 2010 agricultural census (Landwirtschaftszählung 2010; LZ 2010) provided the first official data on pasturing of sheep. Those data are now being used for years as of 1990, and they have replaced the pertinent assumptions used until the NIR 2011.

Other changes in distributions of animal-housing systems, with regard to the NIR 2011, have been made on the basis of assessments of KTBL experts:

- For housing of calves, in the NIR 2012 it is assumed that until 2002 50 % of all calves were housed in tie-stall systems with solid floors and straw bedding and 50 % were housed with deep straw bedding, and that as of 2003, as a result of a ban on tie-stall systems, 100 % were housed with deep straw bedding.
- For housing of heifers, all straw-based systems have solid floors with straw bedding, since such systems are more common in Germany than are housing systems using deep straw bedding.
- For suckler cows, a greater frequency for housing with deep straw bedding is assumed than was assumed for the Submission 2011. That change is in keeping with the assessment of the reviewers who carried out the In-Country Review for the Submission 2010.

Table 324, Table 325,Table 326 and Table 327 in Annex Chapter 19.4.1 show the applicable distributions of housing, storage and application procedures, and they provide data on pasture access. The tables also include information relative to emission factors (including that for NH_3). For further details, cf. HAENEL et al. (2012).

6.1.3.2.5 Straw bedding in connection with solid-manure systems (CRF 4.B)

In calculation of N_2O and NO emissions from manure management, the N quantities introduced into the system via straw bedding are taken into account. In the present NIR 2012, straw bedding is treated as straw whose N proportion, with respect to dry-matter content, is 0.58 % (for a dry-matter-content proportion of 86 %); the corresponding figure used for the NIR 2011 was 0.5 %. That increase in N content is the result of a recommendation provided by reviewers during the In-Country Review in September 2010. It brings the N content in straw bedding into line with the value used in calculation of emissions from harvest residues.

Table 324 (cf. Annex Chapter 19.4.1) shows the system-related quantities of straw bedding in fresh plant matter.

6.1.3.3 Changes in animal models (CRF 4.A, 4.B)

A comparison with neighbouring European countries has shown that the N excretions calculated with the German dairy-cow model used to date are too high. Revised calculations of energy requirements for lactation, along with improved adjustment of indexes for energy in feed to national standard values, lead overall to reductions of gross energy intake (GEI) and of N excretions.

For dairy cows, calculation of division of N excretions between stall and pasture was brought into line with the customary procedure for all animals (cf. Chapter 6.1.3.2.3). This has led to a slight shifting of N excretions from stall to pasture.

For heifers and fattening bulls, review of the pertinent animal N balance revealed that the model used to date would not be able to meet animals' raw-protein requirements. As a result, the pertinent energy-requirements calculations and feed index values were updated. This, in turn, has led to a slight reduction in gross energy intake (GEI). On the other hand, N excretions have increased for both animal categories.

In the suckler cows category, the relative proportion of metabolisable energy (ME) ingested with pasturage, with respect to total-ME intake via roughage, is now calculated as a function of time spent in pasture (the earlier, constant 50 % estimate is no longer being used). In cases in which calculation yields a value greater (smaller) than 50 %, the gross energy intake (GEI) increases (falls) with respect to the earlier version of the model. The relevant N excretions are not affected by these changes, since a national standard value of 82 kg N per place and year is used for them.

For stud bulls, the daily metabolisable energy (ME) requirements have been adjusted in accordance with values given in current literature (now, 110 MJ place^{-1} d^{-1} instead of the former value of 100 MJ place^{-1} d^{-1}). This has led directly to higher values for gross energy intake (GEI). The relevant N excretions are not affected by these changes, since a national standard value of 84 kg N per place and year is used for them.

In keeping with results of the peer review of HAENEL et al. (2011a), and in order to provide a better reflection of the situation in Germany, the mean body weight for sows was increased from 200 to 220 kg animal^{-1}, the weaning weight for suckling piglets was reduced from 8.5 to 8 kg animal^{-1}, the duration of lactation was increased from 25 to 28 days, and the daily metabolisable energy (ME) requirements for all feeding phases were updated. Those changes have increased gross energy intake (GEI) and N excretions.

Previously, for fattening pigs, the annual number of fattening cycles was calculated from starting weight, end weight after fattening, mean daily weight gain and assumed duration for stall cleaning between successive cycles, since no throughput-number data were available. Data for actual throughput (i.e. numbers of cycles per time period) are now available, as the result of a 2010 survey of the German Länder. The resulting values are lower than the previously calculated values. In comparison to the earlier version of the model, the gross energy intake (GEI) and N excretions per place and year are lower.

To date, N excretions for lambs have been viewed in terms of values for intensive fattening operations (3 kg place^{-1} a^{-1}). In order to take account of the higher N excretions occurring in pasture fattening (5 kg place^{-1} a^{-1}), an N-excretions figure of 4 kg place^{-1} a^{-1} has been used in inventory calculations for lambs.

For turkeys, the various different sources of input data used to date have been replaced with a consistent database: As of the Submission 2012, all figures relative to final weight, weight gain, duration of fattening and feed-conversion efficiency are being based on data from poultry-data yearbooks for the period from 1990 to the present. The relative population proportion for turkey roosters is determined, from the available incomplete data, as a constant mean. Calculation of the N content in feed, averaged over all feeding phases, has been revised. As a result of such updating, N excretions for all turkeys, in the period 1990 to

1993, are higher in the present Submission than they have been in earlier Submissions, while they show a reduction, with respect to the last Submission, for the rest of the time series.

6.1.4 Total uncertainty of all emissions in Sector 4

Along with emissions calculations, the total uncertainty for all emissions in Sector 4 was calculated; cf. Table 133. That calculation was carried out on the basis of the Tier 1 method described in IPCC Good Practice Guidance and Uncertainty Management (GPGAUM) (2000), "Quantifying Uncertainties in Practice". That procedure, in turn, is based on thorough application of Gaussian error correction. By way of convention, the fact that such error correction assumes a normal distribution is ignored, and the normal-distribution required is not met by - or cannot be checked for - some of the activity data and emission factors that enter into the calculation. Furthermore, Gaussian error calculation is oriented to use of standard errors. In contrast to that orientation, the Tier 1 method described in IPCC GPGAUM (2000), "Quantifying Uncertainties in Practice" (cf. p. 6.14 in the paragraph relative to columns E and F), requires entry of half of the 95 % confidence interval, which value amounts to about double the standard error. It can be shown, however, that the calculation rules for Guassian error calculation (cf. Equ. 6.3 6.3 and Equ. 6.4 in IPCC GPGAUM, 2000) also apply to multiples of the standard error.

With regard to asymmetric distributions, IPCC GPGAUM (2000), "Quantifying Uncertainties in Practice" (p. 6.14), requires, for the Tier 1 method, that the larger of the two intervals [2.5 percentile; mean value] and [mean value; 97.5 percentile] be used. That requirement has been fulfilled for Table 133. Details on Tier-1 uncertainties calculation for the German inventory are presented in HAENEL et al. (2012). In the Tier-2 method, uncertainties have to be calculated in accordance with the actual intervals, however.

Table 133 shows the total uncertainty for all emissions of Sector 4, for the year 2010, along with the uncertainty for the overall trend since 1990. All emissions values are given in CO_2 equivalents, using the greenhouse warming potential (GWP) conversions customarily applied, 21 kg kg^{-1} for CH_4 and 310 kg kg^{-1} for N_2O.

As the column "Combined uncertainty as % of total national emissions" in Table 133 shows, the total uncertainty of all emissions from Sector 4 results predominantly from the uncertainties for N_2O emissions from the area of agriculturally used soils, especially the indirect emissions from leaching and surface run-off. As a rule, the uncertainties for the relevant emission factors are considerably higher than those for activity data, and they thus figure predominantly in the total uncertainty.

Table 133: Total-uncertainties calculation for emissions from Sector 4 (animal husbandry and use of agricultural soils)

Source category	Gas	Base year emissions, in CO_2 equivalents (GWP$_{CH4}$ = 21, GWP$_{N2O}$ = 310)	Year 2010 emissions, in CO_2 equivalents	Activity data uncertainty (half the 95 % confidence interval)	Emission factor uncertainty (half the 95 % confidence interval)	Combined uncertainty (half the 95 % confidence interval)	Combined uncertainty as % of total national emissions in year 2010	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg a-1	Gg a-1	%	%	%	%	%	%	%	%	%
Enteric fermentation, dairy cows	CH4	13498.4	10898.6	6	40	40.4	6.5	0.00	0.13	0.02	1.11	1.11
Enteric fermentation, other cattle	CH4	11843.5	8294.0	6	40	40.4	5.0	0.02	0.10	0.63	0.85	1.05
Enteric fermentation, pigs	CH4	599.9	552.7	10	40	41.2	0.3	0.00	0.01	0.03	0.09	0.10
Enteric fermentation, sheep	CH4	548.7	350.9	10	60	60.8	0.3	0.00	0.00	0.07	0.06	0.09
Enteric fermentation, goats	CH4	9.5	15.7	20	60	63.2	0.0	0.00	0.00	0.01	0.01	0.01
Enteric fermentation, horses	CH4	169.7	161.3	10	60	60.8	0.1	0.00	0.00	0.02	0.03	0.03
Enteric fermentation, mules, asses	CH4	1.8	1.8	100	60	116.6	0.0	0.00	0.00	0.00	0.00	0.00
Enteric fermentation, buffalo	CH4	0.0	2.7	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, dairy cows	CH4	2320.1	2321.7	6	40	40.4	1.4	0.01	0.03	0.21	0.24	0.32
Manure management, other cattle	CH4	1767.6	1186.1	6	40	40.4	0.7	0.00	0.01	0.12	0.12	0.17
Manure management, pigs	CH4	2118.0	1933.1	10	40	41.2	1.2	0.00	0.02	0.10	0.33	0.34
Manure management, sheep	CH4	18.7	12.0	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, goats	CH4	0.4	0.7	20	60	63.2	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, horses	CH4	26.3	25.0	10	40	41.2	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, mules, asses	CH4	0.2	0.2	100	40	107.7	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, buffalo	CH4	0.0	0.2	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, poultry	CH4	73.5	93.8	20	40	44.7	0.1	0.00	0.00	0.02	0.03	0.04
Manure management, dairy cows	N2O	1048.8	835.0	6	100	100.2	1.2	0.00	0.01	0.02	0.09	0.09
Manure management, other cattle	N2O	1020.6	839.6	6	100	100.2	1.2	0.00	0.01	0.01	0.09	0.09
Manure management, pigs	N2O	367.0	463.9	10	100	100.5	0.7	0.00	0.01	0.20	0.08	0.21
Manure management, sheep	N2O	32.8	22.0	10	100	100.5	0.0	0.00	0.00	0.01	0.00	0.01
Manure management, goats	N2O	1.1	1.8	20	100	102.0	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, horses	N2O	61.7	58.8	10	100	100.5	0.1	0.00	0.00	0.01	0.01	0.01
Manure management, mules, asses	N2O	0.7	0.7	100	100	141.4	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, buffalo	N2O	0.0	0.4	10	100	100.5	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, poultry	N2O	37.6	46.0	20	100	102.0	0.1	0.00	0.00	0.02	0.02	0.02

Source category	Gas	Base year emissions, in CO_2 equivalents	Year 2010 emissions, in CO_2 equivalents	Activity data uncertainty (half the 95 % confidence interval)	Emission factor uncertainty (half the 95 % confidence interval)	Combined uncertainty (half the 95 % confidence interval)	Combined uncertainty as % of total national emissions in year 2010	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		(GWP_{CH4} = 21, GWP_{N2O} = 310)										
		Gg a-1	Gg a-1	%	%	%	%	%	%	%	%	%
Soils, mineral fertilizers	N2O	12722.4	9129.8	20	80	82.5	11.2	0.01	0.11	1.14	3.10	3.31
Soils, application of manure	N2O	5478.8	4680.8	60	80	100.0	6.9	0.00	0.06	0.23	4.77	4.78
Soils, N-fixing crops	N2O	855.1	469.2	50	80	94.3	0.7	0.00	0.01	0.22	0.40	0.45
Soils, crop residues	N2O	5123.5	5513.7	50	80	94.3	7.7	0.02	0.07	1.31	4.68	4.86
Soils, organic soils	N2O	4814.7	4793.8	20	200	201.0	14.3	0.01	0.06	2.14	1.63	2.69
Soils, grazing	N2O	2019.7	1334.5	40	200	204.0	4.0	0.00	0.02	0.73	0.91	1.16
Soils, indirect emissions (deposition)	N2O	2862.8	2213.5	50	100	111.8	3.7	0.00	0.03	0.13	1.88	1.89
Soils, indirect emissions (leaching, run-off)	N2O	13600.3	11054.5	170	380	416.3	68.2	0.00	0.13	0.12	31.94	31.94
Soils, sewage sludge emissions	N2O	166.9	170.0	20	80	82.5	0.2	0.00	0.00	0.03	0.06	0.07
Total		83211.1	67478.5									
Overall uncertainty (half the 95% confidence interval) (%)							72.1					33.1

6.1.5 Quality assurance and control

6.1.5.1 Review of input data and emissions results

As a result of discussion relative to GAS-EM input data and results – inter alia, with the Association for Technology and Structures in Agriculture (KTBL) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) – of peer reviews of draft publications and of ERT recommendations from the In-Country Reviews of September 2010, a number of sub-models and input data have been reviewed via comparison with relevant national standards and results of other countries. This led to a number of modifications of the GAS-EM model; cf. Chapters 6.1.3, 6.2.2.2, 6.3.2.2.2,6.3.3, 6.3.4.2.2 and 6.5.2.1.8. A detailed list of the changes made in emissions calculations between the Submission 2011 and the Submission 2012 is also provided by HAENEL et al. (2012), Chapter 1.3.3.

To support quality control, a special QC/QA matrix was created that lists the methodological changes' impacts on transparency, consistency, comparability, completeness and accuracy. The "four eyes" principle has been applied conscientiously to all updating and recalculations. Prior to being introduced, methods changes have been published in peer-reviewed publications and checked by national experts, to ensure that the changes conform to the latest scientific findings and properly reflect the situation in Germany.

At the conclusion of calculations with the GAS-EM inventory model, the results of emissions calculations were reviewed via comparison with the previous year's results and with the help of plausibility checks. After the relevant activity data and place-related emission factors (IEF) had been entered into the Central System of Emissions (CSE) database, the emissions as calculated in the CSE were compared against the emissions results that had been obtained with the GAS-EM inventory model.

6.1.5.2 Quality System for Emissions Inventories

Quality control (pursuant to Tier 1 for asses, goats and buffalo; pursuant to Tiers 1 & 2, for cattle, swine, sheep and horses and agricultural soils) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

6.1.5.3 Comparisons with the previous year's results

This year's emissions calculations were also checked via comparison with the previous year's results, in the framework of source-specific recalculations (cf. Chapters 6.2.5, 6.3.2.5 and 6.5.5).

6.1.5.4 Verification

The national emissions results calculated with the GAS-EM inventory model cannot be compared with other pertinent data from Germany, since no such data are available. Instead, the implied emission factors (IEF) and other emissions-relevant figures are compared with the relevant IPCC default values and with relevant data of other countries. That process is discussed in the following, in the relevant sub-chapters.

6.1.5.5 Reviews and reports

The agricultural section of the German emissions inventory was reviewed in 2004 by Finnish experts, in the context of a bilateral assessment process. In the main, it was judged to be complete and in conformance with proper scientific practice (LECHTENBÖHMER et al., 2005, unpublished). The In-Country Review carried out by UNFCCC (UNFCCC, 2005) reached the same result.

In June 2007, the German inventory was reviewed in the framework of the "Initial Review under the Kyoto Protocol and Annual 2006 Review under the Convention".

In September 2009, a centralized review was carried out. Its most important result was that Germany's use of the new IPCC Guidelines 2006, in source category 4.D in the agriculture sector, was not accepted.

That problem was then considered by the In-Country Review of September 2010. As a result of that review, the Resubmission 2010 was submitted. The changes implemented in it served as a basis for the Submission 2011 and Submission 2012.

The comments presented in "Synthesis & Assessment Reports" and "Reports of the individual review of the greenhouse gas inventories of Germany" were taken as the occasion to review the relevant calculation procedures specifically, and to revise them as necessary.

6.2 Enteric fermentation (4.A)

6.2.1 Source category description (4.A)

CRF 4.A	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Dairy cattle (CRF 4.A.1)	**CH_4**	**L**	**T/T2**	**13,498.4**	**(1.10%)**	**10,898.6**	**(1.14%)**	**-19.26%**
Non-dairy cattle (CRF 4.A.1)	**CH_4**	**L**	**-/T2**	**11,843.5**	**(0.97%)**	**8,294.0**	**(0.87%)**	**-29.97%**
Other animals (buffalo, sheep, goats, horses, swine, mules & asses) (CRF 4.A.2-9)	CH_4	-	-	1,329.6	(0.11%)	1,085.2	(0.11%)	-18.38%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	CS/D/Tier1/Tier 2	M/Q/AS/RS/NS	CS/D

The category *Dairy cattle* (4.A.1.a) is the most important emissions source within the source category *enteric fermentation*. It is a key category in terms of emissions level and trend. The reasons for its status as a key category include the high animal weights involved, the high yields involved and – in keeping with the first two factors – the high gross energy intakes involved. The source category *Other cattle* (4.A.1.b) is a key category in terms of emissions level.

Microbial reactions in the animals' stomachs release CH_4. The quantities released per animal and unit of time depend on the animal species in question, individual-animal yield and feed composition.

Germany reports on emissions of methane (CH_4) from enteric fermentation in housing of dairy cattle, other cattle (calves, heifers, bulls, suckler cows and stud bulls), swine (sows, including suckling piglets weighing up to 8 kg $Tier^{-1}$, weaning piglets, fattening pigs and boars), sheep, goats, horses, mules and asses and buffalo.

Table 134 in Chapter 6.2.2.4 shows all CH_4 emissions from the source category *enteric fermentation*, in the form of a time series. The CH_4-emissions trend is shaped by decreasing animal counts – for cattle especially, throughout the entire period, and for all animal categories since the early 1990s – and by improved feed digestibility, which is partly offset by increasing GE intake levels in connection with increases in milk yield, animal weights and pregnancy rates.

CH_{4-} emissions from enteric fermentation, as a percentage of total CH_4 emissions from the German agricultural sector, have decreased slightly over the years (1990: 80.8 %; 2010: 78.4 %). Overall, CH_4 emissions from enteric fermentation decreased 24.0 % between 1990 and 2010.

6.2.2 Methodological issues (4.A)

6.2.2.1 Methods

In category 4.A "Enteric fermentation", CH_4 emissions of dairy cattle, of other cattle and of swine are determined via a Tier-2 method (IPCC, 1996b, 4.15 ff; IPCC, 2006, 10.24 ff).

In the Tier 2 method, spatially and annually variable emission factors are calculated from country-specific / regionally specific and time-dependent gross energy intake (cf. Chapter 6.3.4.2.1), and from the pertinent methane-conversion factor, in accordance with the following formula:

Equation 4: Calculation of the CH_4 emission factor pursuant to IPCC (1996b)

$$EF_{\mathrm{CH4,ent}} = GE \cdot \frac{x_{\mathrm{CH4,GE}}}{\eta_{\mathrm{CH4}}}$$

Where

$EF_{CH4,\ ent}$	Emission factor for CH_4 from enteric fermentation (in kg animal $place^{-1}$ a^{-1} CH_4)
GE	Gross energy intake (in MJ animal $place^{-1}$ a^{-1} GE)
$x_{CH4,\ GE}$	Methane-conversion factor (in MJ MJ^{-1})
η_{CH4}	Energy content of methane (η_{CH4} = 55.65 MJ (kg $CH_4)^{-1}$)

For dairy cattle, the standard methane-conversion factor pursuant to IPCC (1996b), Table A-1, is used: 0.06 MJ MJ^{-1}. For swine, the standard methane-conversion factor pursuant to IPCC (1996b), Table A-4, is used: 0.006 MJ MJ^{-1}.

For the other cattle category, the methane-conversion factor fluctuates slightly from year to year, due to changes in the composition of the total population (mean: 0.0615 MJ MJ^{-1}; Minimum: 0.0614 MJ MJ^{-1}; Maximum: 0.0617 MJ MJ^{-1}. For calves, a conversion factor of 2 % is used, on the basis of a national expert assessment (Flachowsky, Institut für Tierernährung (Institute for animal nutrition) of the former FAL, Braunschweig) oriented to the fact that calves become ruminants only gradually; cf. KIRCHGESSNER (1997), p. 430 ff, for example, and PENN STATE COLLEGE OF AGRICULTURAL SCIENCES (2011). Neither IPCC (1996b), which uses a figure of 6 %, nor IPCC (2006), which uses 0 %, take account of calves' gradual development into ruminants. For each of the categories suckling cows, heifers, fattening bulls and stud bulls, a methane-conversion factor of 6.5 % is used, in accordance with IPCC (2006), Table 10.12. While that value is higher than the standard value pursuant to IPCC (1996b), it provides a better representation of the circumstances prevailing in Germany, with regard to fodder quality.

Calculations for sheep, goats, horses, mules and asses and buffalo are carried out with Tier 1 methods for which no methane-conversion factor is required. The Tier-1 method uses default emission factors.

A more detailed description of calculation of CH_4 emissions from enteric fermentation is provided by HAENEL et al. (2012).

6.2.2.2 Changes in methods

The relevant methods were not changed relative to the NIR 2011. The differences in CH_4 emissions from enteric fermentation arising in comparison to the NIR 2011 are the result of changes in the pertinent animal models and activity data (cf. Chapter 6.1.3.3). Those changes are discussed in the "Recalculations" chapter (Chapter 6.2.5).

6.2.2.3 Activity data and additional information (4.A)

With regard to animal head counts, the reader's attention is called to Chapter 6.1.3.2. The data on gross energy intake (GE) are provided in Chapter 6.1.3.2.1.

6.2.2.4 Calculated emissions (4.A)

The CH_4 emissions from enteric fermentation, for all German animal husbandry, are listed in Table 134.

Table 134: CH_4 emissions E_{CH4} from animal husbandry (enteric fermentation) (4s1.A)

[Gg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	1270	1147	1118	1115	1108	1113	1115	1082	1067	1067
[Gg a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
E_{CH4}	1046	1059	1021	1007	980	975	954	958	972	975
[Gg a^{-1} CH_4]	**2010**									
E_{CH4}	966									

As Table 135 shows, almost all CH_4 emissions from enteric fermentation in Germany result from keeping of cattle. In addition, dairy cattle are the most important source category within the "cattle" group. The emissions contributions from animals that are not listed are very low.

Table 135: CH_4 emissions from enteric fermentation (4.A.1.a)

[Gg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	643	584	572	576	572	574	577	562	549	547
Other cattle	564	504	487	480	479	481	479	462	460	464
Swine	29	24	25	25	24	23	24	24	26	26
Sheep	26	26	24	24	23	24	24	23	23	22
[Gg a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	532	539	527	526	518	518	501	505	517	520
Other cattle	458	463	437	423	405	400	396	396	399	400
Swine	25	26	26	26	26	27	26	27	27	27
Sheep	22	22	22	22	22	21	20	20	19	19
[Gg a^{-1} CH_4]	**2010**									
Dairy cattle	519									
Other cattle	395									
Swine	26									
Sheep	17									

The emissions reduction seen since 1990 (along with increasing emission factors for dairy cattle, heifers, fattening bulls, fattening pigs, sows and weaned piglets, and unchanging emission factors for all other animals; cf. Chapter 6.2.2.5) is a result of decreasing animal head counts, especially those that occurred in 1990/1991 as a result of German reunification. In later years, the decreases in animal populations are tied to increasing yields per individual animal (milk yield, weight gain). With regard to emissions trends, the impact of decreasing animal head counts is offset – at least partly – by increases in per-animal yields.

6.2.2.5 Emission factors (4.A)

Table 136 shows the chronological development of mean emission factors $IEF_{CH4, ent}$ for dairy cattle, other cattle and swine.

Table 136: CH_4 emission factors for animal husbandry (enteric fermentation) (4.A.1.a)

[kg^{-1} place^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	101.2	103.6	106.7	108.6	108.5	109.7	111.1	111.8	113.6	114.8
Other cattle	42.9	43.8	45.0	45.3	44.8	45.1	45.4	45.3	45.5	45.8
Swine	1.08	1.10	1.11	1.12	1.13	1.14	1.15	1.15	1.16	1.15
[kg^{-1} place^{-1} a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
Dairy cattle	116.4	118.5	119.1	120.4	120.8	122.2	122.8	124.0	122.5	123.7
Other cattle	46.0	46.1	45.7	45.6	45.5	45.5	45.7	46.0	45.6	45.7
Swine	1.16	1.17	1.18	1.17	1.18	1.17	1.18	1.19	1.18	1.19
[kg^{-1} place^{-1} a^{-1}]	**2010**									
Dairy cattle	124.1									
Other cattle	45.8									
Swine	1.18									

Table 137 shows, by way of example for 2009, the emission factors for the sub-categories for other cattle:

Table 137: CH_4 emission factors (enteric fermentation) for "other cattle", for 2010, in comparison with the default values for western Europe pursuant to IPCC (1996b)-4.11, Table 4-4 and IPCC (2006)-10.29, Table 10.11

	[kg place^{-1} a^{-1} CH_4]
Calves	4.3
Heifers	40.8
Bulls	56.4
Suckler cows	76.1
Stud bulls (mature males)	85.3
Total for other cattle	**45.8**
IPCC (1996) default	48
IPCC (2006) default	57

For sheep, goats, large horses, mules and asses and buffalo, the default emission factors pursuant to IPCC (1996b)-4.10, Table 4-3, are used. Calculations for small horses were carried out with an emission factor that was estimated as follows: Pursuant to DLG (2005: p. 54), the average daily metabolisable-energy requirements for a light horse or pony amount to 57.5 MJ d^{-1}, or about 65% of those for a heavy horse (89 MJ d^{-1}). That percentage is also used for the relationship between the relevant emission factors. Table 138 shows the emission factors used for sheep, goats, large horses, small horses and ponies, mules and asses and buffalo.

Table 138: The emission factors (enteric fermentation) used in the inventory for sheep, goats, large horses, small horses and ponies, mules and asses and buffalo

Animal category	***EF*** **[kg place^{-1} a^{-1} CH_4]**
Sheep	8
Goats	5
Heavy horses	18
Light horses, ponies	12
Mules and asses	10
Buffalo	55

6.2.3 Uncertainties and time-series consistency (4.A)

With regard to the uncertainties in the area of methane emissions from enteric fermentation, the reader's attention is called to Table 133 in Chapter 6.1.4 (total uncertainty of the German GG inventory).

All emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and all data gaps have been filled in.

6.2.4 Source-specific quality assurance / control and verification (4.A)

Chapter 6.1.5 provides an overview of measures implemented relative to source-specific QA/QC and verification.

In the framework of verification, the present chapter presents, with reference to 2009, a comparison between a) data from German dairy-cattle husbandry, b) IPCC default values and c) data from neighbouring countries, including the UK (from 2009; UNFCCC Submission 2011, Chapter 6.2.4, Table 130). Germany has the fourth-highest IEF_{CH4} among the ten countries being compared. As was expected, the comparison shows a linear correlation between IEF_{CH4} and GE intake, and a good linear correlation between IEF_{CH4} and milk yield (r^2=0.78), although the German IEF_{CH4} is disproportionately high with respect to milk yield –

for example, it is considerably higher than that of the UK and that of the Czech Republic, even though those countries have comparable milk-yield levels. The IEF_{CH4} shows no clear correlation with animal weight.

Some 60 % of gross energy intake of German dairy cattle is used to energy requirements for milk production. The remaining 40 % are used to meet basic energy requirements (the large size of the figure is tied especially to the large animal weights involved) and energy requirements for production of young. In this regard, the results for Germany can be compared only with those for Belgium, since no data on milk yield and animal weight are available for the Netherlands and Switzerland. The discrepancy between the German IEF and the IPCC default values can be explained as the result of higher energy intake that is related, in turn, to higher weight and higher milk yields.

Table 139: Methane emissions from enteric fermentation in dairy cows, in various countries – a comparison of Implied Emission Factors (*IEF*) for 2009

	IEF $_{CH_4}$ [kg place^{-1} a^{-1} CH_4]	**GE intake** [MJ place^{-1} d^{-1}]	**Milk yield** kg place^{-1} d^{-1}	**Animal weight** [kg animal^{-1}]
Austria	115.67	293.9	16.62	700
Belgium	123.76	314.5	18.79	600
Czech Republic	117.48	294.6	19.13	585
Denmark	133.70	343.2	23.53	575
France	116.98	k. A.	17.13	k. A.
Germany	**123.71**	**314.4**	**19.11**	**642**
Netherlands	127.00	k. A.	k. A.	k. A.
Poland	97.03	246.6	12.58	500
Switzerland	121.46	308.6	22.1	650
UK	109.43	278.1	19.49	k. A.
IPCC(1996)-3-4.11, 4.31, 4.39 (Western Europe)	100	254.7	11.5	550
IPCC (2000)-4.13-4.20		Equation 4.1-4.11		
IPCC(2006)-10.15-10.21, 10.29, 10.72	109	Equation 10.3-10.16	16.44[1)]	600

[1)] calculated on the basis of 6,000 kg place^{-1} a^{-1}

Source: Germany: Submission 2012; other countries: UNFCCC 2011; k. A: no data (keine Angabe)

The German IEF_{CH4} for other cattle lie within the middle of the range for central European values, although the value for GE intake lies at the lower end of the values listed. The GE-intake figures provided in Table 140 for the "other cattle" group show wide scattering. In their arithmetic mean, 133.7 MJ place^{-1} d^{-1}, they correspond well with the default value of IPCC (1996b), however, while the default value of IPCC (2006) proves to be too high in the context of this comparison. For other cattle, as was the case for dairy cattle, the German IEF and the German gross energy intake are fairly comparable to the corresponding data from Belgium, even if the GE-intake figure for other cattle in Belgium is somewhat higher than the corresponding German figure. Switzerland also has a relatively low GE-intake figure. All in all, the German IEF for other cattle is a solid 5 % below the arithmetic mean of the IEF values given in Table 140. That value, at 48.3 kg place^{-1} a^{-1} CH_4, is quite close to the default value of IPCC (1996b).

In the swine category (Table 140), some countries calculate with the default IEF of IPCC (1996b) (1.50 kg place^{-1} a^{-1} CH_4), which is noticeably higher than the values given by those countries that explicitly calculate the IEF. Presumably, the default IEF of IPCC (1996b & 2006) cannot figure in any adequate description of the central European situation for swine. The IEF minimum is reported by Denmark. Since that country's GE value is very high at the same time, it may be assumed that Denmark uses a comparatively low methane-conversion factor for enteric fermentation in swine. Switzerland, on the other hand, calculates with the same conversion factor that Germany use, and thus the German and Swiss results can be directly inter-converted. No other comparisons are possible, due to the data gaps in Table 140.

Table 140: Methane emissions from enteric fermentation in other cattle and swine, in various countries – a comparison of Implied Emission Factors (*IEF*) for 2009

	Other cattle		**Swine**	
	IEF $_{CH_4}$ **[kg place^{-1} a^{-1} CH_4]**	**GE intake [MJ place^{-1} d^{-1}]**	***IEF*** $_{CH_4}$ **[kg place^{-1} a^{-1} CH_4]**	**GE intake [MJ place^{-1} d^{-1}]**
Austria	56.18	142.76	1.50	38.00
Belgium	45.28	112.17	1.50	k. A.
Czech Republic	51.55	130.99	1.50	k. A.
Denmark	43.11	130.34	1.01	40.41
France	52.75	k. A.	k. A.	k. A.
Germany	**45.72**	**109.05**	**1.18**	**30.07**
Netherlands	35.72[1)]	k. A.	1.50	k. A.
Poland	48.90	124.27	1.50	k. A.
Switzerland	39.16[1)]	102.86[1)]	1.36	34.64
UK	43.08	189.00	1.50	k. A.
IPCC (1996)-3-4.10, 4.11, 4.39, 4.42 developed countries, Western Europe	48.00	135.10	1.50	38.00
IPCC (2000)-4.13-4.20		Equation 4.1-4.11		
IPCC (2006)-10.15-10.21, 10.28, 10.29, Western Europe	57.00	Equation 10.3-10.16	1.50	Equation 10.3-10.16

1) calculated from reported original data

Source: Germany: Submission 2012; other countries: UNFCCC 2011; k. A: no data (keine Angabe)

6.2.5 *Source-specific recalculations (4.A)*

In comparison to the Resubmission 2010, the following changes have resulted (cf. Table 141 and Table 142):

- As a result of the changes in the animal models and in the feeding data (cf. Chapter 6.1.3.3), changes have occurred in gross energy intake for dairy cattle and – with the exception of calves – for all other cattle. Those changes have brought about a noticeable reduction in the emission factor for dairy cattle. The changes are offset somewhat in the group of other cattle: A slight reduction in the mean emission factor has result for other cattle. As a result of these changes, the national total emissions of CH_4 from enteric fermentation, for both dairy cattle and the group of other cattle, are slightly lower than the corresponding values in the Submission 2011.

- For sows, an increase in animal weight, along with a longer lactation phase (cf. Chapter 6.1.3.3) have led to an increase in the emission factor. Since the emission factor describes the annual total emissions per animal place, the reduction in the throughput figure (cf. Chapter 6.1.3.3) for fattening pigs leads to a lower emission factor. The mean emission factor for all swine has increased slightly for all years covered by the report. In calculation of national total emissions of CH_4 from enteric fermentation in swine, in some years of the period covered by the report the increase in the emission factor is more than offset by a reduction in the total number of swine, with respect to the NIR 2011 (cf. Chapter 6.1.3.2.1). Therefore, although the emission factor has increased in some years (as in 2009, for example), a reduction is seen in national total emissions of CH_4 from enteric fermentation in swine.
- No changes in emission factors are seen for the group of other animals that contribute to national total emissions of CH_4 from enteric fermentation (sheep, goats, horses, mules and asses, buffalo). On the other hand, updating of horse counts (cf. Chapter 6.1.3.2.1) leads to changes in total emissions from that group.
- As a result of the above-described changes, enteric-fermentation-related total methane emissions from the German agricultural sector have decreased by about 2.5 % with respect to the NIR 2011.

Table 141: Comparison of resulting CH_4 emission factors as reported in 2012 and in 2011 (4.A)

[kg place^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2012	101.2	103.6	106.7	108.6	108.5	109.7	111.1	111.8	113.6	114.8
Dairy cattle, 2011	105.9	108.5	111.6	113.7	113.6	114.8	116.4	117.1	118.9	120.3
Other cattle, 2012	42.9	43.8	45.0	45.3	44.8	45.1	45.4	45.3	45.5	45.8
Other cattle, 2011	42.9	43.7	45.0	45.4	44.8	45.2	45.4	45.3	45.6	45.9
Swine, 2012	1.08	1.10	1.11	1.12	1.13	1.14	1.15	1.15	1.16	1.15
Swine, 2011	1.06	1.09	1.09	1.10	1.10	1.11	1.12	1.13	1.14	1.13
[kg place^{-1} a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2012	116.4	118.5	119.1	120.4	120.8	122.2	122.8	124.0	122.5	123.7
Dairy cattle, 2011	121.9	124.1	124.7	126.1	126.5	128.0	128.6	129.8	128.3	128.2
Other cattle, 2012	46.0	46.1	45.7	45.6	45.5	45.5	45.7	46.0	45.6	45.7
Other cattle, 2011	46.1	46.2	45.8	45.8	45.7	45.7	45.9	46.2	45.8	46.0
Swine, 2012	1.16	1.17	1.18	1.17	1.18	1.17	1.18	1.19	1.18	1.19
Swine, 2011	1.14	1.14	1.14	1.14	1.15	1.15	1.15	1.15	1.16	1.17

Table 142: Comparison of CH_4 emissions (enteric fermentation) as reported in 2012 and in 2011 (4.A)

[Tg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	1.270	1.147	1.118	1.115	1.108	1.113	1.115	1.082	1.067	1.067
Total, 2011	1.300	1.173	1.145	1.141	1.136	1.140	1.143	1.110	1.096	1.094
Dairy cattle, 2012	0.643	0.584	0.572	0.576	0.572	0.574	0.577	0.562	0.549	0.547
Dairy cattle, 2011	0.673	0.611	0.599	0.603	0.599	0.600	0.604	0.589	0.575	0.573
Other cattle, 2012	0.564	0.504	0.487	0.480	0.479	0.481	0.479	0.462	0.460	0.464
Other cattle, 2011	0.563	0.503	0.488	0.481	0.479	0.482	0.480	0.463	0.461	0.465
Swine, 2012	0.0286	0.0245	0.0252	0.0249	0.0239	0.0232	0.0239	0.0244	0.0262	0.0255
Swine, 2011	0.0287	0.0246	0.0252	0.0248	0.0238	0.0231	0.0236	0.0244	0.0260	0.0256
Other animals, 2012	0.0347	0.0349	0.0333	0.0338	0.0335	0.0348	0.0350	0.0336	0.0326	0.0306
Other animals, 2011	0.0347	0.0346	0.0333	0.0333	0.0335	0.0344	0.0350	0.0345	0.0344	0.0305
[Tg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	1.046	1.059	1.021	1.007	0.980	0.975	0.954	0.958	0.972	0.975
Total, 2011	1.072	1.086	1.047	1.033	1.006	1.001	0.979	0.984	0.999	0.998
Dairy cattle, 2012	0.532	0.539	0.527	0.526	0.518	0.518	0.501	0.505	0.517	0.520
Dairy cattle, 2011	0.557	0.564	0.552	0.551	0.542	0.542	0.525	0.528	0.541	0.539
Other cattle, 2012	0.458	0.463	0.437	0.423	0.405	0.400	0.396	0.396	0.399	0.400
Other cattle, 2011	0.459	0.464	0.438	0.425	0.407	0.402	0.398	0.398	0.401	0.402
Swine, 2012	0.0252	0.0255	0.0260	0.0261	0.0257	0.0267	0.0265	0.0272	0.0269	0.0273
Swine, 2011	0.0252	0.0253	0.0257	0.0261	0.0254	0.0266	0.0263	0.0270	0.0268	0.0275
Other animals, 2012	0.0310	0.0315	0.0313	0.0313	0.0312	0.0305	0.0302	0.0304	0.0292	0.0282
Other animals, 2011	0.0307	0.0315	0.0311	0.0313	0.0314	0.0305	0.0299	0.0304	0.0296	0.0291

6.2.6 Planned improvements (4.A)

At the recommendation of the ERT of the in-country review of September 2010, an effort is being made to derive a national methane-conversion factor for dairy cattle.

Efforts to improve modelling of feeding of swine continue. To date, the required highly detailed data have been obtained, nationwide, via surveys of experts, and they have been evaluated (Dämmgen et al., 2011b). The next planned next work step is to process the data for GAS-EM inventory model. Possibly, findings from official survey of protein inputs in swine fattening during the period November 2010 to October 2011, which took place in fall 2011, can enter into the model. Improved modelling of feeding of swine will affect data on gross energy intake, which serve as a basis for calculating CH_4 emissions from enteric fermentation.

In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.

6.3 Manure management (4.B)

6.3.1 *Source category description (4.B)*

CRF 4.B	Natural gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Dairy cattle (CRF 4.A.1)	**CH_4**	**-**	**-/T2**	**2,320.1**	**(0.19%)**	**2,321.7**	**(0.24%)**	**0.07%**
Non-dairy cattle (CRF 4.A.1)	CH_4	-	-	1,767.6	(0.14%)	1,186.1	(0.12%)	-32.90%
Dairy cattle (CRF 4.B.1)	N_2O	-	-	1,048.8	(0.09%)	835.0	(0.09%)	-20.39%
Non-dairy cattle (CRF 4.B.1)	**N_2O**	**-**	**-/T2**	**1,020.6**	**(0.08%)**	**839.6**	**(0.09%)**	**-17.74%**
Other animals (buffalo, sheep, goats, horses, poultry, mules & asses) (CRF 4.B.2-7;9)	CH_4	-	-	119.1	(0.01%)	132.0	(0.01%)	10.85%
Other animals (buffalo, sheep, goats, horses, mules & asses) (CRF 4.B.2-7)	N_2O	-	-	96.4	(0.01%)	83.7	(0.01%)	-13.14%
Swine (CRF 4.B.8)	**CH_4**	**-**	**-/T2**	**2,118.0**	**(0.17%)**	**1,933.1**	**(0.20%)**	**-8.73%**
Swine (CRF 4.B.8)	N_2O	-	-	367.0	(0.03%)	463.9	(0.05%)	26.43%
Poultry (CRF 4.B.9)	N_2O	-	-	37.6	(0.00%)	46.0	(0.00%)	22.34%

Gas	Method used	Source for the activity data	Emission factors used
CH_4	D/Tier 1/Tier 2	M/Q/AS/RS/NS	CS/D
N_2O	CS/Tier 1	M/Q/AS/RS/NS	CS
NO_X			CS

The source category *Manure management* is a key category, pursuant to Tier 2 analysis, for CH_4 and N_2O emissions from dairy cattle and for CH_4 emissions (only) from swine.

In sector 4.B, Germany reports on CH_4, N_2O and NO from manure management.

The greenhouse-gas emissions involved in the area of manure management include CH_4 and N_2O from storage of farm manure in stalls and in storage facilities. CH_4 occurs when methanogenic bacteria break down organic substances in anaerobic environments. N_2O occurs in nitrification and denitrification processes during manure storage.

NO from manure management occurs via nitrification in surface layers of manure storage facilities and in manure that is ventilated (to prevent smells or to promote composting).

Calculations of CH_4, N_2O and NO emissions from manure management must take account of a range of factors, including animal category; animal excretions (which, in turn, are a function of animal yield and of diet); the amounts of time spent by relevant animals in various defined areas (pastures, stalls); the types of stalls used; nitrogen inputs from straw used for bedding; and the type of manure storage involved.

In keeping with the IPCC Guidelines, VS contributions from bedding material are not taken into account. This does not result in underestimation of emissions, since the more VS are brought into a solid-manure system, via straw bedding, the drier the system will be and thus the lower its CH_4 emissions will be.

The fact that part of the liquid manure is processed in biogas systems, and that such processing reduces CH_4 emissions from liquid-manure storage, is not taken into account, due to a lack of representative activity data. KTBL is currently processing such data; cf. Chapter 6.3.2.6.

In 2010, a total of 21.6 % (1990: 19.2 %) of total CH_4 emissions from German agriculture were CH_{4}- emissions from manure management. From 1990 to 2010, such manure-management emissions decreased by about 11.9 %. That reduction is due largely to a decrease in animal populations in the period 1990 to 1992, as a result of German reunification, and it is intensified via a slight increase in use of low-emissions storage systems. The relevant systems are shown in Table 152. Part of that reduction is offset, however, by an increase in VS excretions resulting from increases in per-animal yields.

In 2010, manure management accounted for a 5.4 % share of total N_2O emissions from German agriculture. The corresponding share for 1990 was 5.1 %. From 1990 to 2010, N_2O emissions from manure management decreased by 11.8 %. As with the decrease in CH_4 emissions, that effect was due largely to a reduction in animal populations. It was partly offset by an increase in use of storage systems with higher emissions. Another offsetting effect consists of increases in per-animal yields (in this context, because of the increases in N excretions per animal that such increases entail).

6.3.2 Methane emissions from manure management (4.B, methane)

6.3.2.1 Source category description (4.B, Methane)

Cf. Chapter 6.3.1.

6.3.2.2 Methodological issues (4.B, Methane)

6.3.2.2.1 Methodological issues (4.B, Methane)

The Tier-1 method uses an IPCC default value for the CH_4 emission factor for manure management. The Tier-1 method is used only for geese (poultry emission factor pursuant to IPCC (1996b), Table B-7: 0.78 kg place^{-1} a^{-1} CH_4).

Equation 5: Calculation of total CH_4 emissions from manure management

$$E_{\mathrm{CH4,MM}} = \alpha \cdot \rho_{\mathrm{CH4}} \cdot \sum_{\mathrm{i,\,j,\,k}} n_{\mathrm{i}} \cdot VS_{\mathrm{i}} \cdot B_{\mathrm{o,i}} \cdot MS_{\mathrm{i,\,j}} \cdot MCF_{\mathrm{i,\,j,\,k}}$$

$E_{\mathrm{CH4,\,MM}}$	Total methane emissions from manure management (in kg a^{-1} CH_4)
α	Factor for conversion of time units (α = 365 d a^{-1})
ρ_{CH4}	Density of methane (ρ_{CH4} = 0.67 kg m^{-3})
n_i	Number of animal places in animal category i (in animal places)
VS_i	VS excretions for animal category i (in kg animal place^{-1} d^{-1})
$B_{o,\,i}$	Maximum methane-production capacity for animal category i (in m^3 kg^{-1} CH_4)
$MS_{i,\,j}$	Relative proportion of housing places, for animal category i, whose excrement occurs in manure management system j (in animal place animal place^{-1})
$MCF_{i,\,j,\,k}$	Methane-conversion factor for manure management system j and climate region k (in kg kg^{-1})

With regarding to the animal-place numbers n_i cf. Chapter 6.3.2.2.3.

As of the Submission 2012, VS excretions are being calculated not with the IPCC method but with the national procedure of DÄMMGEN et al. (2011a):

Equation 6: Calculation of VS excretions

$$VS_{i} = m_{feed, DM, i} \cdot (1 - X_{DOM, i}) \cdot (1 - x_{ash, feed})$$

VS_i	VS excretions for animal category i (in kg animal place^{-1} d^{-1})
$m_{feed, DM, i}$	Dry-matter intake, animal category i (in kg animal place^{-1} d^{-1})
$X_{DOM, i}$	Digestibility of organic matter, animal category i (in kg kg^{-1})
$X_{ash, i}$	Ash content of feed, animal category i (in kg kg^{-1})

With regard to the input data (dry-matter intake, digestibility of organic matter, ash content of feed), cf. Chapter 6.1.3.2.2. National input data for the VS calculation are used for dairy cattle, other cattle, swine and poultry (except for ducks and geese). The resulting VS excretions are listed in Chapter 6.3.2.2.3. For sheep, goats, horses, mules and asses, buffalo and ducks, IPCC default values for VS are used.

At present, Germany does not have national data relative to maximum methane-formation rates B_o, for calculation of CH_4 emissions from manure storage (cf. in this regard Chapter 6.3.2.6). For this reason, IPCC default values are used in this area (IPCC, 2006: 10.77 ff); cf. Table 143. Those values are either in keeping with those from IPCC (1996b), p. 4.43 ff, Table B-3 through B-7, or, with the exception of those for horses, are higher. IPCC (1996b) puts the emissions for horses at 0.33 m^3 kg^{-1} CH_4.

Table 143: Maximum methane-formation capacity B_o, pursuant to IPCC (2006)-10.77ff (4.B(a)s1)

[m^3 kg^{-1}]	B_o
Dairy cattle	0.24
Other cattle	0.18
Swine	0.45
Sheep	0.19
Goats	0.18
Horses	0.30
Mules and asses	0.33
Buffalo	0.10

For pullets, the maximum B_o value that IPCC (2006), Table 10A-9, provides for poultry is used, as a conservative approach : 0.39 m^3 kg^{-1} CH_4 (laying hens). That value is higher than the value given in IPCC (1996b), Table B-7, for poultry overall (0.32 m^3 kg^{-1} CH_4).

Table 144 shows the time series for the German B_o mean value for poultry; for geese the maximum B_o value that IPCC (2006), Table 10A-9, provides for poultry was also used: 0.39 m^3 kg^{-1} CH_4 (laying hens). The B_o mean value for poultry is consistently higher than the value given by IPCC (1996b), Table B-7, for poultry overall, 0.32 m^3 kg^{-1} CH_4.

Table 144: Maximum methane-formation capacity B_o for poultry (4.B(a)s1)

[m^3 kg^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Poultry	0.374	0.374	0.373	0.373	0.373	0.372	0.372	0.372	0.371	0.371
[m^3 kg^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Poultry	0.371	0.371	0.371	0.370	0.370	0.370	0.370	0.370	0.369	0.369
[m^3 kg^{-1}]	**2010**									
Poultry	0.368									

Spatially and chronologically differentiated data are available relative to description of the frequency of storage systems for solid and liquid manure and to duration of pasturing (cf. 6.1.3.2.4).

At present, Germany does not have national methane-conversion factors *MCF* (cf. in this regard Chapter 6.3.2.6). The pertinent IPCC default values are used. In the process, the data in IPCC (2006)-10.44ff are used instead of the data in IPCC (1996b) -3-4.25, since the first data set differentiates more effectively between the different systems involved. Efforts are currently underway to obtain national MCF and B_o values; cf. Chapter 6.3.2.6.

The *MCF* of 0.39 kg kg^{-1} given in IPCC (2000)-4.36f for liquid-manure storage and storage under slatted floors is not used, since it was derived for a temperature of 15°C (ZEEMAN, 1994), which is not in keeping with the annual mean temperatures for Germany.

Table 145 shows the storage-system and pasturing categories commonly used in Germany, along with the *MCF* values used in the inventory. The values for 11°C are used in only about 1 % of all German districts. For "liquid manure with fixed cover" (including tent structures) and "liquid manure with artificial floating cover", the MCF applying to liquid manure with no floating cover was used, since the IPCC does not provide any pertinent default values. In general, the MCF values used by Germany are higher than the values given by the IPCC (1996b) for cool climates (0.1 kg kg^{-1} for all systems except for deep straw bedding, solid-manure storage systems and pasture; solid-manure storage systems and pasture: 0.01 kg kg^{-1}; no figures for deep straw bedding).

Table 145: Methane-conversion factors *MCF* used in the German inventory, in [kg kg^{-1}] (4.B(a)s1)

		≤10°C	11°C
Liquid manure	Outdoor storage with no cover, no floating cover	0.17	0.19
	Fixed cover	0.17	0.19
	Natural floating cover	0.10	0.11
	Artifical floating cover (chopped straw)	0.17	0.19
	Floating cover foil	0.17	0.19
	Storage under slatted floors > 1 month	0.17	0.19
Slurry		0.17	0.19
Solid manure	Deep straw bedding	0.17	0.19
	Solid-manure storage systems	0.02	0.02
Pasture		0.01	0.01

With regard to the mean *MCF* values, for important animal categories, as determined in the framework of emissions calculations with the GAS-EM inventory model, cf. Chapter 6.3.2.2.3.

6.3.2.2.2 Methodological changes (4.B, Methane)

The methods used for VS calculation were changed from Submission 2011 to Submission 2012. For Submission 2012, such calculation is no longer carried out pursuant to IPCC, on the basis of GE intake, but in accordance with the national method of Dämmgen et al. (2011a), as a function of dry-matter intake, digestibility of organic matter and ash content of feed (cf. Chapter 6.1.3.2.1).

6.3.2.2.3 Activity data and additional information (4.B, methane)

With regard to animal head counts, the reader's attention is called to Chapter 6.1.3.2.

The VS excretions, calculated with national input data, for dairy cattle, other cattle, swine and poultry (not including geese), are shown in Table 146.

The VS values shown in Table 146, which were calculated with national data, are lower than the default values of the IPCC (1996b) for dairy cattle (5.1 kg d^{-1} VS), other cattle (2.7 kg d^{-1} VS), swine (0.5 kg d^{-1} VS) and poultry (0.1 kg d^{-1} VS). With the exception of those for poultry, the IPCC default values (2006) are similar in level to the corresponding values in IPCC (1996). For poultry, IPCC (2006) lists values ranging from 0.01 kg d^{-1} VS for broilers and 0.07 kg d^{-1} VS for turkeys.

Table 146: Daily VS excretions, for dairy cows, other cattle, swine and poultry (not including geese) (4.B(a)s1)

[kg place^{-1} d^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	3.45	3.49	3.58	3.63	3.63	3.65	3.69	3.70	3.75	3.77
Other cattle	1.38	1.40	1.45	1.46	1.44	1.45	1.46	1.46	1.46	1.48
Swine	0.24	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.26
Poultry, not including geese	0.022	0.022	0.022	0.022	0.021	0.021	0.021	0.021	0.021	0.021
[kg place^{-1} d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	3.81	3.86	3.87	3.90	3.90	3.93	3.94	3.97	3.94	3.96
Other cattle	1.48	1.49	1.47	1.47	1.46	1.46	1.47	1.47	1.46	1.46
Swine	0.26	0.26	0.27	0.26	0.27	0.26	0.27	0.27	0.27	0.27
Poultry, not including geese	0.022	0.023	0.022	0.024	0.025	0.025	0.025	0.026	0.026	0.026
[kg place^{-1} d^{-1}]	**2010**									
Dairy cattle	3.97									
Other cattle	1.47									
Swine	0.27									
Poultry, not including geese	0.026									

For all other animals, the VS default values pursuant to IPCC (2006), Tables 10A-6 and 10A-9, were used; cf. Table 147. Those values are either in keeping with those from IPCC (1996b), p. 4.47, Table B-7, or are higher (for goats and horses). The VS excretions of light horses and ponies were derived from those of heavy horses, on the basis of the ratio of pertinent energy requirements (cf. Chapter 6.3.2.1):

Table 147: Daily VS excretions per animal place, for sheep, goats, horses, mules and asses, buffalo and poultry (not including geese) (4.B(a)s1)

[kg place^{-1} d^{-1}]	*VS*
Sheep	0.40
Goats	0.30
Heavy horses	2.13
Light horses and ponies	1.38
Mules and asses	0.94
Buffalo	3.90
Poultry (not including geese)	0.026

The following tables show the applicable distributions for the various manure management systems.

Table 148: Relative shares of liquid-manure-based systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	55.0	55.3	55.4	55.2	70.8	70.8	70.9	70.9	72.3	72.4
Other cattle	60.3	60.3	59.2	58.3	57.5	56.5	55.9	55.3	55.2	54.6
Swine	80.0	79.2	79.4	80.1	86.5	86.6	86.9	86.8	88.4	88.5
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo	0.0	0.0	0.0	0.0	0.0	0.0	42.0	42.0	42.0	42.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	72.5	72.7	72.9	73.0	73.1	73.2	73.3	73.5	73.5	73.5
Other cattle	53.3	52.6	51.6	50.6	49.3	48.3	47.3	46.2	45.0	43.9
Swine	88.8	89.0	89.5	89.8	89.9	90.3	90.6	90.9	91.3	91.7
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	**2010**									
Dairy cattle	73.6									
Other cattle	42.8									
Swine	91.9									
Sheep	NO									
Goats	NO									
Horses	NO									
Mules/asses	NO									
Buffalo	42.0									
Poultry	NO									

Table 149: Relative shares of straw-based systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	26.7	26.2	26.2	26.4	15.5	15.5	15.4	15.4	14.4	14.3
Other cattle	25.1	24.7	25.1	25.6	26.1	26.5	26.7	27.0	26.8	27.2
Swine	20.0	20.8	20.6	19.9	13.5	13.4	13.1	13.2	11.6	11.5
Sheep	49.7	49.5	49.3	49.5	49.6	49.7	49.5	49.9	49.8	49.7
Goats	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Horses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Mules/asses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Buffalo	0.0	0.0	0.0	0.0	0.0	0.0	42.0	42.0	42.0	42.0
Poultry	100	100	100	100	100	100	100	100	100	100
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	14.6	14.7	14.9	15.0	15.2	15.4	15.6	15.7	15.8	15.9
Other cattle	28.3	29.1	30.1	31.1	32.1	33.1	34.0	35.0	36.2	37.2
Swine	11.2	11.0	10.5	10.2	10.1	9.7	9.4	9.1	8.7	8.3
Sheep	49.9	49.7	49.9	49.6	49.7	49.6	49.8	49.7	49.9	49.9
Goats	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8
Horses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Mules/asses	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5	79.5
Buffalo	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Poultry	100	100	100	100	100	100	100	100	100	100
[%]	**2010**									
Dairy cattle	16.0									
Other cattle	38.1									
Swine	8.1									
Sheep	48.9									
Goats	65.8									
Horses	79.5									
Mules/asses	79.5									
Buffalo	42.0									
Poultry	100									

Table 150: Pasturing: relative shares of housing systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	18.4	18.5	18.4	18.5	13.8	13.8	13.8	13.8	13.5	13.5
Other cattle	14.6	15.0	15.7	16.1	16.4	17.0	17.4	17.7	18.1	18.2
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	50.3	50.5	50.7	50.5	50.4	50.3	50.5	50.1	50.2	50.3
Goats	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Horses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Mules/asses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Buffalo	0.0	0.0	0.0	0.0	0.0	0.0	16.0	16.0	16.0	16.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	13.0	12.7	12.3	12.1	11.8	11.5	11.2	10.9	10.7	10.6
Other cattle	18.4	18.3	18.3	18.3	18.6	18.6	18.6	18.8	18.9	18.9
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	50.1	50.3	50.1	50.4	50.3	50.4	50.2	50.3	50.1	50.1
Goats	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Horses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Mules/asses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Buffalo	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	2010									
Dairy cattle	10.4									
Other cattle	19.0									
Swine	NO									
Sheep	51.1									
Goats	34.2									
Horses	20.5									
Mules/asses	20.5									
Buffalo	16.0									
Poultry	NO									

Table 152 lists the methane-conversion factors *MCF* resulting, on an average for all liquid-manure-based systems, for dairy cattle, other cattle and swine.

Table 151: Methane-conversion factors (MCF) for liquid-manure-based systems for dairy cows, other cattle and swine (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	14.0	13.9	13.9	13.9	13.5	13.4	13.4	13.4	13.4	13.4
Other cattle	13.2	13.2	13.1	13.1	12.6	12.7	12.7	12.7	12.8	12.7
Swine	17.0	17.0	17.0	17.0	16.3	16.3	16.3	16.3	16.3	16.3
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	13.7	13.7	13.8	13.9	14.0	14.1	14.2	14.3	14.3	14.4
Other cattle	13.0	13.2	13.3	13.3	13.4	13.4	13.5	13.6	13.6	13.7
Swine	16.1	15.9	15.8	15.7	15.6	15.4	15.3	15.2	15.1	14.9
[%]	2010									
Dairy cattle	14.5									
Other cattle	13.8									
Swine	14.8									

In keeping with IPCC (2006)-10.44, the default MCF of 2 % is used for calculations for mammals in systems with solid floors and straw bedding, throughout the entire report period. That value is higher than the default value of 1 % given by IPCC (1996b), Table B-3 through Table B-7. For deep-straw-bedding systems, a temperature-dependent default MCF of 17 to 19 % is used. Table 152 lists the methane-conversion factors *MCF* resulting, on an average for all straw-based systems, for dairy cattle, other cattle and swine. The noticeable increase for other cattle occurring from 2002 to 2003 is a result of a transition in housing of calves; for such housing, it is assumed that until 2002 50 % of all calves were housed in tie-stall systems with solid floors and straw bedding and 50 % were housed with deep straw bedding, and that as of 2003, as a result of a ban on tie-stall systems, 100 % were housed with deep straw bedding (assessment of KTBL experts).

Table 152: Methane-conversion factors (MCF) for liquid-manure-based systems for dairy cows, other cattle and swine (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	2.0	2.0	2.0	2.0	2.2	2.2	2.2	2.2	2.2	2.2
Other cattle	5.3	5.2	5.5	5.5	6.0	5.9	5.8	5.8	5.9	6.0
Swine	5.9	5.8	5.8	5.8	6.0	6.0	6.0	6.0	6.1	6.1
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.0	2.0
Other cattle	6.4	6.6	6.8	7.5	7.5	7.5	7.5	7.6	7.7	7.7
Swine	6.0	6.0	5.9	5.9	5.8	5.8	5.7	5.7	5.6	5.5
[%]	**2010**									
Dairy cattle	2.0									
Other cattle	7.7									
Swine	5.4									

For pasturing, and for all years concerned, the default MCF of 1 %, as proposed by both IPCC (1996b) and IPCC (2006), is used.

For all poultry categories, a MCF of 1.5 %, in keeping with IPCC (2006)-10.82, is used. (IPCC 2006, Table 10A-9, does give a MCF value of 1 % for ducks. That value does not seem justified, however, since it is nearly impossible to keep a duck stall dry enough for it.) The MCF used in the inventory model is thus higher, for all poultry categories, than the value given by IPCC (1996b), Table B-7, for all poultry as a whole (1 %).

6.3.2.2.4 Calculated CH_4 emissions (4.B, methane)

Table 153 presents the time series for all CH_4 emissions from manure management.

Table 153: Total CH_4 emissions from manure management (4s1)

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	301.18	269.00	267.15	265.07	279.96	277.47	279.85	275.14	281.27	278.92
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
	272.91	276.63	271.91	271.53	265.07	267.75	262.86	266.35	268.38	270.38
[Gg a^{-1}]	**2010**									
	265.38									

Table 153 shows an emissions decrease after 1990 that is limited primarily to the years after German reunification and that points primarily to decreases in herd sizes. As the comparison of Table 153 and Table 154 shows, nearly two-thirds of total emissions occur in keeping of cattle, while keeping of swine contributes about one-third of all emissions. The small remainder is divided up among the other animal categories.

Table 154: CH_4 emissions from manure management for dairy cattle, other cattle and swine (4.s1.)

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	110.5	101.5	98.9	98.6	117.5	117.4	117.8	114.3	113.0	112.4
Other cattle	84.2	75.7	73.9	72.5	70.1	69.9	69.1	66.4	66.0	66.9
Swine	100.9	86.2	89.0	88.5	86.7	84.4	87.1	88.8	96.7	94.1
[Gg a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	108.8	110.6	108.7	108.8	107.4	107.5	104.6	105.7	109.4	110.2
Other cattle	66.1	66.9	62.9	62.1	59.1	58.3	57.5	57.3	57.6	57.5
Swine	92.2	93.2	94.4	94.5	92.4	95.7	94.4	96.7	94.9	96.2
[Gg a^{-1}]	2010									
Dairy cattle	110.6									
Other cattle	56.5									
Swine	92.1									

6.3.2.2.5 *CH_4 emission factors (4.B, methane)*

Table 155 shows the chronological development of mean emission factors for CH_4 emissions from manure management for dairy cattle, other cattle and swine.

Table 155: CH_4 emission factors (IEF) for manure management (4.B(a)s1)

[kg pl^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	17.4	18.0	18.4	18.6	22.3	22.4	22.7	22.7	23.4	23.6
Other cattle	6.4	6.6	6.8	6.8	6.6	6.6	6.5	6.5	6.5	6.6
Swine	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.2	4.3	4.3
[kg pl^{-1} a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	23.8	24.3	24.6	24.9	25.1	25.4	25.6	26.0	25.9	26.2
Other cattle	6.6	6.7	6.6	6.7	6.6	6.6	6.6	6.7	6.6	6.6
Swine	4.2	4.3	4.3	4.2	4.2	4.2	4.2	4.2	4.2	4.2
[kg pl^{-1} a^{-1}]	2010									
Dairy cattle	26.4									
Other cattle	6.5									
Swine	4.1									

6.3.2.3 Uncertainties and time-series consistency (4.B, methane)

With regard to the uncertainties in the area of methane emissions from manure management, the reader's attention is called to Table 133 in Chapter 6.1.4 (total uncertainty of the German GG inventory).

All emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and all data gaps have been filled in.

6.3.2.4 Source-specific quality assurance / control and verification (4.B, methane)

Chapter 6.1.5 provides an overview of measures implemented relative to source-specific QA/QC and verification.

In the framework of verification, the results obtained for 2009 were compared with the 2009 values of neighbouring countries and of the UK (Submission 2011 for 2009, UNFCCC 2011). Germany's CH_4 IEF from manure management for dairy cattle is similar in level to the corresponding figures for the UK and Switzerland, and thus lies in the upper part of the range for all CH_4 IEF, even though its VS excretions figure is at lower end of the relevant scale (where it is comparable to that of Belgium). Considerably higher CH_4 IEFs are seen in Denmark and the Netherlands, while the other countries concerned have values that are lower – in some cases, considerably lower – than the level for Germany, the UK and Switzerland. In actual fact, even the similar CH_4 IEF values of the UK, Switzerland and Germany are only conditionally comparable, since they have been obtained from very different data for VS excretions, frequencies of liquid-manure systems and methane-conversion factors MCF. At the same time, it must be remembered that Germany, for the present NIR 2012, has used a new national VS-calculation procedure; cf. Chapter 6.3.2.2.1. The IEF default value given in IPCC (1996b) lies near the lower end of the IEF scale (Table 156), while the default-value range pursuant to IPCC (2006) clearly describes the circumstances prevailing in central Europe more effectively.

For other cattle (cf. Table 157) and swine (s. Table 158), Germany's emission factors lie within the range covered by the values for neighbouring countries. The high French emission factors are the result of simultaneously high VS excretions and *MCF* values; the effects of that combination are not offset by the somewhat lower use of liquid-manure systems seen in France.

In the poultry category (cf. Table 159), the German IEF value is similar in level to the corresponding results for Belgium, Denmark and the Netherlands. The value obtained is considerably lower than the IEF default value in IPCC (1996b); the default value in IPCC (2006) provides a better description of the situation prevailing in central Europe. For nearly all poultry categories, the German VS-excretions figures are calculated on the basis of national input data. The mean VS value derived from those calculated figures, for poultry, is at the lower end of the default-value range in IPCC (2006) and, thus, is considerably lower than the IPCC-1996 default value for VS.

Table 156: CH_4 emissions from storage of farm manure from dairy cattle, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters for 2009

	***IEF*$_{CH4}$** [kg place^{-1} a^{-1} CH_4]	**VS excretions** [kg place^{-1} d^{-1}]	**Frequency of liquid-manure systems** [%]	**Mean *MCF* for liquid-manure systems** [%]
Austria	8.56	4.24	30.38	8.64
Belgium	16.31	3.88	11.86	19.00
Czech Republic	14.00	k. A.	40.00	k. A.
Denmark	33.03	6.20	k. A.	k. A.
France [1)]	18.30	5.10	10.60	45.00
Germany	**26.21**	**3.96**	**73.55**	**14.41**
Netherlands	41.73	k. A.	k. A.	k. A.
Poland	10.53	4.58	7.68	39.00
Switzerland	25.66	6.16	67.80	10.00
UK	26.88	0.01	30.60	39.00
IPCC (1996)-3-4.13, 4.43, Western Europe, cool region	14	5.1	40	10
IPCC(2000)-4.36				39.00
IPCC (2006)-10.38, 10.77, Western Europe, cool region	21 through 23 [2)]	5.1	35.7	17 through 19 [2)]

[1] France: Only temperate zone; frequency of liquid-manure systems calculated from original data

[2] Range for the systems and/or temperatures occurring in Germany

Source: Germany: Submission 2012; other countries: UNFCCC 2011; k. A: no data (keine Angabe)

Table 157: CH_4 emissions from storage of farm manure from other cattle, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters for 2009

	IEF $_{CH4}$ **[kg place^{-1} a^{-1} CH_4]**	**VS excretions [kg place^{-1} d^{-1}]**	**Frequency of liquid-manure systems [%]**	**Mean *MCF* for liquid-manure systems [%]**
Austria	3.98	1.95	21.21	8.32
Belgium	2.60	1.35	4.04	19.00
Czech Republic	6.00	k. A.	50.00	k. A.
Denmark	10.45	2.81	k. A.	k. A.
France 1)	19.87	2.70	36.42	45.00
Germany	**6.58**	**1.46**	**43.91**	**13.69**
Netherlands	7.45 2)	k. A.	k. A.	k. A.
Poland	4.93	2.15	11.89	39.00
Switzerland	5.05 2)	2.02 2)	46.58 2)	10.00 2)
UK	4.15	0.01	6.00	39.00
IPCC (1996)-3-4.39, 4.44, Western Europe, cool region	6	2.7	50	10
IPCC(2000)-4.36				39.00
IPCC (2006)-10.78, Western Europe, cool region	6 through 7 3)	2.6	25.2	17 through 19 3)

1 France: Only temperate zone; frequency of liquid-manure systems calculated from original data
2) Calculated from reported original data
3 Range for the systems and/or temperatures occurring in Germany
Source: Germany: Submission 2012; other countries: UNFCCC 2011; k. A: no data (keine Angabe)

Table 158: CH_4 emissions from storage of farm manure from swine, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters for 2009

	IEF $_{CH4}$ **[kg place^{-1} a^{-1} CH_4]**	**VS excretions [kg place^{-1} d^{-1}]**	**Frequency of liquid-manure systems [%]**	**Mean *MCF* for liquid-manure systems [%]**
Austria	1.15	0.27	79.16	3.39
Belgium	9.68	0.49	6.21	19.00
Czech Republic	3.00	k. A.	76.00	k. A.
Denmark	2.07	0.20	k. A.	k. A.
France 1)	21.01	0.50	83.23	45.00
Germany	**4.18**	**0.27**	**91.91**	**14.81**
Netherlands	4.40	k. A.	k. A.	k. A.
Poland	6.54	0.50	28.63	39.00
Switzerland	5.43	0.50	98.61	10.00
UK	7.06	NE	31.30	k. A.
IPCC (1996)-3-4.13, 4.42, 4.46, Western Europe, cool region	3	0.5	"pit>1month":73%	10
IPCC(2000)-4.36				39.00
IPCC (2006)-10.80, 10.81, Western Europe, cool region	Sows, boars: 9 through 10 2) Other: 6	Sows, boars: 0.46 Other: 0.30	"pit>1month": 70%	17 through 19 2)

1 France: Only temperate zone; frequency of liquid-manure systems calculated from original data
2 Range for the systems and/or temperatures occurring in Germany
Source: Germany: Submission 2012; other countries: UNFCCC 2011; k. A: no data (keine Angabe)

Table 159: CH_4 emissions from storage of farm manure from poultry, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters for 2009

	IEF$_{CH4}$ **[kg place^{-1} a^{-1} CH_4]**	**VS excretions [kg place^{-1}d^{-1}]**	**Mean animal weight [kg animal^{-1}]**
Austria	0.07	0.10	1.10
Belgium	0.04	0.03	1.60
Czech Republic	0.08	k. A.	k. A.
Denmark	0.02	0.00	2.00
France	0.12	0.10	k. A.
Germany	**0.03**	**0.026 1**	**1.90**
Netherlands	0.03	k. A.	k. A.
Poland	0.08	0.10	1.10
Switzerland	0.12	0.10	k. A.
UK	0.08	k. A.	k. A.
IPCC (1996)-3-4.47, cool region, developed countries	0.078	0.10	1.10
IPCC(2000)-4.36			
IPCC (2006)-10.82, We. Eur., cool reg., dev. countries	0.02 to 0.09	0.01 to 0.07	0.9 to 6.8

[1] not including geese

Source: Germany: Submission 2012; other countries: UNFCCC 2011; k. A: no data (keine Angabe)

6.3.2.5 Source-specific recalculations (4.B, methane)

For the relevant animal categories, Table 160 through Table 162 show the time series for the proportions for the three different main categories of animal-housing systems, in comparison to the data reported in the NIR 2011 (where a change with respect to the NIR 2011 has occurred). As called for in reporting in the CRF tables, the percentage figures refer to excreted N quantities. The reasons for the discrepancies between the reported values, with respect to the NIR 2011, are as follows:

- For cattle and swine, evaluation of the 2010 Agricultural Census (Landwirtschaftszählung 2010) yielded distributions, for 2010, for the various animal-housing systems, that differed from the data previously used. Those data had last been updated for the year 1999 (cf. 6.1.3.2.4). For the years 2000 to 2009, linear interpolation between the old data of 1999 and the data for 2010 produces a gradual transition from the old frequency distribution to the new one.
- For swine, the numbers of animal places in the categories weaners and fattening pigs have changed. Because the housing frequencies in liquid-manure-based and straw-based systems differ for those two animal categories, those changes affect the overall result for all swine.
- Since the animal-housing systems in Table 160 bis Table 162 are divided in accordance with excreted N, model-related changes in N excretions have to be taken into account; cf. Chapter 6.1.3.3:
    - For dairy cattle, the method for dividing N excretions between pasture and stall has been improved.
    - In the other cattle and swine categories, the levels of N excretions have changed in some sub-categories (for cattle: heifers and fattening bulls; for swine: sows, weaners and fattening pigs).

- The 2010 Agricultural Census collected a first set of data on pasturing of sheep. It is not possible to produce a time series as of 1990, however. For that reason, the results of the agricultural census are being used for all years as of 1990. Those results replace the assumptions made through the NIR 2011. In the present NIR, changes occur nonetheless from year to year in the relative proportions for straw-based housing and for pasturing. The reason for those changes is that while the data for each Land (state) are constant, the result at the national level is a weighted mean derived from the Länder data, each set of which incorporates animal counts that vary from year to year.

Table 160: Comparison of the relative shares of liquid-manure-based systems, as reported in 2012 and 2011, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2012	55.0	55.3	55.4	55.2	70.8	70.8	70.9	70.9	72.3	72.4
Dairy cattle, 2011	54.8	55.2	55.3	55.1	70.8	70.8	70.9	70.9	72.2	72.3
Other cattle, 2012	60.3	60.3	59.2	58.3	57.5	56.5	55.9	55.3	55.2	54.6
Other cattle, 2011	59.9	60.0	58.5	57.7	56.6	55.7	55.1	54.6	54.3	53.7
Swine, 2012	80.0	79.2	79.4	80.1	86.5	86.6	86.9	86.8	88.4	88.5
Swine, 2011	80.8	80.3	80.5	81.1	87.3	87.4	87.7	87.7	89.2	89.0
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle, 2012	72.5	72.7	72.9	73.0	73.1	73.2	73.3	73.5	73.5	73.5
Dairy cattle, 2011	72.3	72.4	72.3	72.4	72.4	72.4	72.3	72.5	72.7	72.7
Other cattle, 2012	53.3	52.6	51.6	50.6	49.3	48.3	47.3	46.2	45.0	43.9
Other cattle, 2011	53.5	53.7	53.6	53.6	53.3	53.2	53.3	53.3	53.2	53.4
Swine, 2012	88.8	89	89.5	89.8	89.9	90.3	90.6	90.9	91.3	91.7
Swine, 2011	89.2	89.3	89.3	89.4	89.4	89.6	89.5	89.5	89.8	90.0

Table 161: Comparison of the relative shares of straw-based systems, as reported in 2012 and 2011, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2012	26.7	26.2	26.2	26.4	15.5	15.5	15.4	15.4	14.4	14.3
Dairy cattle, 2011	26.8	26.2	26.2	26.4	15.4	15.3	15.3	15.3	14.3	14.2
Other cattle, 2012	25.1	24.7	25.1	25.6	26.1	26.5	26.7	27.0	26.8	27.2
Other cattle, 2011	26.7	25.9	25.9	26.2	26.6	26.9	27.0	27.1	26.9	27.3
Swine, 2012	20.0	20.8	20.6	19.9	13.5	13.4	13.1	13.2	11.6	11.5
Swine, 2011	19.2	19.7	19.5	18.9	12.7	12.6	12.3	12.3	10.8	11.0
Sheep, 2012	49.7	49.5	49.3	49.5	49.6	49.7	49.5	49.9	49.8	49.7
Sheep, 2011	28.9	30.0	29.5	28.8	28.9	29.1	28.5	28.9	29.0	27.9
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle, 2012	14.6	14.7	14.9	15.0	15.2	15.4	15.6	15.7	15.8	15.9
Dairy cattle, 2011	14.3	14.3	14.4	14.2	14.3	14.3	14.4	14.3	14.0	14.0
Other cattle, 2012	28.3	29.1	30.1	31.1	32.1	33.1	34.0	35.0	36.2	37.2
Other cattle, 2011	27.4	27.3	27.2	27.2	27.3	27.2	27.1	27.1	27.3	27.2
Swine, 2012	11.2	11.0	10.5	10.2	10.1	9.7	9.4	9.1	8.7	8.3
Swine, 2011	10.8	10.7	10.7	10.6	10.6	10.4	10.5	10.5	10.2	10.0
Sheep, 2012	49.9	49.7	49.9	49.6	49.7	49.6	49.8	49.7	49.9	49.9
Sheep, 2011	28.4	28.2	28.5	27.7	28.3	28.3	28.8	28.8	28.9	28.5

Table 162: Comparison of the relative shares of for pasturing, as reported in 2012 and 2011, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2012	18.4	18.5	18.4	18.5	13.8	13.8	13.8	13.8	13.5	13.5
Dairy cattle, 2011	18.4	18.6	18.5	18.5	13.9	13.9	13.8	13.8	13.5	13.5
Other cattle, 2012	14.6	15.0	15.7	16.1	16.4	17.0	17.4	17.7	18.1	18.2
Other cattle, 2011	13.4	14.1	15.6	16.1	16.8	17.4	17.9	18.3	18.8	19.0
Sheep, 2012	50.3	50.5	50.7	50.5	50.4	50.3	50.5	50.1	50.2	50.3
Sheep, 2011	71.1	70.0	70.5	71.2	71.1	70.9	71.5	71.1	71.0	72.1
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle, 2012	13.0	12.7	12.3	12.1	11.8	11.5	11.2	10.9	10.7	10.6
Dairy cattle, 2011	13.4	13.4	13.3	13.3	13.3	13.3	13.3	13.2	13.2	13.3
Other cattle, 2012	18.4	18.3	18.3	18.3	18.6	18.6	18.6	18.8	18.9	18.9
Other cattle, 2011	19.2	19.1	19.2	19.2	19.5	19.6	19.5	19.6	19.5	19.4
Sheep, 2012	50.1	50.3	50.1	50.4	50.3	50.4	50.2	50.3	50.1	50.1
Sheep, 2011	71.6	71.8	71.5	72.3	71.7	71.7	71.2	71.2	71.1	71.5

For dairy cattle, other cattle, swine and poultry, Table 163 presents a comparison of a) the VS-excretion figures calculated for the NIR 2012 and b) the corresponding values reported in the NIR 2011. On the one hand, the differences are due to the differences in the methods used for VS calculation in the two submissions; cf. Chapter 6.3.2.2.1. On the other hand, the results are also influenced by changes in calculations of energy requirements (dairy cattle, heifers, fattening bulls, sows; cf. Chapter 6.1.3.3), in key index values for feed (dairy cattle, heifers, fattening bulls, stud bulls; cf. Chapter 6.1.3.2.2), and, for swine, in the animal counts in sub-categories (weaners, fattening pigs; cf. Chapter 6.1.3.2.1).

Table 163: Comparison of daily VS excretions as reported in 2012 and as reported in 2011 (4.B)

[kg place^{-1} d^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2012	3.45	3.49	3.58	3.63	3.63	3.65	3.69	3.70	3.75	3.77
Dairy cattle, 2011	3.97	4.03	4.14	4.21	4.22	4.26	4.31	4.33	4.38	4.42
Other cattle, 2012	1.38	1.40	1.45	1.46	1.44	1.45	1.46	1.46	1.46	1.48
Other cattle, 2011	1.33	1.36	1.42	1.44	1.42	1.44	1.46	1.46	1.47	1.48
Swine, 2012	0.24	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.26
Swine, 2011	0.26	0.26	0.27	0.27	0.27	0.27	0.27	0.27	0.28	0.27
Poultry, 2012	0.022	0.022	0.022	0.022	0.021	0.021	0.021	0.021	0.021	0.021
Poultry, 2011	0.017	0.017	0.018	0.018	0.018	0.017	0.018	0.018	0.018	0.018
[kg place^{-1} d^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2012	3.81	3.86	3.87	3.90	3.90	3.93	3.94	3.97	3.94	3.96
Dairy cattle, 2011	4.47	4.53	4.55	4.58	4.59	4.63	4.65	4.68	4.64	4.63
Other cattle, 2012	1.48	1.49	1.47	1.47	1.46	1.46	1.47	1.47	1.46	1.46
Other cattle, 2011	1.49	1.49	1.48	1.47	1.47	1.47	1.48	1.48	1.47	1.47
Swine, 2012	0.26	0.26	0.27	0.26	0.27	0.26	0.27	0.27	0.27	0.27
Swine, 2011	0.27	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Poultry, 2012	0.022	0.023	0.022	0.024	0.025	0.025	0.025	0.026	0.026	0.026
Poultry, 2011	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

The changes in the VS excretions also affect the implied emission factors (IEF) and the CH_4 emissions. Additional reasons for the changes in those values include a) for the NIR 2012, an error in the methane-conversion factor was corrected (now, MCF = 0.17 kg kg^{-1} for deep straw bedding, instead of 0.02 kg kg^{-1}) and b) as a result of the 2010 Agricultural Census (Landwirtschaftszählung 2010) (and of the linear interpolation carried out between 1999 and 2010; cf. Chapter 6.1.3.2.4), the frequency distributions for management systems for years as of 2000 have changed.

Table 164 and Table 165 show, for the important categories of dairy cattle, other cattle and swine, comparisons of implied emission factors (IEF) and CH_4 emissions as reported in the NIR 2011 and as reported in the current NIR 2012. Emissions from keeping of dairy cattle and swine are lower than was reported in the NIR 2011, while the emissions caused by other cattle are higher than was reported in the NIR 2011.

Table 164: Comparison of CH_4 emission factors (IEF), as reported in 2012 and as reported in 2011, for manure management (4.B(a)s1)

[kg place^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle, 2012	17.4	18.0	18.4	18.6	22.3	22.4	22.7	22.7	23.4	23.6
Dairy cattle, 2011	20.0	20.8	21.3	21.5	25.8	26.0	26.3	26.4	27.2	27.5
Other cattle, 2012	6.4	6.6	6.8	6.8	6.6	6.6	6.5	6.5	6.5	6.6
Other cattle, 2011	5.8	6.0	6.1	6.1	5.7	5.7	5.8	5.7	5.7	5.7
Swine, 2012	3.8	3.9	3.9	4.0	4.1	4.1	4.2	4.2	4.3	4.3
Swine, 2011	4.0	4.1	4.1	4.1	4.2	4.3	4.3	4.4	4.5	4.4
[kg place^{-1} a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle, 2012	23.8	24.3	24.6	24.9	25.1	25.4	25.6	26.0	25.9	26.2
Dairy cattle, 2011	27.7	28.2	28.3	28.6	28.6	28.9	29.0	29.2	29.1	29.1
Other cattle, 2012	6.6	6.7	6.6	6.7	6.6	6.6	6.6	6.7	6.6	6.6
Other cattle, 2011	5.8	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Swine, 2012	4.2	4.3	4.3	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Swine, 2011	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.6	4.6

Table 165: Comparison of CH_4 emissions, as reported in 2012 and as reported in 2011, for manure management for dairy cattle, other cattle and swine (4.B)

[Gg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**301.2**	**269.0**	**267.2**	**265.1**	**280.0**	**277.5**	**279.8**	**275.1**	**281.3**	**278.9**
Total, 2011	**315.1**	**282.5**	**279.1**	**276.7**	**293.8**	**291.5**	**294.2**	**290.5**	**296.8**	**294.1**
Dairy cattle, 2012	110.5	101.5	98.9	98.6	117.5	117.4	117.8	114.3	113.0	112.4
Dairy cattle, 2011	127.1	116.9	114.1	114.0	136.1	136.1	136.8	132.8	131.5	130.9
Other cattle, 2012	84.2	75.7	73.9	72.5	70.1	69.9	69.1	66.4	66.0	66.9
Other cattle, 2011	75.7	68.7	65.9	64.5	61.3	61.2	60.8	58.4	57.9	58.2
Swine, 2012	100.9	86.2	89.0	88.5	86.7	84.4	87.1	88.8	96.7	94.1
Swine, 2011	107.6	92.1	94.4	93.6	91.4	89.2	91.5	94.2	102.2	100.2
[Gg a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**272.9**	**276.6**	**271.9**	**271.5**	**265.1**	**267.8**	**262.9**	**266.4**	**268.4**	**270.4**
Total, 2011	**288.0**	**291.2**	**286.3**	**286.0**	**279.0**	**282.8**	**276.6**	**280.7**	**284.2**	**287.0**
Dairy cattle, 2012	108.8	110.6	108.7	108.8	107.4	107.5	104.6	105.7	109.4	110.2
Dairy cattle, 2011	126.8	128.3	125.4	125.0	122.7	122.2	118.2	119.1	122.8	122.5
Other cattle, 2012	66.1	66.9	62.9	62.1	59.1	58.3	57.5	57.3	57.6	57.5
Other cattle, 2011	57.4	58.2	54.7	53.1	50.7	50.1	49.6	49.5	49.7	49.8
Swine, 2012	92.2	93.2	94.4	94.5	92.4	95.7	94.4	96.7	94.9	96.2
Swine, 2011	98.9	99.5	101.0	102.5	100.0	105.0	103.4	106.2	105.7	108.6

6.3.2.6 Planned improvements (4.B, methane)

With regard to the improvement in modelling of feeding of swine, cf. Chapter 6.2.6.

At the recommendation of the ERT of the in-country review of September 2010, an effort is being made to determine methane-conversion factors (MCF), for the storage procedures commonly used in Germany, that adequately represent national circumstances and are consistent with pertinent measurements. Since the methane-conversion factor *MCF* and the maximum methane-formation capacity B_o have to be set in relation to one another, efforts are also being made to derive national values for B_o. The results will be reviewed by the newly created KTBL working group on climate protection (sub- working group on manure management) (KTBL = Association for Technology and Structures in Agriculture).

The fact that part of the liquid manure is processed in biogas systems is currently not being taken into account in the inventory, due to a lack of representative activity data. KTBL is currently carrying out a project aimed at supporting collection of required activity data and emission factors for future reports. In addition, a number of research projects on the same topic are being carried out in Germany.

In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.

6.3.3 NMVOC emissions from manure management (4.B, NMVOC)

The IPCC does not provide any method for calculating NMVOC emissions from manure-management. EMEP (2009)-4B-41 notes: "Data on NMVOC emissions from animal husbandry do not allow any direct estimation of emission factors …". In the framework of the 2010 In-Country Review, the ERT found that the emission factors of HOBBS et al. (2004) that had been used were questionable, that they lead to considerable overestimation of NMVOC emissions and that therefore they had not been included in EMEP (2009). The ERT recommended that Germany, like Finland and Denmark, not report any NMVOC emissions from the agricultural sector. As of the present Submission 2012, NMVOC emissions from the agricultural sector are thus no longer reported.

6.3.4 N_2O and emissions from manure management (4.B, N_2O & NO)

6.3.4.1 Source category description (4.B, N_2O & NO)

Cf. Chapter 6.3.1.

6.3.4.2 Methodological issues (4.B, N_2O & NO)

6.3.4.2.1 Methods (4.B, N_2O & NO)

N_2O emissions are calculated separately for all animal categories, taking account of the applicable manure-management systems, in accordance with the following formula:

Equation 7: Calculation of N_2O emissions from manure management

$$E_{\mathrm{N2O\text{-}N}} = \sum_{\mathrm{i,j}} [(N_{\mathrm{excr,\,i}} + N_{\mathrm{straw,\,i,\,j}}) \cdot MS_{\mathrm{i,\,j}}] \cdot EF_{\mathrm{N2O\text{-}N,\,j}}$$

where:

E_{N2O-N}	Total N_2O-N emissions from manure management (kg a^{-1} N_2O-N)
$N_{excr, i}$	Total N excretions of animal category i (kg a^{-1} N)
$N_{straw, i, j}$	N input via straw bedding, for animal category i and manure-management system j (kg a^{-1} N), $N_{straw, i, j}$ = 0 for liquid-manure systems and pasturing
$MS_{i, j}$	Relative proportion of manure management system j in animal category i (place place^{-1})
$EF_{N2O-N, j}$	N_2O-N emission factor for manure management system j (kg kg^{-1} N_2O-N)

With regard to total N excretions and total N inputs via straw bedding, cf. Chapters 6.1.3.2.3 & 6.3.4.2.3. The emission factors given in Chapter 6.3.4.2.5 describe emissions from stalls and storage systems together.

NO emissions from manure management (not including application and pasturing) are calculated with the help of the emission factors given in Chapter 6.3.4.2.5. This simple approach yields NO emissions that are proportional to the relevant N_2O emissions.

N_2O and NO emissions from soil, resulting from manure application and N excretions in pastures, are reported under 4.D.

6.3.4.2.2 Methodological changes (4.B, N_2O & NO)

The relevant methods were not changed relative to the NIR 2011. The differences in N_2O and NO emissions from manure management arising in comparison to the NIR 2011 are the result of changes in the pertinent activity data (cf. Chapter 6.3.4.2.3) and animal models (cf. Chapter 6.1.3.3). Those changes are discussed in the "Recalculations" chapter (Chapter 6.3.4.5).

6.3.4.2.3 Activity data and additional information (4.B(b))

The activity data consist of the total N excretions and the total N inputs from straw bedding, along with the relative frequencies of the various manure management systems within the various animal categories.

The data required for calculation of total N excretions, and of total N inputs via straw bedding, include the numbers of animal places (cf. Chapter 6.1.3.2.1), the N excretions per place (cf. Chapter 6.1.3.2.3), the straw-bedding quantities required per animal place and the N content of those quantities (cf. Chapter 6.1.3.2.5).

The total annual N excretions calculated for the various relevant manure-management systems are listed in Table 166 through Table 168.

Table 166: Total annual N excretions for liquid-manure-based systems (4.B(b))

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	332.1	306.9	302.7	303.8	378.3	378.7	381.1	369.9	368.0	366.9
Other cattle	319.2	286.8	273.2	266.2	263.9	261.4	258.3	247.0	245.2	245.1
Swine	250.4	211.1	218.3	217.5	225.1	219.2	226.3	230.2	251.0	243.8
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo [1]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	356.9	363.1	354.1	353.4	347.8	348.3	338.0	341.4	348.6	351.7
Other cattle	236.4	235.2	217.9	207.6	194.1	188.0	181.8	177.0	174.0	170.1
Swine	240.5	244.5	250.2	251.0	245.4	254.1	250.9	257.2	252.3	255.8
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Buffalo	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg a^{-1}]	**2010**									
Dairy cattle	351.2									
Other cattle	163.8									
Swine	243.6									
Sheep	NO									
Goats	NO									
Horses	NO									
Mules/asses	NO									
Buffalo	0.08									
Poultry	NO									

[1] Through 1995, the system included no buffalo

Table 167: Total annual N excretions for straw-based systems (4.B(b))

[Gg a-1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	161.5	145.3	143.1	145.5	83.0	82.7	82.8	80.5	73.2	72.5
Other cattle	132.9	117.3	116.0	116.6	119.7	122.7	123.5	120.3	119.0	122.3
Swine	62.8	55.6	56.7	53.9	35.1	33.8	34.2	34.9	32.8	31.8
Sheep	12.6	12.2	11.3	11.5	11.1	11.5	11.4	11.1	11.0	10.7
Goats	0.65	0.62	0.65	0.67	0.69	0.72	0.76	0.83	0.90	0.98
Horses	18.9	19.7	20.5	21.7	23.0	24.0	25.0	22.9	20.8	18.7
Mules/asses	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Buffalo [1]	0	0	0	0	0	0	0.00	0.01	0.01	0.01
Poultry	77.1	74.2	71.2	70.7	71.6	71.7	71.6	73.3	75.8	74.2
[Gg a-1]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	71.8	73.4	72.6	72.7	72.4	73.4	71.9	73.1	74.7	75.9
Other cattle	125.4	130.3	127.3	127.6	126.6	128.8	130.8	134.2	140.0	143.9
Swine	30.5	30.2	29.5	28.6	27.4	27.2	26.0	25.7	24.0	23.1
Sheep	10.7	10.8	10.6	10.6	10.5	10.3	9.9	9.8	9.4	9.1
Goats	1.01	1.16	1.16	1.16	1.16	1.23	1.30	1.30	1.37	1.59
Horses	19.2	19.7	20.1	20.5	20.0	19.5	20.3	21.1	20.1	19.0
Mules/asses	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Buffalo	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.07
Poultry	79.9	82.1	81.6	84.2	89.3	88.9	88.9	94.2	93.6	93.7
[Gg a-1]	**2010**									
Dairy cattle	76.4									
Other cattle	146.0									
Swine	21.5									
Sheep	8.4									
Goats	1.08									
Horses	18.0									
Mules/asses	0.23									
Buffalo	0.08									
Poultry	94.3									

[1] Through 1995, the system included no buffalo

Table 168: Total annual N excretions in pasture (4.B(b))

[Gg a-1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	110.9	102.6	100.8	101.6	73.9	74.0	74.3	72.0	68.8	68.2
Other cattle	77.5	71.2	72.6	73.5	75.2	78.6	80.4	79.0	80.3	81.7
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	12.7	12.4	11.6	11.7	11.2	11.6	11.6	11.2	11.1	10.8
Goats	0.34	0.32	0.34	0.35	0.36	0.38	0.40	0.43	0.47	0.51
Horses	4.9	5.1	5.3	5.6	5.9	6.2	6.5	5.9	5.4	4.8
Mules/asses	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Buffalo [1]	0	0	0	0	0	0	0.00	0.00	0.00	0.01
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg a-1]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	64.0	63.4	59.9	58.5	56.1	54.7	51.5	50.5	50.9	50.6
Other cattle	81.7	81.7	77.4	74.9	73.1	72.2	71.6	72.0	73.0	73.3
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	10.7	10.9	10.6	10.8	10.7	10.4	10.0	9.9	9.4	9.2
Goats	0.53	0.60	0.60	0.60	0.60	0.64	0.68	0.68	0.72	0.83
Horses	5.0	5.1	5.2	5.3	5.2	5.0	5.3	5.5	5.2	4.9
Mules/asses	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Buffalo	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg a-1]	**2010**									
Dairy cattle	49.7									
Other cattle	72.9									
Swine	NO									
Sheep	8.8									
Goats	0.56									
Horses	4.6									
Mules/asses	0.06									
Buffalo	0.03									
Poultry	NO									

[1] Through 1995, the system included no buffalo

Table 169: Annual totals for N inputs via straw bedding, in straw-based systems (4.B(b))

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	17.2	14.7	13.9	13.8	7.8	7.7	7.6	7.4	6.6	6.5
Other cattle	19.2	16.3	16.2	16.3	17.0	17.4	17.4	17.1	16.9	17.6
Swine	3.18	2.86	2.91	2.79	1.87	1.78	1.80	1.83	1.70	1.65
Sheep	0.92	0.89	0.83	0.84	0.81	0.84	0.83	0.82	0.81	0.78
Goats	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06
Horses	6.46	6.73	7.00	7.43	7.87	8.22	8.57	7.84	7.12	6.40
Mules/asses	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Buffalo [1]	0	0	0	0	0	0	0.00	0.00	0.00	0.00
Poultry	0.77	0.78	0.78	0.82	0.85	0.89	0.93	0.96	0.99	1.02
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Dairy cattle	7.2	7.1	7.0	6.9	6.7	6.7	6.5	6.5	6.7	6.7
Other cattle	17.9	18.3	17.8	17.7	17.4	17.6	17.7	18.0	18.7	19.0
Swine	1.58	1.53	1.51	1.48	1.40	1.41	1.36	1.35	1.28	1.26
Sheep	0.78	0.79	0.78	0.78	0.77	0.75	0.72	0.72	0.69	0.67
Goats	0.07	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.11
Horses	6.57	6.75	6.88	7.00	6.84	6.67	6.95	7.22	6.87	6.51
Mules/asses	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Buffalo	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Poultry	1.08	1.13	1.19	1.25	1.25	1.24	1.27	1.30	1.35	1.42
[Gg a^{-1}]	**2010**									
Dairy cattle	6.7									
Other cattle	19.1									
Swine	1.18									
Sheep	0.61									
Goats	0.07									
Horses	6.15									
Mules/asses	0.08									
Buffalo	0.01									
Poultry	1.48									

[1] Through 1995, the system included no buffalo

6.3.4.2.4 Calculated N_2O and NO emissions

The following tables show the calculated N_2O emissions from manure management, broken down by animal categories and by management systems. N_2O and NO emissions have been decreasing considerably with regard to the base year. Cattle husbandry accounts for the major part of N_2O emissions (81 % in 1990, and a decrease to 74 % in 2010). Due to the proportionality in the emission factors involved (cf. Chapter 6.3.4.2.5), the same figures apply, in the same manner, for NO emissions.

Table 170: N_2O emissions from manure management, by animal categories (4.B)

[Gg a-1 N2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cattle	3.383	3.063	3.018	3.049	3.049	3.046	3.059	2.973	2.898	2.888
Other cattle	3.292	2.904	2.855	2.831	2.947	2.970	2.957	2.859	2.842	2.897
Swine	1.184	1.105	1.148	1.127	1.136	1.100	1.136	1.155	1.210	1.175
Sheep	0.106	0.103	0.095	0.097	0.093	0.097	0.096	0.094	0.093	0.090
Goats	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005
Horses	0.199	0.207	0.216	0.229	0.243	0.253	0.264	0.242	0.219	0.197
Mules/asses	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Buffalo [1]	0	0	0	0	0	0	0.0000	0.0001	0.0002	0.0002
Poultry	0.121	0.117	0.112	0.111	0.112	0.113	0.113	0.115	0.119	0.117
[Gg a-1 N2O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Dairy cattle	2.824	2.859	2.788	2.767	2.719	2.719	2.636	2.655	2.695	2.706
Other cattle	2.876	2.919	2.776	2.788	2.686	2.672	2.649	2.658	2.709	2.729
Swine	1.188	1.238	1.294	1.328	1.334	1.413	1.426	1.491	1.489	1.535
Sheep	0.090	0.091	0.089	0.089	0.089	0.087	0.083	0.082	0.079	0.077
Goats	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.008	0.009
Horses	0.203	0.208	0.212	0.216	0.211	0.206	0.214	0.223	0.212	0.201
Mules/asses	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Buffalo	0.0004	0.0004	0.0004	0.0005	0.0006	0.0007	0.0008	0.0009	0.0010	0.0012
Poultry	0.126	0.129	0.128	0.132	0.140	0.140	0.140	0.148	0.147	0.147
[Gg a-1 N2O]	2010									
Dairy cattle	2.694									
Other cattle	2.708									
Swine	1.497									
Sheep	0.071									
Goats	0.006									
Horses	0.190									
Mules/asses	0.002									
Buffalo	0.0014									
Poultry	0.148									

[1] Through 1995, the system included no buffalo

As the following table shows, the level of total N_2O emissions from liquid-manure-based systems in 2010 was largely similar to the corresponding level in 1990, while in the category solid-manure systems the value for 2010 is about 80 % of the value for 1990. This result reflects the development in the distribution of management systems (cf. Chapters 6.1.3.2.4 and 6.3.2.2.3). In part, that development has been modified by developments in animal populations and yield levels.

Table 171: N_2O emissions from manure management, total and by system categories (4.s2.B)

[Gg a-1 N2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	8.292	7.505	7.450	7.450	7.587	7.585	7.631	7.444	7.389	7.372
Liquid-manure-based	4.489	4.086	4.008	3.982	4.735	4.692	4.717	4.598	4.646	4.613
Straw-based	3.803	3.420	3.442	3.469	2.852	2.893	2.915	2.846	2.743	2.759
[Gg a-1 N2O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total	7.318	7.453	7.296	7.330	7.188	7.246	7.158	7.268	7.342	7.407
Liquid-manure-based	4.513	4.575	4.466	4.420	4.308	4.341	4.252	4.298	4.311	4.341
Straw-based	2.804	2.878	2.830	2.909	2.880	2.905	2.906	2.970	3.030	3.066
[Gg a-1 N2O]	2010									
Total	7.317									
Liquid-manure-based	4.262									
Straw-based	3.055									

The following table lists the NO emissions calculated for manure management overall.

Table 172: NO emissions (E_{NO}) from manure management

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
ENO	1.131	1.023	1.016	1.016	1.035	1.034	1.041	1.015	1.008	1.005
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
ENO	0.998	1.016	0.995	1.000	0.980	0.988	0.976	0.991	1.001	1.010
[Gg a^{-1}]	**2010**									
ENO	0.998									

6.3.4.2.5 *Emission factors (4.B, N_2O & NO)*

For liquid-manure systems, Germany uses N_2O emission factors that are higher than those specified by the IPCC (1996b/2000) (IPCC, 2006); consequently, the pertinent emissions cannot be underestimated. For solid-manure systems, Germany uses N_2O emission factors that are lower than those specified by the IPCC (1996b/2000). The lower emission factors are based on evaluation of measurements made in Germany and central Europe, at the plant level and in special test arrays (not laboratory experiments) (FREIBAUER, 2003; KTBL, 2005). Reseach on greenhouse-gas emissions from solid-manure systems has nearly come to a standstill since then, with the result that the database has not changed since FREIBAUER (2003) and KTBL (2005). On the basis of those data, for solid-manure systems with cattle and swine, Germany uses an emission factor of 0.005 kg N_2O-N (kg N)$^{-1}$, which agrees with the default emission factor of the IPCC (2006). Results with manure-storage systems in Denmark (deep straw bedding with cattle) and in the UK (poultry faeces) have confirm that use of the default emission factor of the IPCC (2006) does not lead to underestimation of emissions.

Table 173: Emission factors for emissions of N_2O-N from manure management (in relation to total excreted N and straw-bedding N) (4.B(b))

Farm manure		Emission factor [kg kg^{-1} N]
Liquid manure / slurry	Outdoor storage with no cover [a]	0.000
	Fixed cover [b]	0.005
	Natural floating cover [a]	0.005
	Floating cover (wood chips) [c]	0.000
	Floating cover (foil) [c]	0.000
	Liquid manure below slatted floor [a]	0.002
Solid manure[a]		0.005
Deep straw bedding [a]		0.010
Poultry, solid manure or faeces [a]		0.001

[a] Source: See text.
[b] Worst-case assumption: Like natural floating cover, since no information is available.
[c] Assumption: Wood-chip or foil floating covers permit no N_2O formation.

IPCC does not given any emission factors for NO. The Tier-1 emission factors given in EMEP (2009) refer to animal places and thus cannot be used in the GAS-EM inventory model, which, in the framework of the N-flow concept (cf. Chapter 6.1.2.4), requires emission factors that are related to N quantities. At the same time, comparative calculations show that the German total NO emissions from Sector 4.B as calculated with the Tier-1 method pursuant to EMEP (2009) are reproduced with GAS-EM when the NO-N emission factor oriented to N is set as 10 % of the N_2O-N emission factor.

The emission factors for N_2 emissions, which in the N-flow concept (cf. Chapter 6.1.2.4) also have to be taken into account, were derived from N_2O-N emission factors, in accordance with experiments carried out in the UK (JARVIS & PAIN, 1994): The N_2 emission factor is three times the N_2O-N emission factor.

Table 174 through Table 177 show the time series for the implied N_2O-N emission factors for the two manure-management-system categories, "liquid-manure-based" and "straw-based", and for dairy cattle, other cattle, swine and all livestock overall. These emission factors are defined as the quotient of the total N_2O emissions from a management system (given in N) and the total quantity of the N excreted by the animals in the system. For straw-based systems, the total N_2O emissions comprise both the emissions resulting from the animals' N excretions and the emissions from the N introduced via straw bedding.

Table 174: Dairy cattle, mean N_2O-N emission factors

[kg kg-1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid-manure-based	0.00376	0.00372	0.00372	0.00374	0.00390	0.00390	0.00389	0.00390	0.00390	0.00390
Straw-based	0.00559	0.00557	0.00555	0.00554	0.00560	0.00560	0.00559	0.00559	0.00559	0.00559
[kg kg-1]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Liquid-manure-based	0.00390	0.00388	0.00386	0.00384	0.00382	0.00380	0.00379	0.00377	0.00374	0.00371
Straw-based	0.00563	0.00560	0.00559	0.00557	0.00555	0.00554	0.00552	0.00551	0.00550	0.00549
[kg kg-1]	**2010**									
Liquid-manure-based	0.00369									
Straw-based	0.00548									

Table 175: Other cattle, mean N_2O-N emission factors

[kg kg-1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid-manure-based	0.00371	0.00366	0.00363	0.00363	0.00379	0.00378	0.00378	0.00378	0.00377	0.00376
Straw-based	0.00686	0.00681	0.00711	0.00717	0.00731	0.00735	0.00734	0.00736	0.00742	0.00753
[kg kg-1]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Liquid-manure-based	0.00374	0.00372	0.00370	0.00367	0.00365	0.00363	0.00360	0.00358	0.00356	0.00354
Straw-based	0.00755	0.00754	0.00755	0.00793	0.00790	0.00790	0.00788	0.00788	0.00790	0.00788
[kg kg-1]	**2010**									
Liquid-manure-based	0.00352									
Straw-based	0.00785									

Table 176: Swine, mean N_2O-N emission factors

[kg kg-1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid-manure-based	0.00169	0.00195	0.00198	0.00199	0.00239	0.00238	0.00240	0.00239	0.00238	0.00238
Straw-based	0.00526	0.00526	0.00526	0.00526	0.00528	0.00527	0.00527	0.00527	0.00527	0.00527
[kg kg-1]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Liquid-manure-based	0.00248	0.00257	0.00267	0.00277	0.00287	0.00298	0.00307	0.00316	0.00325	0.00334
Straw-based	0.00526	0.00525	0.00526	0.00526	0.00526	0.00526	0.00527	0.00527	0.00528	0.00528
[kg kg-1]	**2010**									
Liquid-manure-based	0.00344									
Straw-based	0.00529									

Table 177: All farm animals, mean N_2O-N emission factors (4.s2.B)

[kg kg-1]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid-manure-based	0.00317	0.00323	0.00321	0.00322	0.00347	0.00348	0.00347	0.00345	0.00342	0.00343
Straw-based	0.00519	0.00512	0.00522	0.00524	0.00527	0.00530	0.00531	0.00526	0.00523	0.00530
[kg kg-1]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Liquid-manure-based	0.00344	0.00345	0.00346	0.00346	0.00348	0.00350	0.00351	0.00353	0.00354	0.00355
Straw-based	0.00526	0.00526	0.00525	0.00536	0.00527	0.00529	0.00529	0.00526	0.00531	0.00532
[kg kg-1]	**2010**									
Liquid-manure-based	0.00357									
Straw-based	0.00531									

6.3.4.3 Uncertainties and time-series consistency (4.B, N_2O & NO)

With regard to the uncertainties in the area of N_2O emissions from enteric fermentation, the reader's attention is called to Table 133 in Chapter 6.1.4 (total uncertainty of the German GG inventory).

All emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and all data gaps have been filled in.

6.3.4.4 Source-specific quality assurance / control and verification (4.B, N_2O & NO)

Chapter 6.1.5 provides an overview of measures implemented relative to source-specific QA/QC and verification.

A comparison carried out in the framework of verification of "implied emission factors" for N_2O emissions from Germany (current report) and neighbouring countries, including the UK (Submission 2011 for 2009, UNFCCC 2011), shows that all other countries, in general, use the N_2O-N default emission factors from IPCC (1996b), Table 4-22 (0.001 kg kg^{-1} N for liquid manure and 0.02 kg kg^{-1} N for solid manure; slight divergencies are seen in the cases of Belgium, Denmark and the UK). The German N_2O-N emission factors, which differ from the IPCC (1996b) default values, are described in Chapter 6.3.4.2.5. On average, for all animal husbandry, an N_2O-N-IEF for liquid manure of 0.00357 kg kg_{-1} N, and an IEF for solid manure of 0.00484 kg kg_{-1} N, result for Germany.

A comparison of N-excretion data (Table 178) with those of neighbouring countries shows that Germany's values for dairy cattle, after model-/feed-related corrections (cf. Chapter 6.1.3.3), are about in the middle of the range covered by the values reported by neighbouring countries. A similar result is obtained with regard to excretions of other cattle. The IPCC (1996b) default value for dairy cattle seems to be too low for central Europe, while the default value for other cattle fits better, on average, with the reported area.

The N excretions of swine as reported by Germany lie within the middle range of the corresponding data reported by neighbouring countries. The IPCC (1996b) default value is noticeably higher than the corresponding level prevailing in Germany and central Europe.

In the poultry category, German has the highest N excretions of all countries compared. Since the compositions of poultry populations in other countries are not reported, the comparability of the values is limited. The IPCC default values of 1996, 0.60 kg $place^{-1}$ a^{-1}, and of 2006, 0.55 kg $place^{-1}$ a^{-1} (for calculation cf. Table 178) underestimate the situation in Germany. The German value, on the other hand, lies well within the value range given by EMEP (2009), and it is nearly the same as the EMEP value for laying hens, 0.77 kg $place^{-1}$ a^{-1}.

Table 178: N excretions per animal place, for dairy cattle, other cattle, swine and poultry of various countries

	Dairy cattle [kg place^{-1} a^{-1}]	Other cattle [kg place^{-1} a^{-1}]	Swine [kg place^{-1} a^{-1}]	Poultry [kg place^{-1} a^{-1}]
Austria	97.11	46.57	9.57	0.55
Belgium	115.07	54.26	10.06	0.58
Czech Republic	100.00	70.00	20.00	0.60
Denmark	138.12	47.82	8.40	0.53
France	100.00	57.51	16.46	0.60
Germany	**114.10**	**44.36**	**11.92**	**0.73**
Netherlands	127.00	44.78 [1]	8.87	0.65
Poland	86.70	58.09	13.56	0.35
Switzerland	110.23	37.96 [1]	9.18	0.54
UK	110.01	55.32	10.60	0.57
Default IPCC (1996b, Table B-1)	100	70	20	0.6
IPCC (2006)-10.59, 10.72, 10.78,10.80, 10.81, 10.82	105.12 [2]	50.59 [2]	9.31 / 30.35 [2, 4]	0.55 [2,3]
EMEP (2009)-4.B-26	105.00	41.00	12.1 / 34.5 [4]	0.36 to 1.64

Source: Germany for 2010: Submission 2012; other countries for 2009: UNFCCC 2011

1) Calculated from reported original data

2 Calculated pursuant to IPCC (2006), with the IPCC's standard values for weight and N excretions and, in the case of poultry, with the national animal counts in the various poultry sub-categories (Submission 2012)

3 Assumptions for lacking values: Weight of geese = 1/2 standard weight of turkeys (IPCC 2006); N excretions of geese = standard N excretions of turkeys (IPCC 2006); weight of pullets = 1/2 standard weight of laying hens (IPCC 2006); N excretions of pullets = standard N excretions of laying hens (IPCC 2006)

4 IPCC (2006): Sows and boars: 30.35, other: 9.31; EMEP (2009): Sows: 34.5, fattening pigs: 12.1

6.3.4.5 Source-specific recalculations (4.B, N_2O & NO)

Table 180 shows a comparison of N_2O emissions from manure management, for liquid-manure-based and straw-based systems, as calculated for the present NIR 2012, and as reported in the NIR 2011. For all years in the period covered by the report, emissions from liquid-manure-based systems have decreased in comparison to the corresponding values reported in the NIR 2011. On the other hand, only until 2001 are emissions from straw-based systems as now reported lower than they were in the NIR 2011; as of 2002 they are increasingly higher than the values reported in the NIR 2011. The primary reasons for this are:

- In both manure-management-system categories, the decrease in total N excretions throughout the entire period covered by the report (cf. Chapter 6.1.3.2.3, Table 132) initially leads to a reduction of N_2O emissions.
- For straw-based systems, the reduction is intensified, for all years covered by the report, via change in straw-based housing systems for heifers (transition from deep-straw-bedding systems to systems with solid floors and straw bedding; cf. Chapter 6.1.3.2.4)
- On the other hand, emissions increase in that more and more suckler cows are kept in systems with deep straw bedding (cf. Chapter 6.1.3.2.4).
- Emissions also rise (slightly), for straw-based systems, via updating, from 2011 to 2012, of the N content in straw bedding (i.e. the updating led to an increase) (cf. Chapter 6.1.3.2.5).

- In the category of straw-based systems, the observed shift from a reduction to an increase of N_2O emissions, as of the beginning of the 2000s, is due to changes in the percentage-based distributions of management systems occurring between the NIR 2011 and the NIR 2012; cf. Table 160 through Table 162 in Chapter 6.3.2.5.

As a result of the above-described changes, total emissions are lower in the period 1990 to 2003, and higher in the years as of 2005, than the corresponding total emissions calculated for the NIR 2011.

Table 179: Comparison of N_2O emissions from manure management, as reported in 2012 and as reported in 2011, and as total emissions and by system categories (4.s2.)

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**8.292**	**7.505**	**7.450**	**7.450**	**7.587**	**7.585**	**7.631**	**7.444**	**7.389**	**7.372**
Total, 2011	**8.947**	**8.039**	**7.853**	**7.840**	**7.976**	**7.977**	**8.039**	**7.881**	**7.815**	**7.730**
Liquid-manure-based, 2012	4.489	4.086	4.008	3.982	4.735	4.692	4.717	4.598	4.646	4.613
Liquid-manure-based, 2011	4.559	4.149	4.073	4.061	4.880	4.860	4.888	4.791	4.831	4.803
Straw-based, 2012	3.803	3.420	3.442	3.469	2.852	2.893	2.915	2.846	2.743	2.759
Straw-based, 2011	4.388	3.890	3.780	3.779	3.095	3.118	3.151	3.090	2.984	2.926
[Gg a^{-1} N_2O]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**7.318**	**7.453**	**7.296**	**7.330**	**7.188**	**7.246**	**7.158**	**7.268**	**7.342**	**7.407**
Total, 2011	**7.584**	**7.660**	**7.437**	**7.373**	**7.189**	**7.205**	**7.050**	**7.123**	**7.189**	**7.195**
Liquid-manure-based, 2012	4.513	4.575	4.466	4.420	4.308	4.341	4.252	4.298	4.311	4.341
Liquid-manure-based, 2011	4.701	4.758	4.633	4.606	4.481	4.518	4.411	4.458	4.504	4.517
Straw-based, 2012	2.804	2.878	2.830	2.909	2.880	2.905	2.906	2.970	3.030	3.066
Straw-based, 2011	2.883	2.901	2.804	2.767	2.708	2.687	2.639	2.665	2.685	2.677

The NO emissions have changed, with respect to the NIR 2011, in the same manner that the N_2O emissions have changed, since both emissions types come from the same N pool and since the NO emission factors are directly proportional to the N_2O emission factors (cf. Chapter 6.3.4.2.5). The following table shows the relevant changes in the total NO emissions:

Table 180: Comparison of total NO emissions (E_{NO}) from manure management, as reported in 2012 and as reported in 2011

[Gg a^{-1} NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NO} 2012	1.131	1.023	1.016	1.016	1.035	1.034	1.041	1.015	1.008	1.005
E_{NO} 2011	1.220	1.096	1.071	1.069	1.088	1.088	1.096	1.075	1.066	1.054
[Gg a^{-1} NO]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
E_{NO} 2012	0.998	1.016	0.995	1.000	0.980	0.988	0.976	0.991	1.001	1.010
E_{NO} 2011	1.034	1.045	1.014	1.005	0.980	0.983	0.961	0.972	0.980	0.981

6.3.4.6 Planned improvements (4.B, N_2O & NO)

The national N_2O emission factors currently being used by Germany are to be reviewed by the newly created KTBL working group on climate protection (sub- working group on manure management).

Improvement of modelling of feeding of swine, and collection of data on N-reduced feeding of swine (both mentioned in Chapter 6.3.2.6), are expected to make the results for N_2O and NO emissions from manure management more precise.

6.4 Rice cultivation (4.C)

No rice is cultivated in Germany (NO).

6.5 Agricultural soils (4.D)

6.5.1 Source category description (4.D)

CRF 4.D	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Direct soil emissions	**N_2O**	**L**	**T/T2**	**29,161.4**	**(2.39%)**	**24,757.1**	**(2.60%)**	**-15.10%**
Indirect emissions	**N_2O**	**L**	**T/T2**	**16,463.1**	**(1.35%)**	**13,268.0**	**(1.39%)**	**-19.41%**
Pasture, Range and Paddock Manure	**N_2O**	**-**	**-/T2**	**2,019.7**	**(0.17%)**	**1,334.5**	**(0.14%)**	**-33.93%**

Gas	Method used	Source for the activity data	Emission factors used
CO_2		IE	
N_2O	C/D/Tier 1/Tier 2	M/AS/RS/NS	D
NO_X			D

With regard to direct and indirect N_2O emissions, the source category *Agricultural soils* is a key category in terms of emissions level. With regard to direct emissions, it is also a key category in terms of trend. In addition, N_2O emissions from Pasture, range and paddock manure are a key category pursuant to the results of Tier-2 key-category analysis.

Microbial transformations of N compounds (nitrification and denitrification) lead to emissions of N_2O. A distinction is made between direct and indirect N_2O emissions from soils. Direct emissions comprise N_2O emissions resulting from manure application, pasturing, application of mineral fertiliser and sewage sludge, biological N-fixing, crop residues and cultivation of organic soils. So-called indirect N_2O emissions result from deposition of reactive nitrogen and via leaching and surface run-off.

From 1990 to 2010, N_2O emissions from soils decreased by 17.5 %. Their share of total N_2O emissions from German agriculture has remained nearly constant throughout the same period (1990: 94.9 %; 2010: 94.6 %).

6.5.2 Methodological issues (4.D)

6.5.2.1.1 Basic concept

N_2O emissions from soils are calculated in proportion to the quantity of nitrogen added to the soil anthropogenically. That N quantity also includes quantities from manure application and pasturing. Those N fractions are calculated with the help of the N-flow concept; cf. Chapter 6.1.2.4.

A detailed description of calculation of N_2O emissions from agricultural soils is provided by HAENEL et al. (2012). The following chapters present the most important aspects of such calculation, including the pertinent changes with respect to the NIR 2011.

6.5.2.1.2 Direct N_2O emissions from agricultural soils (4.Ds1.2, 4.Ds1.3)

Direct N_2O emissions from application of mineral fertilisers are calculated, via a Tier 1 method pursuant to IPCC (1996b)-4.92 ff, as a proportion of the N quantity that remains from the N quantity in applied fertiliser after deduction of N losses via NH_3 and NO emissions. In the German inventory, the remaining N quantity is calculated not with the help of the value $Frac_{GASF}$ but with values for explicitly calculated NH_3 and NO emissions. (With regard to $Frac_{GASF}$, cf. Chapter 6.5.2.1.7.) The activity data used are the quantities of mineral fertiliser sold at the Länder level, as recorded in statistics. Pursuant to IPCC(1996b)-4.89, Table 4-18, the emission factor is set as $EF_{fert,\ N2O}$ = 0.0125 kg kg^{-1} N_2O-N.

Calculation of direct N_2O emissions as a result of application of farm fertiliser is carried out analogously to calculation of such emissions from application of mineral fertiliser. Consequently, the emission factor is set to $EF_{man,\ N2O}$ = 0.0125 kg kg^{-1} N_2O-N. For determination of the activity data, i.e. the N quantities entering the soil following application, cf. Chapter 6.1.2.4.

Since 2008, imports and exports of mineral fertilisers, pursuant to waste statistics, yield a net balance with a slight export surplus or of zero. In a conservative approach, they are thus not taken into account in the inventory.

Direct N_2O emissions from N excretions in pasture are calculated in accordance with IPCC (1996b). The quantity of N excretions produced by an animal in pasture is calculated as the product of the animal's total N excretions and the relative proportion of time the animal spends in pasture. The emission factor $EF_{graz,\ N2O}$ = 0.02 kg kg^{-1} N_2O-N is the same for all animal categories, and it is applied to the N quantities excreted.

IPCC (1996b), pg. 4.89, recommends that emissions from use of sewage sludges not be calculated. IPCC (2000), on the other hand, proposes that sewage sludges should be treated like mineral and farm fertiliser. For this reason, in the German inventory sewage sludges are taken into account in the area of direct N_2O emissions, in keeping with IPCC (2006)-11.7. For each Land (state) in Germany, the N quantities that enter into agricultural systems via sewage sludges are taken from data of the Federal Environment Agency and (since 2009) of the Federal Statistical Office. While other types of N emissions from use of mineral fertiliser are calculated, no other N emissions from sewage sludges are calculated; as a result, the N quantities tied to sewage sludges are used directly as activity data. Consequently, by analogy to the situation with application of mineral fertiliser, the emission factor is set to $EF_{sl,\ N2O}$ = 0.0125 kg kg^{-1} N_2O-N.

Direct N_2O emissions from cultivation of organic soils are calculated in proportion to the applicable area (cf. Chapter 6.5.2.2, Table 183). Pursuant to IPCC (2000), Table 4.17, an emission factor of 8 kg ha^{-1} a^{-1} N_2O-N is used.

Direct N_2O emissions from biological N fixing are calculated in proportion to the quantity of bound N. For each crop, that quantity is determined as the product of the cultivated area and the specific fixing rate. The relevant data for the cultivated areas are provided by the Federal Statistical Office, while the fixing data are obtained from FAUSTZAHLEN (1993), p. 477, and from Saxony's state institute for agriculture (Sächsische Landesanstalt für Landwirtschaft; LABER, 2005, p. 86). Consequently, by analogy to the situation with application of mineral fertiliser, the emission factor is set to $EF_{fix,\ N2O}$ = 0.0125 kg kg^{-1} N_2O-N.

Direct N_2O emissions from crop residues are calculated as a proportion of the N quantities remaining in the soil (IPCC, 2006, 11.13). Those quantities result from the applicable figures for cultivated areas, yields and crop-specific N content. The data for cultivated areas and yields are reported by the Federal Statistical Office (STATISTISCHES BUNDESAMT: FS3 R3). The data on relative N content found in crop residues are taken from a list of the Institute of Vegetable and Ornamental Crops (IGZ; 2007) and from the Fertiliser Ordinance (Düngeverordnung (DüV, 2007). The N quantities removed from relevant areas, for straw bedding in animal husbandry, are deducted. Consequently, by analogy to the situation with application of mineral fertiliser, the emission factor is set to $EF_{fix,\ N2O}$ = 0.0125 kg kg^{-1} N_2O-N.

6.5.2.1.3 Indirect N_2O emissions from agricultural soils, as a result of deposition of reactive nitrogen (4.Ds1.3)

Indirect N_2O emissions from agricultural soils include a) N_2O emissions from deposition of previously emitted, reactive nitrogen and b) N_2O emissions from surface runoff and leaching.

The German procedure for calculating deposition-related N_2O emissions, as described below, accords with the meaning of the Tier 1 procedure in IPCC (2006)-11.21. The equation for that procedure, 11.9 (IPCC, 2006: 11.21) is not used by Germany, however, since that equation does not take account of NH_3-N emissions from straw bedding and legume cultivation and of and NO-N emissions from straw bedding. Since, furthermore, that equation is not consistent with the definition of $Frac_{GASM}$ in CRF Table 4.Ds2 (cf. Chapter 6.5.2.1.7), it can be used only as an approximation in checking of the German N_2O emissions reported in the inventory (cf. Chapter 6.5.3).

The German inventory calculates the deposition-related N_2O emissions as the product of the N_2O-N conversion factor, 44/28, the emission factor (0.01 kg kg-1 N, IPCC, 1996, Table 4-23) and the sum of the N content of the following NH_3 and NO emissions, which are described further below:

- NH_3 emissions from use of mineral fertilisers
- NO emissions from use of mineral fertilisers
- NH_3 emissions from manure management, including application
- NO emissions from manure management, including NO as a consequence of manure application
- NH_3 emissions from pasturing
- NO emissions from pasturing
- NH_3 emissions from legume cultivation

As of the present Submission 2010, NO emissions from legume cultivation and from crop residues are no longer reported, since neither the IPCC nor EMEP (2009) provide a pertinent method. This can be justified in that no free ammonium occurs in N fixing by legumes, and that crop residues, as an NO source, are implicitly included in the measurements for NO emission factors for fertilisers, since the relevant emission factors in STEHFEST & BOUWMAN (2006) were calculated without deduction of "background emissions", i.e. were calculated as measured total emissions per quantity of fertiliser.

NH_3 and NO emissions from use of mineral fertiliser are calculated as a proportion of the N quantity applied. The NH_3 emission factors for the various fertiliser types are calculated, pursuant to EMEP (2009)-4D-Table 3-2, as a function of spring temperatures. Such temperature data is obtained from the regionally differentiated statistics of the Deutscher Wetterdienst German meteorological service) (cf. HAENEL et al., 2012). The NO emission factor is given in Chapter 6.5.2.1.5.

NH_3 emissions from manure management are calculated separately for the areas stall, storage and application area, with the N quantity at the beginning of the stall-storage-application chain including the nitrogen introduced with straw bedding (cf. Chapters 6.1.2.4

and 6.1.3.2.5). Differentiated NH_3 emission factors are available for the stalling, storage and application procedures commonly used in Germany (cf. HAENEL et al., 2012).

NO emissions from manure management are a) combined for the stall and storage categories and b) calculated as a consequence of manure application. The NO emission factors for the stall-storage area are set at 10 % of the relevant N_2O emission factor (cf. Chapters 6.3.4.2.1 and 6.3.4.2.5). The emission factor for NO as a result of application is given in Chapter 6.5.2.1.2.

NH_3 and NO emissions from excretions during grazing are calculated in proportion to the N quantity excreted. The NH_3 emission factors are differentiated by type of animal; cf. EMEP (2009)-4B-26. The NO emission factor is given in Chapter 6.5.2.1.2.

NH_3 emissions from legume cultivation are calculated in proportion to the N quantity fixed (with regard to calculation of the N quantity fixed, cf. Chapter 6.5.2.1.2). Pursuant to EMEP (2006)-B1020-12, the NH_3 emission factor is set as $EF_{fix, NH3}$ = 0.01 kg kg^{-1} NH_3-N.

6.5.2.1.4 Indirect N_2O emissions from agricultural soils, as a result of leaching and surface runoff (4.Ds1.3)

The indirect N_2O emissions from leaching and surface runoff are obtained, via a simple Tier 1 method pursuant to IPCC (1996b), p. 4.109, as the products of the N_2O-N conversion factor, 44/28, the activity data, the fraction of the soil N quantity affected by leaching and surface runoff ($Frac_{LEACH}$; cf. Chapter 6.5.2.1.8) and the relevant emission factor (0.025 kg kg-1 N, IPCC, 1996b, Table 4-23).

The activity data are obtained as the sum of the following sub- activity figures (for calculation of NH_3 and NO emissions, and of direct N_2O emissions, cf. Chapters 6.5.2.1.3 and 6.5.2.1.2; the N_2 emissions are calculated with the same procedure used for the direct N_2O emissions, with the N_2O-N emission factor being replaced by the N_2 emission factor 0.1 kg kg^{-1} N; cf. HAENEL et al. (2012):

- The sub- activity data for the areas of mineral-fertiliser application and farm-manure application, and for pasturing, consist of the applied / excreted N quantities, less the N losses from direct N_2O emissions and from NH_3, NO and N_2 emissions.
- The sub- activity data for application of sewage sludge consists of the relevant N quantity applied, less the N losses via direct N_2O emissions. (No NH_3, NO and N_2 emissions are calculated.)
- The sub- activity data for biological N fixing consists of the fixed N quantity, less the N losses from direct N_2O emissions and from NH_3, NO and N_2 emissions. (For calculation of fixed N quantities cf. Chapter 6.5.2.1.2.)

For crop residues, the sub- activity level is obtained as the applicable N content (with regard to calculation of these N quantities, cf. Chapter 6.5.2.1.2), less the N losses via direct N_2O emissions and via NO and N_2 emissions. (No NH_3 emissions are calculated).

6.5.2.1.5 NO emissions

The procedure for calculating NO emissions is described in Chapter 6.5.2.1.3. The following table shows the emission factors used.

Table 181: Emission factors EF_{NO} for NO emissions from agricultural soils

	EF_{NO} kg kg^{-1} NO-N]	Remark
Application of mineral fertiliser	0.012	STEHFEST & BOUWMAN (2006)
Application of farm fertiliser	0.012	STEHFEST & BOUWMAN (2006)
Grazing	0.007	EMEP (2007), B1020-12

The NO-N emission factor for pasturing differs from the value used in earlier submissions, which had adopted the N_2O-N emission factor (0.02 kg kg^{-1}). Since no measurement data are available in Germany that would substantiate the high emission factor, from now on the EMEP default value is being used as the emission factor; it reflects European circumstances.

As of the present Submission 2012, NO emissions from legume cultivation and from crop residues are no longer reported; cf. Chapter 6.5.2.1.3.

6.5.2.1.6 NMVOC emissions from agricultural soils and crops

The IPCC does not provide any method for calculating NMVOC emissions from agricultural soils and crops. EMEP (2009) provides a method, but it provides no emission factors. Since no scientifically founded bases for calculation are available, as of the present Submission 2012 NMVOC emissions will no longer be reported in Sector 4.D, just as they are no longer reported in Sector 4.B (cf. Chapter 6.3.3).

6.5.2.1.7 $Frac_{GASF}$ and $Frac_{GASM}$

The values described in the following, $Frac_{GASF}$ and $Frac_{GASM}$, are calculated with the help of input and output data after emissions calculations have been completed. They are thus "diagnostic" figures; they are not used for emissions calculation.

$Frac_{GASF}$ is the relative N-quantity fraction that is emitted, as NH_3-N and NO-N, as a result of application of mineral fertilisers ($Frac_{GASF}$). $Frac_{GASF}$ is calculated in accordance with the definition in CRF-4.Ds2.

The definition of $Frac_{GASM}$ given in CRF-4.Ds2 ("Fraction of livestock N excretion that volatilizes as NH_3 and NO_x") is in keeping with the definition implied by Equation 9 in IPCC (1996b)-4.112. This becomes apparent when Equation 9 in IPCC (1996b)-4.112 is reformulated in terms of $Frac_{GASM}$:

Equation 8: Derivation of $Frac_{GASM}$ from Equation 9 in IPCC (1996b)-4.112

$$Frac_{\mathrm{GASM,\,Eq.9}} = \frac{E_{\mathrm{N2O}} / EF_4 - N_{\mathrm{fert}} \cdot Frac_{\mathrm{GASF}}}{N_{\mathrm{ex}}}$$

Where

$Frac_{GASM,\ Eq.\ 9}$	$Frac_{GASM}$ value from Equation 9 in IPCC (1996b)-4.112 (in Gg Gg-1)
E_{N2O} / EF_4	Total emissions of N_2O-N from agricultural soils, via deposition of reactive nitrogen from emissions of NH_3-N and NO-N (in Gg a^{-1} N_2O-N)
$N_{fert} \cdot Frac_{GASF}$	Emissions of N_2O-N via deposition of reactive nitrogen from emissions of NH_3-N and NO-N from application of mineral fertiliser (in Gg a^{-1} N_2O-N)
N_{ex}	total national N quantity from animal excretions (in Gg a^{-1} N)

This definition does not take account of NH_3 and NO emissions from straw bedding, while the German inventory does take account of straw bedding. The N quantity input via straw bedding, and the resulting emissions, are covered by the N-flow concept used by Germany, however (cf. Chapter 6.1.2.4). To ensure the consistency of Germany's inventory results, they thus have to be taken into account in the definition of $Frac_{GASM}$. These considerations lead to the definition of the value as reported by Germany, $Frac_{GASM,\ Germany}$:

Equation 9: Definition of the value $Frac_{\text{GASM, Germany}}$

$$Frac_{\text{GASM, Germany}} = \frac{E_{\text{NH3-N, MM}} + E_{\text{NH3-N, grazing}} + E_{\text{NO-N, storage}} + E_{\text{NO-N, application}} + E_{\text{NO-N, grazing}}}{m_{\text{excr}} + m_{\text{straw}}}$$

Where

$Frac_{\text{GASM, Germany}}$	Nitrogen fraction from animal excrement and straw bedding (straw) that is emitted as NH_3-N and NO-N (in Gg Gg^{-1})
$E_{\text{NH3-N, MM}}$	Emissions of NH_3-N from manure management (in Gg a^{-1} NH_3-N)
$E_{\text{NH3-N, grazing}}$	Emissions of NH_3-N from grazing (in Gg a^{-1} NH_3-N)
$E_{\text{NO-N, storage}}$	Emissions of NO-N manure storage (in Gg a^{-1} NO-N)
$E_{\text{NO-N, application}}$	Emissions of NO-N as a result of manure application (in Gg a^{-1} NO-N)
$E_{\text{NO-N, grazing}}$	Emissions of NO-N as a result of N excretions during grazing (in Gg a^{-1} NO-N)
m_{excr}	N quantity excreted in animal husbandry (including grazing) (in Gg a^{-1} N)
m_{straw}	N quantity introduced in animal husbandry via straw bedding (straw) (in Gg a^{-1} N)

Because the relevant input data vary over time, $Frac_{\text{GASM, Germany}}$ is not a constant.

As a result of the aforementioned differences between the $Frac_{\text{GASM}}$ definitions, it is not possible to confirm the indirect N_2O emissions (CRF-4.Ds1.3.1) as reported in the German inventory by inserting $Frac_{\text{GASM, Germany}}$ into Equation 9 from IPCC (1996b)-4.112.

With regard to the results for $\text{Frac}_{\text{GASF}}$ und $\text{Frac}_{\text{GASM, Germany}}$, cf. Chapter 6.5.2.2.

6.5.2.1.8 The other Frac values

Like $\text{Frac}_{\text{GASF}}$ and $\text{Frac}_{\text{GASM}}$ (cf. Chapter 6.5.2.1.7), the Frac values described below are solely "diagnostic" values that cannot be used for emissions calculation.

$Frac_{\text{BURN}}$ is not reported (NO), since field burning of crop residues is prohibited in Germany.

$Frac_{\text{FUEL}}$ is not reported (NO), since use of animal excrement as fuel is of no significance in Germany.

In keeping with the definition in CRF-4.Ds2, $Frac_{\text{GRAZ}}$ is calculated as the ratio of N excreted during grazing to total N excretions.

$Frac_{\text{LEACH}}$ shows the relative fraction of N soil inputs that is lost via leaching and surface run-off. *Für* $Frac_{\text{LEACH}}$, the German inventory, in keeping with IPCC (1996b), p. 4.106, uses a constant value of 0.30 kg kg^{-1} N.

$Frac_{\text{NCRBF}}$ describes the N fraction in dry matter of N-fixing plants. It is calculated as a weighted average of the contributions of field peas, broad beans, yellow lupins, clover, clover-containing mixtures, alfalfa, garden peas, bush beans and runner beans. The method for calculating $Frac_{\text{NCRBF}}$ has been modified with respect to the NIR 2011: Now, the N content of the entire plant, including harvested parts, is used as a basis, while the earlier calculation method only took crop residues into account.

$Frac_{\text{NCR0}}$ describes the N fraction in the dry matter of non-N-fixing plants (weighted mean from crop cultivation and horticulture). The method for calculating $Frac_{\text{NCR0}}$ has also been modified with respect to the NIR 2011, in a manner similar to the change made for $Frac_{\text{NCRBF}}$.

In accordance with the definition in CRF-4.Ds2, $Frac_{\text{R}}$ / $Frac_{\text{Remove}}$ are calculated as a fraction of the above-ground biomass that is removed as part of the harvest. That fraction can be usefully determined for those crops that form above-ground fruit. In the German inventory, it is calculated for grain, rape, peas, beans, lupins and grasses. Root crops and vegetables are not taken into account (the latter is not included for reasons of inadequate data). The quantities of straw that are used for straw bedding (Chapter 6.1.3.2.5) also do not enter into calculation of $Frac_R$ and $Frac_{Remove}$.

With regard to the uncertainties for the animal population figures, cf. Chapter 6.5.2.2.

6.5.2.2 Activity data and additional information (4.D)

The following tables present activity data and additional information that serve as a basis for calculation of direct and indirect N_2O emissions from the area of agricultural soils.

Table 182 shows the activity data used for calculation of direct N_2O emissions. With regard to determination of these activity data, cf. Chapter 6.5.2.1.2.

The time series for the area covered with organic soils (cf. Table 183) has been updated with respect to the NIR 2011, for consistency with the LULUCF sector (cf. CRF 5.B - Chapter 7.3 and CRF 5.C - Chapter 7.4). The area covered by organic soils consists of that area represented by the data in CRF Table 5B, cell D10 (cropland), and CRF Table 5C, cell D10 (grassland), although the values in cells D 13, 14,19, 22, 25, 27, 30 and 33 (Woody grassland) have to be deducted from the value in cell D 10. An additional 16,786 ha, representing undrained grassland on organic soils, are subtracted from the resulting area. The so-determined area represents the entire area for agriculturally used, drained soils for which N_2O emissions are calculated in the agricultural sector.

Table 182: N quantities on which calculation of direct N_2O emissions is based (4.Ds1.1.1 through 4.Ds1.1.4)

[Gg a⁻¹ N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral fertiliser	2089.3	1943.3	1863.1	1744.9	1552.9	1720.8	1702.7	1689.9	1718.2	1827.7
Farm manure	899.7	808.5	798.1	796.4	810.8	808.8	815.5	799.0	802.1	795.8
Grazing	207.3	192.5	191.5	194.1	167.2	171.4	173.9	169.1	166.7	166.6
Sewage sludges	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
N fixing, legumes	140.4	102.8	87.0	91.6	93.2	95.6	98.9	106.8	115.6	107.7
Crop residues	841.4	802.4	727.6	802.1	740.0	785.2	813.9	855.8	858.2	867.7
[Gg a⁻¹ N]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Mineral fertiliser	1935.9	1768.3	1713.9	1710.8	1747.6	1704.1	1705.6	1525.9	1728.8	1467.3
Farm manure	788.2	801.9	785.9	780.8	766.2	771.1	759.0	770.4	774.2	780.0
Grazing	162.5	162.3	154.2	150.5	146.1	143.5	139.5	139	139.7	139.3
Sewage sludges	33.0	29.9	28.2	29.3	28.3	27.4	27.0	27.8	27.7	27.9
N fixing, legumes	95.6	102.3	97.5	95.5	91.8	94.7	92.7	83.2	76.4	78.3
Crop residues	851.9	882.0	829.0	728.7	933.4	890.9	828.9	890.7	956.7	999.9
[Gg a⁻¹ N]	**2010**									
Mineral fertiliser	1499.3									
Farm manure	768.7									
Grazing	137.0									
Sewage sludges	27.9									
N fixing, legumes	77.0									
Crop residues	905.5									

Table 183: Area of cultivated organic soils, in the NIR 2012 and in the NIR 2011, on which calculation of direct N_2O emissions is based (4.Ds1.1.5)

[thousands of ha]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Org. soils, 2012	1235	1236	1237	1237	1238	1239	1239	1240	1241	1241
Org. soils, 2011	1325	1324	1323	1322	1321	1320	1320	1319	1318	1317
[thousands of ha]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Org. soils, 2012	1242	1241	1239	1238	1237	1235	1234	1233	1232	1231
Org. soils, 2011	1316	1314	1311	1309	1306	1303	1298	1293	1286	1287
[thousands of ha]	**2010**									
Org. soils, 2012	1230									
Org. soils, 2011										

The NH_3 and NO emissions on which calculation of indirect N_2O emissions from deposition of reactive nitrogen is based are summarised in Table 184. With those figures, and via multiplication by 14/17 for NH_3 and 14/30 for NO, the quantity of reactive nitrogen on which N_2O calculation is based can be calculated; cf. Table 185.

Table 184: Sums, as calculated for the inventory, of NH_3 and NO emissions from German agriculture that serve as a basis for calculation of deposition-related indirect N_2O emissions

[Gg a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NH3}	662.8	595.7	584.5	583.6	555.8	559.5	562.4	553.3	557.5	556.1
E_{NO}	89.7	82.5	79.9	76.8	71.3	75.8	75.6	74.6	75.4	78.1
[Gg a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
E_{NH3}	551.7	560.9	548.7	544.5	537.6	531.0	526.5	528.8	530.7	540.4
E_{NO}	80.6	76.7	74.5	74.2	74.6	73.4	73.0	68.6	74.0	67.5
[Gg a^{-1}]	**2010**									
E_{NH3}	513.5									
E_{NO}	67.6									

Table 185: N_2O from deposition: Reactive nitrogen N_{reac} upon which the calculation is based (4.Ds1.3.1)

[Gg a^{-1}N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_{reac}	587.7	529.0	518.6	516.5	491.0	496.1	498.5	490.5	494.3	494.5
[Gg a^{-1}N]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
N_{reac}	491.9	497.7	486.6	483.1	477.5	471.6	467.6	467.4	471.6	476.6
[Gg a^{-1}N]	**2010**									
N_{reac}	454.4									

Table 186: Leached N fraction (including surface run-off) (4.Ds1.3.2)

[Gg a^{-1}N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_{leach}	1116.7	1029.6	980.8	970.5	900.4	961.0	967.1	971.0	980.9	1008.8
[Gg a-1N]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
N_{leach}	1027.6	995.5	958.9	928.8	986.8	965.1	944.1	913.4	984.3	928.3
[Gg a-1N]	**2010**									
N_{leach}	907.7									

For the relevant fraction quantities (*Frac*-Größen, cf. Chapters 6.5.2.1.7 and 6.5.2.1.8), the time series presented in the following tables were calculated for the German inventory. With regard to the definition of $Frac_{GASM, Germany}$ cf. Chapter 6.5.2.1.7. The quantities $Frac_{BURN}$ and $Frac_{FUEL}$ are of no relevance for the German inventory (NO). The value of $Frac_{LEACH}$ remains a constant 0.3 throughout the entire period covered by the report.

Table 187: FracGASF (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{GASF}$	0.034	0.034	0.033	0.036	0.037	0.037	0.038	0.038	0.039	0.039
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{GASF}$	0.039	0.043	0.043	0.043	0.044	0.042	0.044	0.046	0.043	0.054
	2010									
$Frac_{GASF}$	0.044									

Table 188: $Frac_{GASM, Germany}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{GASM, Germany}$	0.316	0.314	0.314	0.312	0.305	0.303	0.302	0.303	0.303	0.302
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{GASM, Germany}$	0.302	0.301	0.301	0.302	0.301	0.301	0.300	0.300	0.299	0.298
	2010									
$Frac_{GASM, Germany}$	0.296									

Table 189: $Frac_{GRAZ}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{GRAZ}$	0.131	0.135	0.136	0.138	0.121	0.124	0.125	0.124	0.122	0.123
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{GRAZ}$	0.121	0.12	0.117	0.115	0.114	0.112	0.111	0.109	0.109	0.108
	2010									
$Frac_{GRAZ}$	0.108									

Table 190: $Frac_{NCRBF}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{NCRBF}$	0.0481	0.0490	0.0475	0.0473	0.0469	0.0450	0.0438	0.0430	0.0417	0.0406
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{NCRBF}$	0.0417	0.0395	0.0402	0.0373	0.0395	0.0417	0.0424	0.0441	0.0437	0.0437
	2010									
$Frac_{NCRBF}$	0.0434									

Table 191: $Frac_{NCR0}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{NCR0}$	0.0274	0.0265	0.0272	0.0272	0.0271	0.0264	0.0260	0.0253	0.0255	0.0248
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{NCR0}$	0.0251	0.0241	0.0251	0.0234	0.0231	0.0240	0.0236	0.0245	0.0225	0.0224
	2010									
$Frac_{NCR0}$	0.0232									

Table 192: $Frac_{R}$ ($Frac_{Remove}$) (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{R}$	0.65	0.64	0.64	0.64	0.63	0.63	0.64	0.63	0.63	0.62
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$Frac_{R}$	0.63	0.62	0.62	0.62	0.62	0.62	0.62	0.63	0.63	0.63
	2010									
$Frac_{R}$	0.63									

Changes in $Frac_{NCR0}$ and $Frac_{NCRBF}$, with respect to the NIR 2011, are the result of modification of the calculation method; cf. Chapter 6.5.2.1.8.

In the present NIR 2012, $Frac_{R}$ ($Frac_{Remove}$) is higher than it is in the NIR 2011, for the following reason: With regard to removal for harvest, until the NIR 2011 silage maize was treated, erroneously, like grain maize, i.e. as if its green above-ground biomass was not removed. As of the present submission, the correct procedure is used, in which the entire above-ground biomass of silage maize is deducted, as part of the harvest.

6.5.2.3 Calculated emissions from the area of agricultural soils (4.D)

The results of the relevant N_2O and NO emissions calculations are presented in Table 193.

Table 193: N_2O and NO emissions E_{N2O} and E_{NO} from agriculturally used soils (4s1, 4s2)

[Gg a^{-1} N_2O], [Gg a^{-1} NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{N2O}	153.7	142.8	137.1	135.9	127.3	134.2	135.0	135.3	136.4	139.6
E_{NO}	88.6	81.5	78.9	75.8	70.3	74.8	74.5	73.6	74.4	77.1
[Gg a^{-1} N_2O], [Gg a^{-1} NO]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
E_{N2O}	141.6	138.1	133.6	130.1	136.5	133.9	131.4	127.9	136.0	129.7
E_{NO}	79.6	75.7	73.5	73.2	73.6	72.4	72.0	67.6	73.0	66.5
[Gg a^{-1} N_2O], [Gg a^{-1} NO]	**2010**									
E_{N2O}	127.0									
E_{NO}	66.6									

As Table 193 clearly shows, N_2O emissions decreased from 1990 to 1992. Thereafter, N_2O emissions fluctuated around a mean of 135.4 Gg a^{-1} N_2O. The pertinent emissions maximum, 153.7 Gg a^{-1} N_2O, occurred in 1990, while the minimum, 127.0 Gg a^{-1} N_2O, occurred in 2010. For 2010, a share of 22.7 % of N_2O emissions from soils can be allocated to use of mineral fertilisers in the soil; 13.7 % can be allocated to crop residues; 11.6 % can be allocated to application of farm manure; 11.9 % can be allocated to cultivation of organic soils; and 27.4 % can be allocated to indirect emissions as a result of leaching and surface runoff. The remaining emissions consist of emissions from grazing, sewage sludge, legumes and indirect emissions from deposition of reactive N species. The time series for N_2O emissions from the various relevant sub-sources are shown in Table 197.

6.5.2.4 Implied emission factors (IEF) (4.D)

No implied emission factor (*IEF*) can be calculated for total N_2O emissions from the area of agricultural soils, because the various relevant N_2O sub-emissions involved are tied to different types of activity data.

With regard to the emission factors that must be assigned to the relevant sub-emissions, we refer to Chapter 6.5.2. An international comparison is presented in Chapter 6.5.3.

6.5.3 Source-specific QA/QC and verification (4.D)

Chapter 6.1.5 provides an overview of measures implemented relative to source-specific QA/QC and verification.

For purposes of verification, the following table compares the N_2O emission factors used for the present NIR 2012 with the corresponding figures, from last year, of neighbouring countries, including the UK (UNFCCC 2011). Apart from a few exceptions, all listed countries use the default emission factors of IPCC (1996b).

Table 194: Comparison of the N_2O emission factors used in the German inventory with those of neighbouring countries

[kg kg^{-1} N_2O-N]	EF_{N2O, min_fert}	$EF_{N2O, manure}$	$EF_{N2O, legumes}$	$EF_{N2O, crop\_residues}$	$EF_{N2O, histosols}$ *	$EF_{N2O, grazing}$	$EF_{N2O, deposition}$	$EF_{N2O, leaching}$
Austria	0.0125	0.0125	0.0125	0.0125	NO	0.0200	0.010	0.0250
Belgium	0.0125	0.0125	0.0125	0.0125	8.00	0.0000	0.025	0.0000
Czech Republic	0.0125	0.0125	0.0125	0.0125	NO	0.0200	0.010	0.0250
Denmark	0.0125	0.0125	0.0125	0.0125	8.00	0.0125	0.000	0.0100
France	0.0125	0.0125	0.0125	0.0125	NO	0.0125	0.000	0.0100
Germany	**0.0125**	**0.0125**	**0.0125**	**0.0125**	**8.00**	**0.0200**	**0.010**	**0.0250**
Netherlands	0.0130	0.0093	0.0100	0.0100	4.70	0.0336	0.010	0.0250
Poland	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.010	0.0251
Switzerland	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.010	0.0250
UK	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.010	0.0250
IPCC(1996)-3-4.89, 4.97, 4.105	0.0125	0.0125	0.0125	0.0125	5.00	0.0200	0.010	0.0250
IPCC (2000)-4.43, 4.60, 4.73	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.010	0.0250
IPCC(2006)-11.6, 11.11, 11.24	0.0100	0.0100	No method	0.0100	8.00	0.01 0.02	0.010	0.0075

* units: kg ha-1 N2O-N

Source: Germany: Submission 2012; other countries: UNFCCC 2011

Table 195 compares the fractions $Frac_{GASF}$, $Frac_{GASM}$, $Frac_{GRAZ}$, $Frac_{LEACH}$, $Frac_{NCR0}$, $Frac_{NCRBF}$ and $Frac_{Remove}$, as determined for Germany, with the corresponding figures for countries that either are neighbours or have agricultural sectors that are comparable to that of Germany.

The spread seen in the case of $Frac_{GASF}$ can be explained as the result of differences in urea fractions. That possibility cannot be comprehensively assessed, however, since the different fertiliser types' shares of the total relevant fertiliser quantities is not known.

The spread seen in the case of $Frac_{GASM}$ is due to the differences, among neighbouring countries, in application techniques and time normally allotted to working fertiliser into the soil. The German $Frac_{GASM}$ value is the $Frac_{GASM, Germany}$ value defined in Chapter 6.5.2.1.7

With regard to $Frac_{LEACH}$, it is worthy of note that most neighbouring countries use the IPCC default value. Use of other $Frac_{LEACH}$ values cannot be understood without additional information. In principle, this also applies to $Frac_{NCR0}$, $Frac_{NCRBF}$ and $Frac_{R}$, although Germany calculates those values from the data used for emissions calculation.

Table 195: Comparison of the *Frac* values used in the German inventory with those of neighbouring countries (those of Germany, for 2009; those of other countries, for 2008)

[kg kg^{-1}]	$Frac_{GASF}$	$Frac_{GASM}$	$Frac_{GRAZ}$	$Frac_{LEACH}$	$Frac_{NCR0}$	$Frac_{NCRBF}$	$Frac_{Remove}$
Austria	0.04	0.27	0.06	0.30	0.01	0.03	0.34
Belgium	0.03	0.31	0.31	0.12	0.02	0.03	0.49
Czech Republic	0.10	0.20	0.21	0.30	0.02	0.03	0.45
Denmark	0.00	0.00	0.00	0.00	0.00	0.00	0.00
France	0.10	0.20	0.41	0.30	0.01	0.03	NA
Germany	**0.04**	**0.30** [1)]	**0.11**	**0.30**	**0.02**	**0.04**	**0.63**
Netherlands	0.05	0.10	0.16	0.12	NE	NE	NE
Poland	0.10	0.20	0.07	0.30	0.01	0.03	0.44
Switzerland	0.04	0.33	0.19	0.20	0.02	0.02	0.70
UK	0.10	0.20	0.52	0.30	0.02	0.03	0.45
IPCC(1996)-3-4.94, 4.106	0.100	0.200	Table 4-19	0.30	0.02	0.03	0.45
IPCC(2006)-11.13, 11.14, 11.24	0.100	0.200	Equation 11.5:	0.30	Equation 11.6:	Equation 11.6:	Equation 11.6:

1) $Frac_{GASM, Germany}$ pursuant to Chapter 6.5.2.1.7

Source: Germany for 2010: Submission 2012; other countries for 2009: UNFCCC 2011

6.5.4 *Uncertainties and time-series consistency (4.D)*

With regard to the uncertainties in the area of N_2O emissions from agricultural soils, the reader's attention is called to Table 133 in Chapter 6.1.4 (total uncertainty of the German GG inventory).

For the NO emission factor for application of mineral fertiliser and farm manure, EMEP (2009)-4D-11, Table 3-1, gives an uncertainty range (95 % confidence interval) that corresponds approximately to a factor of 5. That factor is likely to be suitable for the NO emissions themselves (in light of the considerably lower uncertainty for the pertinent activity data).

EMEP (2009) provides no data for NO from grazing. According to EMEP (2003)-1020-15, the uncertainty factor could well be 5 or higher.

All emissions time series are consistent, since they were calculated with the same method for all years of the report period, and since the input data are also consistent and all data gaps have been filled in.

6.5.5 *Source-specific recalculations (4.D)*

In comparison to the NIR 2011, the following main changes have resulted (cf. Table 196 and Table 197):

- Updating of animal models and key index values for feed, as described in Chapter 6.1.3.3, has led to a reduction of total N excretions with respect to the NIR 2011 (cf. the context for Table 192 in Chapter 6.1.3.2.3). As a direct result, the N quantities entering the soil via manure application and grazing have decreased with respect to the NIR 2011. That, in turn, leads to correspondingly lower N_2O emissions.
- The N quantities from crop residues upon which the N_2O calculation is based are lower, throughout, in the NIR 2012 than the corresponding figures in the NIR 2011. The reason for that is the correction relative to silage maize (cf. Chapter 6.5.2.2). The lower N quantities from crop residues translate into correspondingly lower N_2O emissions.

- In the present NIR 2012, N_2O emissions from cultivation of organic soils are lower, for all years of the period covered by the report, than they were in the NIR 2011. This is due to updating of the time series for the areas with organic soils (cf. Chapter 6.5.2.2)
- In the area of biological N-fixing, a data-transfer error, relative to the area under cultivation with peas, in the year 2009 in Saxony-Anhalt, was corrected. That correction led to slightly lower N-fixing, and a corresponding decrease in N_2O emissions with regard to the NIR 2011.
- The currently reported quantities of landfilled reactive nitrogen are lower than the quantities reported in the NIR 2011. The reasons for this include lower emissions of NH_3 and NO, as a result of updated and thus lower animal N excretions (cf. Chapters 6.1.3.2.3 and 6.1.3.3); new activity data on stall and storage systems and manure application; additional NH_3-reduction measures; and a new assessment with the result that NO emissions from legumes and crop residues do not occur (cf. Chapter 6.5.2.1.3). N_2O emissions are correspondingly lower as a result.
- In the NIR 2012, the N losses from the soil resulting from leaching and surface runoff are lower, for all years of the time series, than the relevant values in the NIR 2011. The reason for this is that total N inputs into the soil from manure application and crop residues have been reduced (see above). A slight partial offset results from intensified N inputs into the soil as a result of elimination of calculation of NO emissions for legumes and crop residues (cf. Chapter 6.5.2.1.3). Overall, N_2O emissions are lower than as reported in the NIR 2011.
- In the area of sewage sludge, the data reported for 2011 and for 2012 differ only with respect to the years 2007 and 2009. This is the result of updating of the sewage-sludge quantity entered for those years.
- The time series for mineral-fertiliser N quantities, and for the resulting N_2O emissions, remain unchanged, as Table 196 and Table 197 show.

As a result of the above-described changes, N_2O emissions from agriculturally used soils have decreased, with respect to the NIR 2011, for all years of the period covered by the report (1990: -4.1 %; 2009: -7.1 %).

Table 196: Comparison of N quantities, as reported in 2011 and as reported in 2012, used to calculate N_2O emissions from agricultural soils (4.D)

[Gg a^{-1} N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral fertilisers, 2012	2089.3	1943.3	1863.1	1744.9	1552.9	1720.8	1702.7	1689.9	1718.2	1827.7
Mineral fertilisers, 2011	2089.3	1943.3	1863.1	1744.9	1552.9	1720.8	1702.7	1689.9	1718.2	1827.7
Manure, 2012	913.6	821.0	810.5	808.6	823.1	821.0	827.8	811.1	814.2	807.8
Manure, 2011	935.9	842.2	828.1	826.0	842.8	841.3	849.0	835.6	838.0	830.2
Grazing, 2012	206.4	191.7	190.7	192.9	166.7	170.8	173.3	168.6	166.2	166.1
Grazing, 2011	212.1	198.6	200.9	204.1	176.1	180.6	184.2	180.4	178.3	177.6
Crop residues, 2012	841.4	802.4	727.6	802.1	740.0	785.2	813.9	855.8	858.2	867.7
Crop residues, 2011	1028.9	981.8	899.4	1012.1	904.7	956.9	1017.8	1055.4	1047.6	1052.7
N fixing, 2012	140.4	102.8	87.0	91.6	93.2	95.6	98.9	106.8	115.6	107.7
N fixing, 2011	140.4	102.8	87.0	91.6	93.2	95.6	98.9	106.8	115.6	107.7
Indirect, deposition 2012	587.7	529.0	518.6	516.5	491.0	496.1	498.5	490.5	494.3	494.5
Indirect, deposition 2011	604.0	545.4	531.1	530.3	506.6	512.9	517.3	512.2	515.6	514.9
Indirect, leaching, 2012	1116.7	1029.6	980.8	970.5	900.4	961.0	967.1	971.0	980.9	1008.8
Indirect, leaching, 2011	1170.5	1081.5	1030.7	1030.5	948.9	1011.4	1026.4	1030.3	1037.3	1063.6
Sewage sludge, 2012	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
Sewage sludge, 2011	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
[Gg a^{-1} N]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Mineral fertilisers, 2012	1935.9	1768.3	1713.9	1710.8	1747.6	1704.1	1705.6	1525.9	1728.8	1467.3
Mineral fertilisers, 2011	1935.9	1768.3	1713.9	1710.8	1747.6	1704.1	1705.6	1525.9	1728.8	1467.3
Manure, 2012	800.0	813.9	797.6	792.4	777.6	782.5	770.2	781.7	785.6	791.4
Manure, 2011	817.4	828.9	808.9	806.5	790.4	794.7	777.8	790.8	798.0	802.5
Grazing, 2012	162.0	161.9	153.7	150.1	145.7	143.1	139.2	138.7	139.3	139.0
Grazing, 2011	174.7	176.8	170.4	168.6	165.5	164.5	160.5	160.6	162.3	161.8
Crop residues, 2012	851.9	882.0	829.0	728.7	933.4	890.9	828.9	890.7	956.7	999.9
Crop residues, 2011	1036.9	1060.6	1011.8	889.8	1133.3	1101.8	1024.7	1147.4	1220.6	1273.5
N fixing, 2012	95.6	102.3	97.5	95.5	91.8	94.7	92.7	83.2	76.4	78.3
N fixing, 2011	95.6	102.3	97.5	95.5	91.8	94.7	92.7	83.2	76.4	78.5
Indirect, deposition 2012	491.9	497.7	486.6	483.1	477.5	471.6	467.6	467.4	471.6	476.6
Indirect, deposition 2011	510.5	517.3	505.8	503.3	501.5	496.6	490.9	495.1	503.7	512.8
Indirect, leaching, 2012	1027.6	995.5	958.9	928.8	986.8	965.1	944.1	913.4	984.3	928.3
Indirect, leaching, 2011	1081.4	1047.4	1011.5	977.2	1045.0	1026.5	1000.5	985.7	1060.1	1006.1
Sewage sludge, 2012	33.0	29.9	28.2	29.3	28.3	27.4	27.0	27.8	27.7	27.9
Sewage sludge, 2011	33.0	29.9	28.2	29.3	28.3	27.4	27.0	26.0	27.7	27.7

Table 197: Comparison of N_2O emissions from agricultural soils as reported in 2011 and as reported in 2012 (4.D)

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{N2O} total, 2012	**153.7**	**142.8**	**137.1**	**135.9**	**127.3**	**134.2**	**135.0**	**135.3**	**136.4**	**139.6**
E_{N2O} total, 2011	**161.5**	**150.3**	**144.3**	**144.3**	**134.3**	**141.5**	**143.3**	**143.6**	**144.5**	**147.4**
Mineral fertilisers, 2012	41.0	38.2	36.6	34.3	30.5	33.8	33.4	33.2	33.7	35.9
Mineral fertilisers, 2011	41.0	38.2	36.6	34.3	30.5	33.8	33.4	33.2	33.7	35.9
Manure, 2012	17.7	15.9	15.7	15.6	15.9	15.9	16.0	15.7	15.8	15.6
Manure, 2011	18.1	16.3	16.0	16.0	16.3	16.3	16.4	16.2	16.2	16.1
Grazing, 2012	16.5	15.8	14.3	15.8	14.5	15.4	16.0	16.8	16.9	17.0
Grazing, 2011	20.2	19.3	17.7	19.9	17.8	18.8	20.0	20.7	20.6	20.7
Crop residues, 2012	15.5	15.5	15.5	15.6	15.6	15.6	15.6	15.6	15.6	15.6
Crop residues, 2011	16.7	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
Organic soils, 2012	6.5	6.0	6.0	6.1	5.3	5.4	5.5	5.3	5.2	5.2
Organic soils, 2011	6.7	6.3	6.3	6.4	5.6	5.7	5.8	5.7	5.6	5.6
N fixing, 2012	2.8	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.3	2.1
N fixing, 2011	2.8	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.3	2.1
Indirect, deposition 2012	9.2	8.3	8.1	8.1	7.7	7.8	7.8	7.7	7.8	7.8
Indirect, deposition 2011	9.5	8.6	8.3	8.3	8.0	8.1	8.1	8.0	8.1	8.1
Indirect, leaching, 2012	43.9	40.4	38.5	38.1	35.4	37.8	38.0	38.1	38.5	39.6
Indirect, leaching, 2011	46.0	42.5	40.5	40.5	37.3	39.7	40.3	40.5	40.7	41.8
Sewage sludge, 2012	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.6	0.6
Sewage sludge, 2011	0.5	0.5	0.5	0.5	0.5	0.7	0.7	0.7	0.6	0.6
[Gg a^{-1} N_2O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
E_{N2O} total, 2012	**141.6**	**138.1**	**133.6**	**130.1**	**136.5**	**133.9**	**131.4**	**127.9**	**136.0**	**129.7**
E_{N2O} total, 2011	**149.3**	**145.6**	**141.2**	**137.2**	**144.8**	**142.6**	**139.4**	**137.8**	**146.2**	**140.3**
Mineral fertilisers, 2012	38.0	34.7	33.7	33.6	34.3	33.5	33.5	30.0	34.0	28.8
Mineral fertilisers, 2011	38.0	34.7	33.7	33.6	34.3	33.5	33.5	30.0	34.0	28.8
Manure, 2012	15.5	15.8	15.4	15.3	15.1	15.1	14.9	15.1	15.2	15.3
Manure, 2011	15.8	16.0	15.7	15.6	15.3	15.4	15.1	15.3	15.4	15.5
Grazing, 2012	16.7	17.3	16.3	14.3	18.3	17.5	16.3	17.5	18.8	19.6
Grazing, 2011	20.4	20.8	19.9	17.5	22.3	21.6	20.1	22.5	24.0	25.0
Crop residues, 2012	15.6	15.6	15.6	15.6	15.5	15.5	15.5	15.5	15.5	15.5
Crop residues, 2011	16.5	16.5	16.5	16.5	16.4	16.4	16.3	16.3	16.2	16.2
Organic soils, 2012	5.1	5.1	4.8	4.7	4.6	4.5	4.4	4.4	4.4	4.4
Organic soils, 2011	5.5	5.6	5.4	5.3	5.2	5.2	5.1	5.1	5.1	5.1
N fixing, 2012	1.9	2.0	1.9	1.9	1.8	1.9	1.8	1.6	1.5	1.5
N fixing, 2011	1.9	2.0	1.9	1.9	1.8	1.9	1.8	1.6	1.5	1.5
Indirect, deposition 2012	7.7	7.8	7.6	7.6	7.5	7.4	7.3	7.3	7.4	7.5
Indirect, deposition 2011	8.0	8.1	7.9	7.9	7.9	7.8	7.7	7.8	7.9	8.1
Indirect, leaching, 2012	40.4	39.1	37.7	36.5	38.8	37.9	37.1	35.9	38.7	36.5
Indirect, leaching, 2011	42.5	41.1	39.7	38.4	41.0	40.3	39.3	38.7	41.6	39.5
Sewage sludge, 2012	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Sewage sludge, 2011	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5

6.5.6 Planned improvements (4.D)

Efforts to improve modelling of feeding of swine continue (DÄMMGEN et al., 2011b). Possibly, findings from official survey of protein inputs in swine fattening during the period November 2010 to October 2011, which took place in fall 2011, can enter into the model. Improved modelling of feeding of swine will affect data on N excretions and, thus, on the N quantities entering the soil via manure management.

In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.

6.6 Prescribed burning of savannas (clearance of land by prescribed burning) (4.E)

Land clearance by prescribed burning is not practiced in Germany (NO).

6.7 Field burning of agricultural residues (4.F)

Burning of agricultural residues is prohibited in Germany. It is not possible to collect data on permitted exceptions. Such exceptions are considered to be irrelevant (NO).

7 LAND USE, LAND USE CHANGES AND FORESTRY (CRF SECTOR 5)

7.1 Overview (CRF Sector 5)

7.1.1 Source categories and total emissions and sinks, 1990 - 2010

In Germany, source category 5, Land Use, Land Use Changes and Forestry includes CO_2 emissions and sinks in the carbon pools above-ground and below-ground biomass, dead wood, dead organic matter and soils from the categories Forest Land (5.A), Cropland (5.B), Grassland (5.C), Wetlands (5.D), Settlements (5.E) and the relevant land-use changes. In the category Other Land (5.F), no anthropogenic emissions and sinks occur, since the relevant land areas are not used. No land-use changes occur in the category Other Land. CH_4 and N_2O from forest fires are taken into account in the land-use category Forest Land. No nitrogen fertilisation in forests takes place in Germany. On the other hand, N_2O emissions are taken into account from drained organic soils in the category forest land; humus mineralisation in mineral soils in categories of conversion to cropland; and CO_2 from liming. In wetlands, industrial peat extraction is taken into account. N_2O emissions from land-use changes on organic soils, leading to cropland and grassland, are reported in CRF Sector 4.D.

Figure 47 and Figure 48 provide an overview, for the present NIR 2012, of the development of greenhouse gas emissions in categories 5.A, 5.B, 5.C, 5.D and 5.E, differentiated by sub-categories and pools.

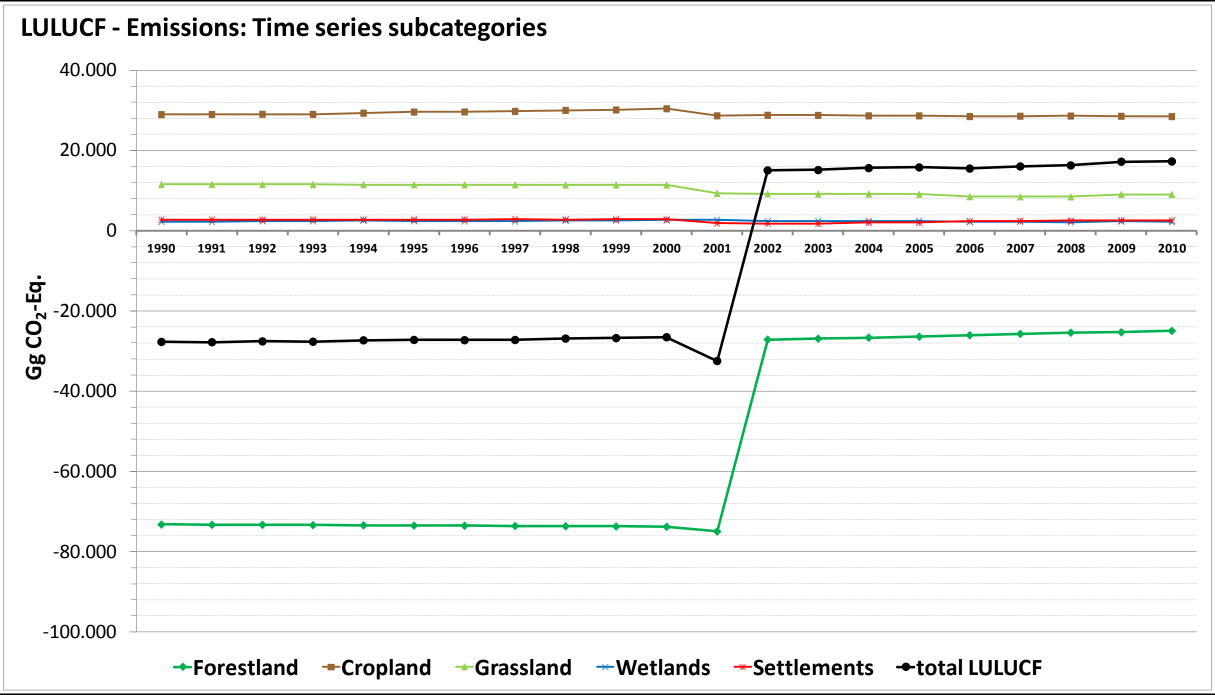


Figure 47: Time series for greenhouse gas emissions and sinks [Gg CO_2 equivalents] in the LULUCF sector since 1990, differentiated by sub-categories

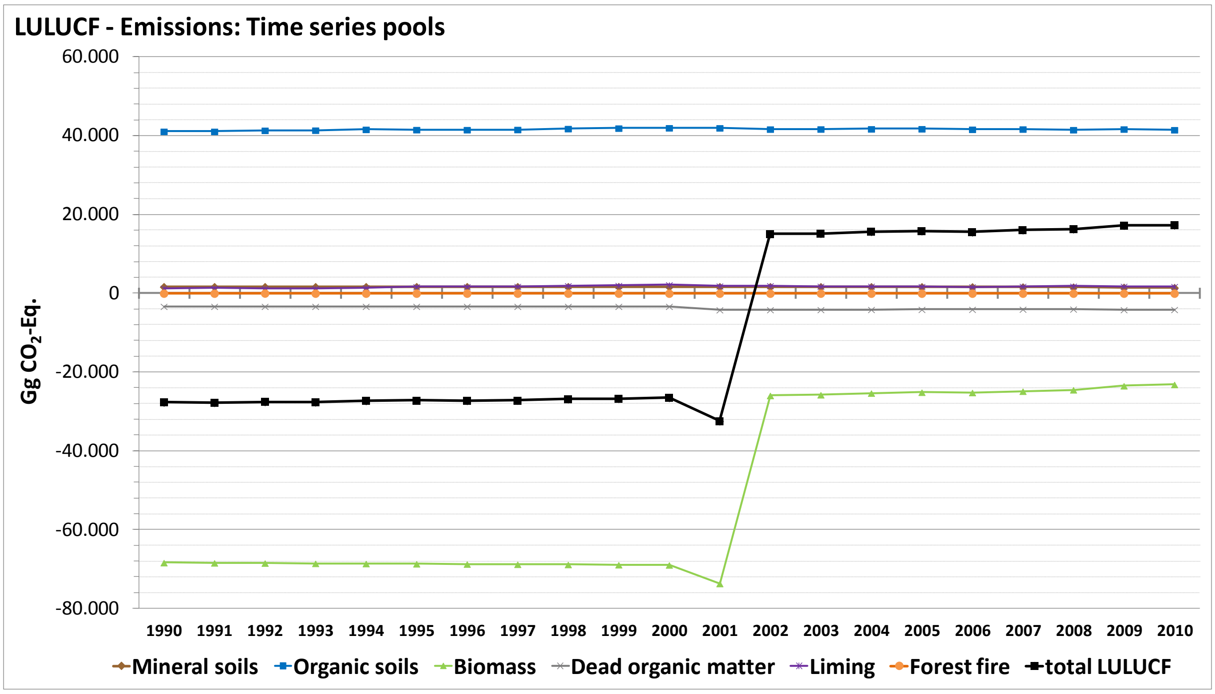


Figure 48: Time series for greenhouse gas emissions and sinks [Gg CO_2 equivalents] in the LULUCF sector since 1990, differentiated by source categories

For the first time in such reports, the present report includes a complete calculation of uncertainties for the entire LULUCF sector, using the Tier 1 method pursuant to IPCC (2000). The pertinent calculation shows that the total uncertainty for the German LULUCF inventory is 21.8 %. The relevant details are presented in the relevant chapters for the individual categories and in Chapter 19.5.4.

7.1.2 Methodological issues

For the present submission, calculation for CRF Sector 5 has been fundamentally changed with respect to the previous years. All the relevant changes required in the German LULUCF reporting system as a result of the 2010 In-Country Review (UNFCCC, 2011), and announced in the action plan for 2012 (FREIBAUER & GENSIOR 2011), have been implemented for the present submission:

4. For the present LULUCF inventory, land use and land-use changes in Germany are being documented for the first time via a complete-coverage sampling grid used to identify land-use areas since 1990. It is based on the existing grid used for the National Forest Inventory (Bundeswaldinventur – BWI; cf. Chapter 7.2.2.1).
5. For all land-use changes, including those in categories 5.B – 5.E, a transition period of 20 years was applied, in keeping with the IPCC Guidelines.
6. The emission factors for mineral soils in connection with land-use changes in categories 5.B – 5.E were recalculated using a symmetric approach and an expanded database (the increase in carbon stocks in connection with land-use changes from category A to B is equal to the decrease in carbon stocks in connection with land-use changes from category B to A).
7. In addition, numerous emission factors for biomass in connection with land-use changes in categories 5.B–5.E were improved with country-specific data derived from research projects and new data sources.
8. The bases of the new methodology were presented in two experts' workshops held in May 2011 (one national and one international). The participants considered the new methodology to be very appropriate for fulfilling the relevant reporting requirements. (Cf. Chapter 19.5.5).

7.1.3 Method for obtaining the land-use matrix

7.1.3.1 Introduction

The 2010 In-Country Review (UNFCCC, 2011) provided recommendations for changing the then-used method for identifying land uses and land-use changes. In the Submission 2011, Germany addressed some of those recommendations. The present submission now addresses the reviewers' key recommendation by introducing a consistent, unified methodology for identifying land-use changes in the LULUC and forestry sector. This expands the previously used sample-based system for determining forest land and land-use changes from and to forest land, for all land-use categories and changes. The new system is based on the grid of the BWI (National Forest Inventory) 2012. Considering the relevant reporting requirements, using the BWI 2012 grid for the sample-based system is an optimal choice, since only with the BWI grid a consistent land-use matrix can be established that is simultaneously consistent with

- the BWI estimates of forest area and
- the BWI carbon-stock change estimates.

The approach thus fulfills the stringent quality criteria required especially for the reporting under the Kyoto Protocol.

7.1.3.2 Database and data processing

The flexible LULUCF survey system consists of all available geographically explicit data sets. In order to use a data source in the system, it must be possible to transfer its pertinent land-use classes, as obtained via interpretation or modelling, into the LULUCF system. In each case, not every data set has to show all land-use classes. It is sufficient if only one – at least – of the six main land-use classes is given. Thus, for each sample point of the grid, a set of associated data distributed over time is available. The data sets differ in terms of their numbers of data items, in terms of their quality with respect to errors of position, preparation and interpretation, and, in some cases, with regard to their underlying definitions.

It is not the aim of this flexible LULUCF system to detect land-use changes as often as possible, but:

- to identify the most reliable land-use information from the wealth of available information,
- to filter out and detect land-use changes, and
- to eliminate any possible uncertainties and sources of error.

Therefore an unambiguous hierarchy system has been set up. Within this system, records have been arranged into a hierarchy of groups beginning with the most precise data (1^{st} quality level) and leading to the least precise data (n^{th} quality level), with precision in each case determined as of the relevant time of data collection. Within the hierarchical system, each entry refers to the state of land use in the year in which the relevant data source was collected, rather than to the pertinent change in one year or over one period. If, for a given year and a given sampling point, different land-use data sets are available, e. g. from different data sources, then the data set with the highest quality level (QL), pursuant to the hierarchy system, is used to define the pertinent land-use class. Where data sources with the same quality level show different land-use categories, additional rules for decision-making have been defined and documented. Such rules can be oriented to references such as verification data – for example, trends shown in agricultural statistics – that are not available in geo-referenced form.

7.1.3.2.1 Data sources

The following data sources / records have been used:

- Information on forest-related LULUCF classes from the National Forest Inventory (Bundeswaldinventur) 1 and 2, for the period 1987 to 2002 for the old German Länder; and from the data of the National Forest Inventory 2 and the Inventory Study (Inventurstudie) 2008 (OEHMICHEN et al. 2011), for 2002 to 2008 throughout Germany,
- The Basic Digital Landscape Model (Digitales Basis-Landschaftsmodell; Basis-DLM) for the years 2000, 2005, 2008 and 2010,
- CORINE 1990, 2000, 2006,
- GSE data for 1990, and for 2002 to 2006, for the new German Länder.

1st quality level: BWI data

Details relative to the National Forest Inventory (BWI) are described in Chapter 7.2.2.1. The BWI is a permanent, systematic cluster sample that is surveyed periodically. At present, BWI data are available referenced to 1987 and 2002 and, in a sub-sample, to 2008 (Inventory

Study 2008). The next BWI, which will be available as of the conclusion of the first commitment period in 2012, will provide new information. Land uses, and land-use changes leading to forest (afforestation) or away from forest (deforestation), are determined for each sample point, with the help of aerial photographs and country-specific maps. The forest definition used by the National Forest Inventory (BMVEL, 2001) is the basis for the reporting under the Convention; cf. Chapter 7.2.3.

The first German report under the Kyoto Protocol uses the following definition of "forest", which accords with the relevant FAO definition:

- Land with tree crown cover of more than about 10% of the area;
- The minimum land area to be taken into account is 0.1 ha;
- The potential tree height at maturity is at least 5 meters.

Within the limits defined by the Marrakesh Accords, that definition is the one that comes closest to the definition used in the National Forest Inventory. Studies (TOMTER et al. 2010) comparing activity-data calculations using the aforementioned definitions have found that the resulting discrepancies are negligible. For that reason, the same area-estimation algorithms have been used for purposes of both the UN Framework Convention on Climate Change and the Kyoto Protocol. At the same time, in a departure from the BWI definition of forest, areas that the BWI designate as forest, but assign to the forest category non-woodland, i.e. because they are permanently non-wooded, were not taken into account in the forestry sector in calculation of carbon stocks and carbon-stock changes.

For the new German Länder, no forest / non-forest information was available for the year 1987 at the relevant BWI points. In the interest of obtaining a maximally consistent database for the new German Länder, the individual-tree data of the BWI 2002 were used in the following manner: For 1987, the sample points were retroactively assigned to the land-use category Forest Land for those cases in which the BWI 2002, at the pertinent forest cluster points, listed trees that were more than 15 years old.

2nd Quality level: Basis-DLM data

The Basic Digital Landscape Model (Basis–Digitales Landschaftsmodell; Basis-DLM) is the basis for Germany's Official Topographical-Cartographical Infomation System (Amtliches Topographisch-Kartographisches Informationssystem; ATKIS®), which is managed by the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV). The ATKIS® system describes Germany's topography in terms of digital landscape and terrain models. "The Basis-DLM uses a vector format to describe topographic objects of the landscapes and the relief of the earth's surface. Each object is assigned to a specific object type and defined in terms of its spatial position, geometric type, descriptive attributes and relations to other objects. Each object has an identification number (identifier) that is unique throughout all objects for Germany. In the Basis-DLM, spatial position is given true to scale, and independently of any representations, within the coordinate system used for land surveying. The object types contained in the DLM, and the manner in which the objects are to be formed, are defined in the ATKIS® object-type catalogue (ATKIS®-OK)" (AdV 1). The informational spectrum of the Basis-DLM is oriented to the contents of standard 1:25,000 topographic maps. At the same time, the Basis-DLM features greater precision of position (± 3m) for the most important point-shaped and line-shaped objects. Data of the Basis-DLM systems of the Länder are adopted by the Federal Agency for Cartography and

Geodesy (BKG) and then checked, harmonised, georeferenced and processed, without any overlapping, for use within a nationally standardised Basis-DLM. The BKG also manages the data, within a special database, for purposes of provision to federal authorities and other agencies.

The purpose of ATKIS® is to provide a maximally up-to-date, high-resolution landscape model (land cover) of Germany, with regularly updated and expanded geometries and content. The surveying administrations of the Länder collect the pertinent data on an ongoing basis; they do not collect data as of a given key date, nor do they collect on a national basis. As a result, new surveying results are continuously transmitted to the Federal Agency for Cartography and Geodesy (BKG) and integrated within ATKIS®. The data are completely revised, at the Länder level, every five years or as otherwise necessary. For areas of central current interest, especially with regard to changes – for example, settlement and transport infrastructure – efforts are normally made to transfer relevant data into the ATKIS® system within 3 – 12 months. The Basis-DLM version maintained and managed by the BKG is always the latest version. No pertinent history data are recorded, nor are old versions archived.

For the reporting agency in the present context, this means:

- Basis-DLM are obtained on an annual basis; the Basis-DLM for a given report year is obtained in September of that year;
- In each case, the version for the current year is archived.

Basis-DLM data sets have been available to the reporting agency, on an annual basis, only since 2005. By chance, a record for the year 2000 could be obtained. No ATKIS® data exist for years prior to 2000.

Each data set in the Basis-DLM comprises some 800 individual layers of differing degrees of detail. For example, polygons with relatively low resolution (such as those showing settlement areas) are found on the lowest level, while polygons with very high resolution and rich detail (such as those showing residential areas) are found on the highest level. A single record thus will contain numerous superimposed polygons that, in terms of content, can be assigned to the same LULUCF categories. All such related content, with all overlays, is read into the system as a whole. As a result, data gaps occur only where the entire pertinent Basis-DLM data record contains no data. In a subsequent step, the areas so defined are merged with the points of the BWI network. Where a point touches several stacked areas, only a single value is chosen, with the help of a priority list. Where the same priorities overlap (for example, vegetation with vegetation), then that area with the lower ATKIS® identification value is used. This data-processing procedure, which has been introduced with the present submission, prevents multiple counting as a result of overlapping, as well as data gaps resulting from improper sorting of polygons (i.e. sorting of polygons into the wrong levels). The procedure has been carried out for the Basis-DLM records from the years 2000, 2005, 2008 and 2010. The Basis-DLM categories are assigned to the LULUCF classes with the help of a key table.

3rd quality level: CORINE Land Cover (CLC) data

CORINE Land Cover (CLC) is a European remote-sensing project, initiated by the EU Commission, for standardising classification of land use and land-use changes. In a process underway since the 1980s, digital satellite images of 32 Member States of the European

Union are being recorded in a standardised format and evaluated with regard to land use. Image data collected in three different years, 1990, 2000 and 2006, are available. CORINE data for the years 1990, 2000 and 2006 are being read into the database, with the help of a script. The CORINE classes are allocated to LULUCF classes with the help of a translation table.

4th quality level: GSE data

The GSE Forest Monitoring project is part of the Global Monitoring for Environment and Security (GMES) programme, which was established in 1998 by the European Commission and the European Space Agency (ESA). In the framework of the GSE Forest Monitoring project, the service "Forest Monitoring: Inputs for national greenhouse-gas reporting (GSE FM-INT; "Wald Monitoring: Inputs für die Nationale Treibhausgasberichterstattung") has been introduced for the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV). The products of that service have included maps of forest cover, land use and land-use changes, for 1990 and for pertinent changes through 2002 and 2005/06; area statistics; and error analyses for the new German Länder (GSE 2003, GSE 2006, GSE 2007, GSE 2009). Further information about the GSE FM-INT project is provided in OEHMICHEN et al. (2011b). For 1989 and 1990, Landsat satellite data were used. For 2001 to 2005, LISS data from the Indian IRS satellites were also used. Forest areas and their changes were classified with the help of Basis-DLM data, aerial photographs, topographic maps and elevation models. Following radiometric and geometric processing of the satellite data, the relevant structures were allocated to LULUCF classes via a monitored classification process. Subsequently, any obvious errors were corrected with the help of additional data sources, such as topographic maps, and any smaller artifacts were removed with filters or by manual retouching. Quality control was carried out on a random-sample basis, using orthophotos. According to the project specifications, all land areas and land-use changes entered into the system have to cover a minimum area of 0.5 hectares. The original data available to the Johann Heinrich von Thünen Institute (vTI) include land areas and land-use changes smaller than the 0.5ha down to a pixel size of 25m x 25m. Such smaller units may be considered similar to the "minimum mapping units" used in the National Forest Inventory (BWI). For purposes of the method used in the present context, the LULUCF classes were divided into land-use classes for the years 1990 and 2005.

7.1.3.2.2 Derivation of LULUCF information

In a subsequent step, each sample point is assigned the pertinent available information relative to land use for each year and data source. Now, classification in keeping with the LULUCF classes can begin. This is achieved via retrospective and prospective comparison – with reference to the year under consideration – to determine the time for each point at which land-use information on the highest available quality level is available (QL-MAX retrospective and QL-MAX prospective). For a BWI point designated as forest to which a land-use change class is to be assigned for 2001, data on the 1st quality level are available – the BWI information. Retrospectively, the last survey year for those data is 1987; prospectively, the next survey year is 2002. The LULUCF class is then derived from those two land-use classes, for the years 1987 and 2002.

Sample points at which the BWI data show forest were validated via on-site inspections during the forest inventories and may be considered correct. The Basis-DLM data for 2010 are also considered current and quality-assured, since that project used a strictly hierarchical nomenclature (and was the first to do so). All other records have been reviewed for plausibility of the assigned land-use class, for a given year, on the basis of additional data, and in keeping with the following criteria:

- Can the classification into a specific LULUCF class be substantiated with pertinent data from a lower quality level?
- Is the time series for the land-use categories for the sample point consistent, i.e. is the land use free of multiple changes? In cases with inconsistencies, the land-use change was placed in the relevant valid category for 2010.
- In cases involving land-use changes, and where placement in a LULUCF class can be substantiated, analysis was carried out to determine whether data of lower quality levels can be used to narrow down the time period in which the change must have occurred.
- To provide an additional criterion, the national trend in land-use changes (except for those changes to and from forest land) was compared with the national land-use-change rates obtained via the periodic land inventories and agricultural-structural inventories of the Federal Statistical Office. Those inventories use land-use-category definitions that differ – widely, in some cases – from those used in the present system.

In the following, an example is provided to illustrate the manner in which the time period in which a land-use change occurs is narrowed down. It is assumed that, on the basis of BWI data, a sample point was classified as forest land in 1987 and as settlements in 2002. If no additional data are available, the land-use change is linearly interpolated between those two years, meaning that 1/15 of the represented area would be converted each year from forest land to settlements. If Basis-DLM data are available for the point, and those data also show the category "forest land" for 2000 and also show the category "settlements" for 2005, then placement in the LULUCF class "forest land converted to settlements" would be logical and justified, and the change period could be narrowed down to 2 years (2000 = forest land in the Basis-DLM and 2002 = settlements pursuant to BWI) (cf. also Figure 49).

For each sample point and time, the process of selecting a land-use category – i.e. of carrying out relevant review and decision-making – has been carried out transparently, on the basis of a decision tree (cf. Chap. 7.1.3.4.1).

For conformity with GPG 2003, land-use changes since 1970 have to be taken into account under the Convention. The purpose of that requirement is to prevent land accumulation in the 20-year conversion classes from beginning in 1990, increasing continuously until 2009 and only then commencing with oscillation. At present, the earliest data available for Germany date from the BWI 1987; and, in general, for the period prior to 1990, no complete and internally consistent (the latter aspect is even more important) national data sets are available. Consequently, the changes in all land-use categories in the period 1990 - 2000 were extrapolated retroactively to 1970. That approach is in keeping with that used, for example, by the Czech Republic and by Austria for the land-use matrix.

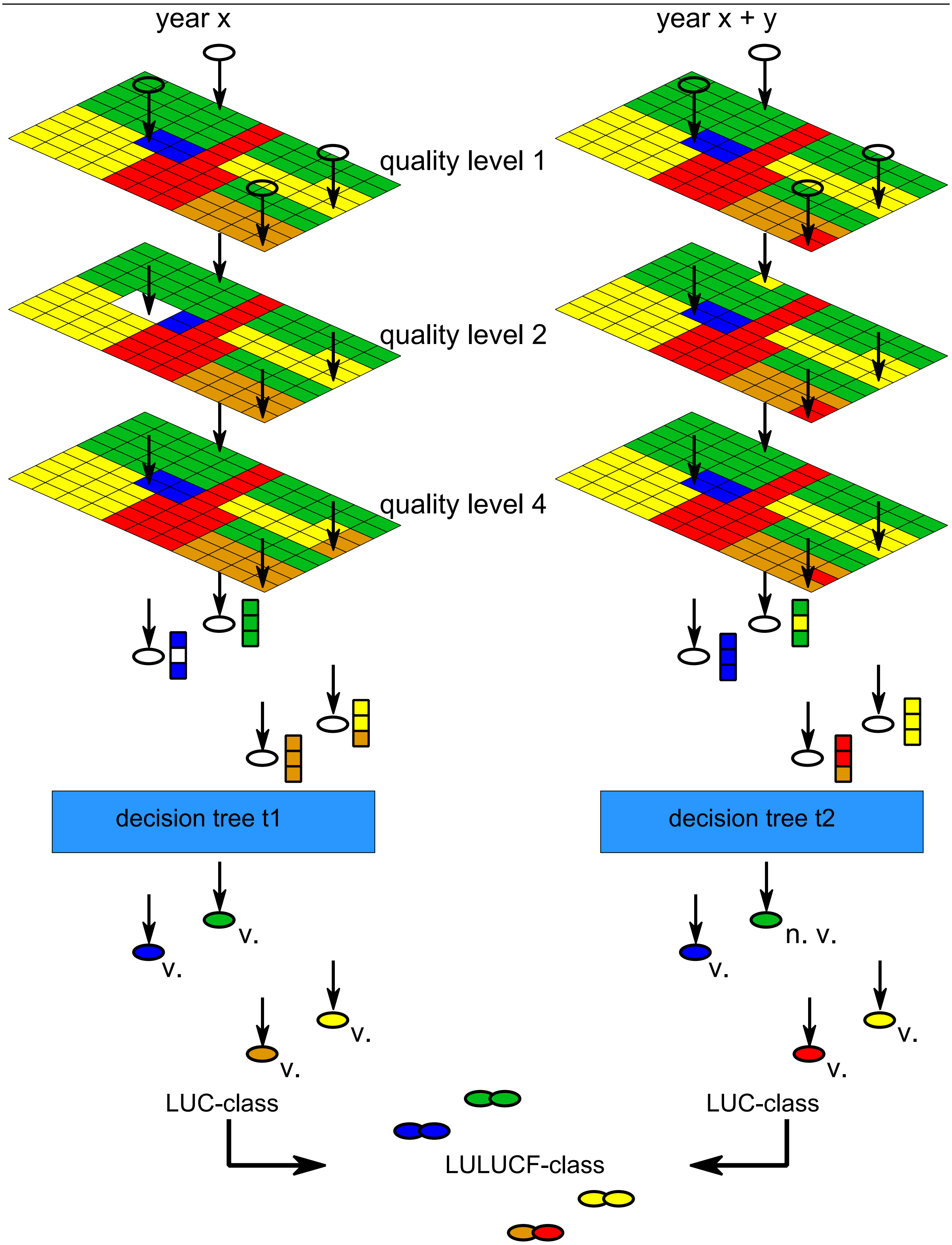


Figure 49: Schematic representation of allocation of sample points to a land-use category

7.1.3.3 Validation and error assessment

With the sampling method, various sources of error, such as

- additional sampling errors,
- differences in definitions, and
- discrepancies between Minimum Mapping Units,

can be quantified. On the other hand, error determination is hampered by the impossibility of achieving 100% accuracy in georeferencing of data sets.

Still, the three error sources mentioned immediately above can be eliminated, over time, via this flexible, sample based system. The reason for this is as follows: Pursuant to the decision tree, placement within a LULUCF category is assumed correct only if such placement has been derived from suitably precise data sets on the 1st quality level, and data from a lower quality level confirm the placement. In every other case – i.e. whenever different data sources disagree about land use at a given time – the relevant sample point has to be evaluated with the help of aerial photos. Due to time limitations, such additional evaluation was not carried out for the current submission. It is planned for the future, however, as part of ongoing inventory improvement. If no decision can be taken for a few points, even with the help of aerial photos, or if no aerial photos are available, the points will be assigned on-site. Once such additional validation has been carried out, inconsistencies in time series resulting from use of data sets with differing definitions, different Minimum Mapping Units or inconsistencies tied to imprecise geographic locations, can no longer occur.

Table 198 shows how many of the points are already considered validated, as a result of agreement in LULUCF categories throughout different quality levels.

Table 198: Percentage shares for validated point data

Year	1990	2000	2005	2008	2010
Already validated, in %	55.07	96.08	98.70	98.95	98.97

The percentage of points in 1990 that have not yet been validated is still very high. This is due to the system because for 1990, only CORINE data are available for all "non-forest" points in the BWI. Plans call for that percentage to be considerably improved via integration of new data sources (in particular, 1990 maps derived from ColorInfraRed data).

7.1.3.4 Step-by-step implementation

Complete implementation of this described new system for detecting land-use changes throughout Germany, over time, will necessitate extensive preliminary work and continuous supporting efforts. For example, the following have to be carried out:

- The various data materials, for different points in time, have to be acquired,
- Geometric corrections (erroneous geometries, etc.) and checks have to be carried out,
- Conversion functions have to be written for converting the original classifications into LULUCF classifications,
- The sample points have to be merged with the maps,
- The decision tree has to be programmed and adjusted as necessary, in keeping with data quality and availability, and
- The "transition-time" procedures have to be programmed and adjusted as necessary, in keeping with data quality and availability.

The decision to use this flexible, sample-based system was made in spring 2011, in consultation with the Single National Entity (Federal Environment Agency) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), which is responsible for forest inventories. Therefore, in 2011 it was possible to implement only the aforementioned nationally available data sources for the 2012 report. In future, point information will continue to be gradually validated, with the help of additional regional data.

Programming of the decision trees for each classification year, and of the "transition-time" procedures, has been adapted in keeping with this current data structure.

7.1.3.4.1 Derivation of land use in the years 1990, 2000, 2005, 2008 and 2010

Each sample point can be assigned to a land-use category for the respective years (1990, 2000, 2005, 2008 or 2010), on the basis of available data (cf. Chapter 7.1.3.2), and in keeping with the relevant quality levels. The basic table is structured as follows:

Table 199: Basis for derivation of land uses

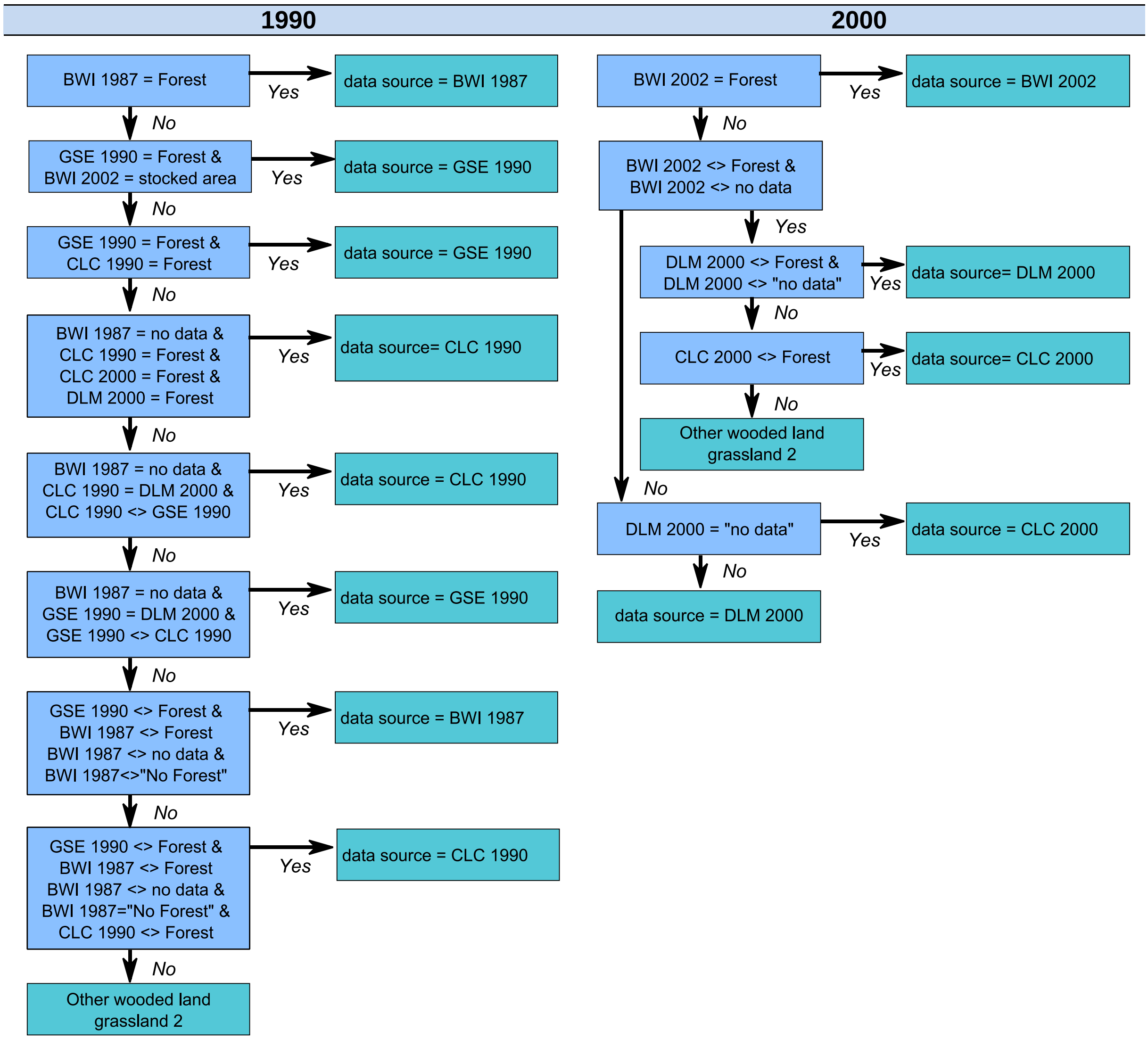
Cluster	Cluster point	BWI 1987	BWI 2002	BWI 2008	DLM 2000	DLM 2005	DLM 2008	DLM 2010	CORINE 1990	CORINE 2000	CORINE 2006	GSE 1990	GSE 2005
xya	1	forl	sett	sett	forl	sett	sett	sett	forl	gras	sett	gse0	gse0

The following codes were used for the land-use classes in the data records of the BWI, Basis-DLM, Corine and GSE:

Table 200: Codes in the basic table

Code	Category	Sub-category
crop	Cropland	Cropland
gra1	Grassland	Permanent grassland (in CRF: Grassland)
gra2	Grassland	Other grassland, woodlands (in CRF: Woody Grassland)
forl	Forest land	Forest land
wetl	Wetland	Wetland (in CRF: Wetlands)
gewa	Wetland	Waters (in CRF: Waters)
sett	Settlements	Settlements
othl	Other land	Other land
nofo	Non-forest land	The information is from BWI data, needs to be further specified with the help of other data sources and must be non-forest land.
bwi0	No information	No land-use information at this point in BWI data
dlm0	No information	No land-use information at this point in Basis-DLM data
clc0	No information	No land-use information at this point in Corine data
gse0	No information	No land-use information at this point in GSE data

For the years 1990, 2000, 2005, 2008 and 2010, the following decision trees (cf. the following Figure 50) were applied to this basic table.


1990
2000
BWI 1987 = Forest
Yes
data source = BWI 1987
No
GSE 1990 = Forest & BWI 2002 = stocked area
Yes
data source = GSE 1990
No
GSE 1990 = Forest & CLC 1990 = Forest
Yes
data source = GSE 1990
No
BWI 1987 = no data & CLC 1990 = Forest & CLC 2000 = Forest & DLM 2000 = Forest
Yes
data source= CLC 1990
No
BWI 1987 = no data & CLC 1990 = DLM 2000 & CLC 1990 <> GSE 1990
Yes
data source = CLC 1990
No
BWI 1987 = no data & GSE 1990 = DLM 2000 & GSE 1990 <> CLC 1990
Yes
data source = GSE 1990
No
GSE 1990 <> Forest & BWI 1987 <> Forest BWI 1987 <> no data & BWI 1987<>"No Forest"
Yes
data source = BWI 1987
No
GSE 1990 <> Forest & BWI 1987 <> Forest BWI 1987 <> no data & BWI 1987="No Forest" & CLC 1990 <> Forest
Yes
data source = CLC 1990
No
Other wooded land grassland 2
BWI 2002 = Forest
Yes
data source = BWI 2002
No
BWI 2002 <> Forest & BWI 2002 <> no data
Yes
DLM 2000 <> Forest & DLM 2000 <> "no data"
Yes
data source= DLM 2000
No
CLC 2000 <> Forest
Yes
data source= CLC 2000
No
Other wooded land grassland 2
No
DLM 2000 = "no data"
Yes
data source = CLC 2000
No
data source = DLM 2000

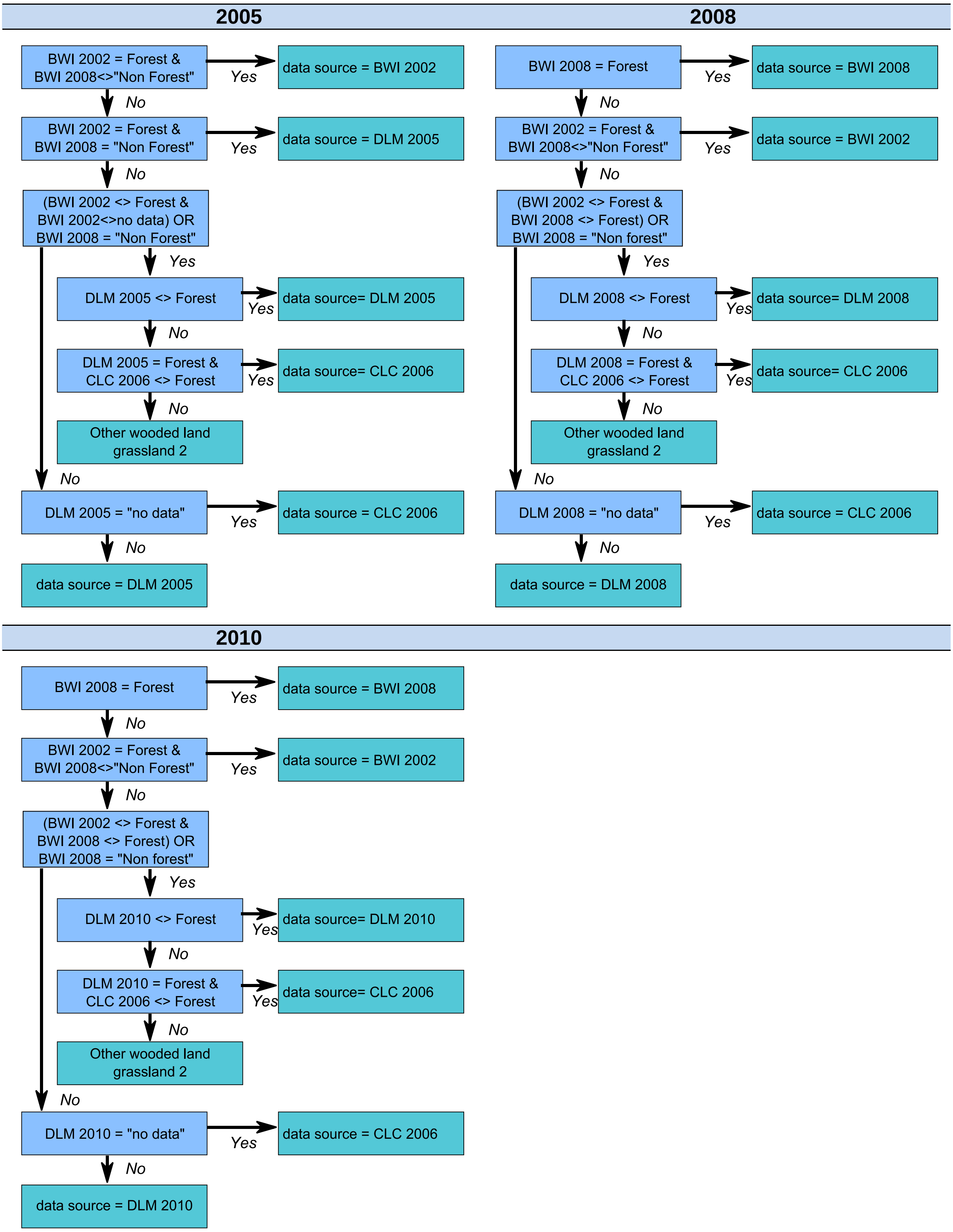


Figure 50: Decision trees for the years 1990, 2000, 2005, 2008, 2010

Use of the decision trees yields a further table, with the most probable land uses per sample point and year (1990, 2000, 2005, 2008 and 2010) and the best data source in each case. The BWI data are listed only for actual forest land, where the BWI returns the information "non-forest land", other data sources are used from then on to determine the land use:

Table 201: Most probable land use and pertinent data sources

Cluster	Cluster point	LU 1990	LU 2000	LU 2005	LU 2008	LU 2010	DB 1990	DB 2000	DB 2005	DB 2008	DB 2010
xya	1	forl	forl	sett	sett	sett	bwi	dlm	dlm	dlm	dlm

7.1.3.4.2 Derivation of annual land-use changes

Subsequently, the relevant land-use change classes were derived for each change period (1990-2000, 2000-2005, 2005-2008, 2008-2010) and each sample point. To that end, an SQL script was programmed; it is documented in the inventory description.

The applicable transition times were implemented in several partial steps. For all land-use changes that occur within a period covered by the included observations (1990-2010), processing was carried out on a point-oriented basis. At the same time, the land-use changes have been spatially correlated with the individual observation points. Land-use changes that occurred prior to that period (1970-1990) are extrapolated retroactively from observations carried out during the first measurement period (1990-2000). In those cases, spatial correlation with the observation points is no longer required, nor is it even possible. As a result, for those cases a change is made from point-based processing to calculation on the basis of area sums.

No annual change data are available within the observation period, as is described in the methods section. The observation period is divided into change periods of differing lengths (1990-2000, 2000-2005, 2005-2008, 2008-2010), with the result that the annual changes in those periods have to be calculated on a proportional basis, via linear interpolation.

7.1.3.5 Land-use changes pursuant to the Convention and the KP

The method described here for determining land-use changes, and the resulting land-use matrix (cf. Table 202), including a 20-year transition time beginning in 1970, are compliant with reporting requirements pursuant to the UN Framework Convention on Climate Change, as set forth in IPCC GPG 2003. Table 203 shows the complete detailed land-use matrix for 2010 by way of example.

For determination of land-use changes pursuant to the Kyoto Protocol, the same basic data set is used, but only land-use changes since 1990 are taken into account and, in the conversion category, they are accumulated for more than 20 years.

Table 202: Land-use changes (LUC), including 20-year transition time, pursuant to reporting under the Convention

Source category	5.A.1 Forest land remaining forest land	5.A.2 … LUC to forest land	5.B.1 Cropland remaining cropland	5.A.2 … LUC to cropland	5.C.1 Grassland remaining grassland	5.A.2 … LUC to grassland	5.D.1 Wetlands remaining wetlands	5.A.2 … LUC to wetlands	5.E.1 Settlements remaining settlements	5.A.2 … LUC to settlements	5.F.1 Other land remaining other land	5.F.2 … LUC to other land
Units	kha	kha	kha	kha	kha	kha	kha	kha	kha	kha	kha	kha
1990	10,204.92	561.73	13,629.95	767.32	6,280.89	382.71	540.64	72.91	2,762.88	512.41	63.28	0.00
1991	10,217.86	561.73	13,638.28	767.32	6,254.62	382.71	540.49	72.91	2,769.55	512.41	61.75	0.00
1992	10,230.81	561.73	13,646.62	767.32	6,228.35	382.71	540.34	72.91	2,776.22	512.41	60.23	0.00
1993	10,243.75	561.73	13,654.95	767.32	6,202.09	382.71	540.19	72.91	2,782.89	512.41	58.70	0.00
1994	10,256.69	561.73	13,663.28	767.32	6,175.82	382.71	540.03	72.91	2,789.55	512.41	57.17	0.00
1995	10,269.64	561.73	13,671.61	767.32	6,149.55	382.71	539.88	72.91	2,796.22	512.41	55.65	0.00
1996	10,282.58	561.73	13,679.95	767.32	6,123.28	382.71	539.73	72.91	2,802.89	512.41	54.12	0.00
1997	10,295.53	561.73	13,688.28	767.32	6,097.02	382.71	539.58	72.91	2,809.55	512.41	52.60	0.00
1998	10,308.47	561.73	13,696.61	767.32	6,070.75	382.71	539.43	72.91	2,816.22	512.41	51.07	0.00
1999	10,321.42	561.73	13,704.94	767.32	6,044.48	382.71	539.28	72.91	2,822.89	512.41	49.55	0.00
2000	10,334.36	561.73	13,713.27	767.32	6,018.21	382.71	539.12	72.91	2,829.56	512.41	48.02	0.00
2001	10,358.84	543.32	13,687.62	760.52	5,995.00	387.38	540.85	75.76	2,837.01	546.67	46.65	0.00
2002	10,383.33	524.91	13,661.97	753.71	5,971.79	392.06	542.58	78.61	2,844.47	580.93	45.28	0.00
2003	10,407.81	506.51	13,636.32	746.91	5,948.58	396.74	544.30	81.46	2,851.93	615.18	43.90	0.00
2004	10,432.29	488.10	13,610.67	740.10	5,925.37	401.41	546.03	84.31	2,859.38	649.44	42.53	0.00
2005	10,456.77	469.69	13,585.02	733.30	5,902.16	406.09	547.76	87.16	2,866.84	683.69	41.16	0.00
2006	10,481.48	447.38	13,577.52	718.88	5,886.95	409.79	550.74	87.78	2,879.39	699.27	40.46	0.00
2007	10,506.18	425.06	13,570.03	704.47	5,871.74	413.50	553.72	88.39	2,891.93	714.84	39.76	0.00
2008	10,530.89	402.75	13,562.53	690.06	5,856.52	417.21	556.70	89.01	2,904.48	730.42	39.07	0.00
2009	10,557.93	375.80	13,564.87	662.84	5,858.89	412.65	559.94	89.96	2,920.32	737.71	38.72	0.00
2010	10,584.98	348.86	13,567.21	635.61	5,861.25	408.09	563.19	90.92	2,936.16	745.01	38.37	0.00

Table 203: Land-use matrix for 2010. In each case, the boldface number on the diagonal shows the area remaining in the same category for the column in question. The other table cells show the relevant land-use changes from 2009 to 2010 (including 20-year transition times)

Land-use matrix for 2010: Areas [kha]								
Initial\final	**Forest land**	**Cropland**	**Grassland (i.t.n.s.)**	**Woody Grassland**	**Wetlands**	**Waters**	**Settlements**	**Other land**
Forest land	**10,584.98**	46.15	50.66	43.83	1.89	5.79	33.34	0
Cropland	121.48	**13,567.21**	0	113.16	1.70	29.38	564.34	0
Grassland (i. t. n. s.)	104.99	422.41	**5,374.81**	44.40	8.21	15.18	112.82	0
Woody Grassland	56.57	57.47	68.22	**373.82**	0.80	4.30	19.60	0
Wetlands (terr.)	14.76	2.50	8.50	0.30	**53.45**	1.19	8.87	0
Waters	1.10	1.40	9.49	0.70	0.30	**508.25**	2.73	0
Settlements	46.48	104.68	136.08	28.83	0	23.07	**2,936.16**	0
Other land	3.48	1.00	14.04	2.49	0.40	0.20	3.29	**38.37**
Σ additions	**348.86**	**635.61**	**286.99**	**233.71**	**13.30**	**79.11**	**744.99**	**0**
Σ reductions	**181.66**	**830.06**	**708.01**	**206.96**	**36.12**	**15.72**	**339.14**	**24.90**
Balance	**167.20**	**-194.45**	**-421.02**	**26.75**	**-22.82**	**63.39**	**405.85**	**-24.90**
Σ Land-use category	**10,933.84**	**14,202.82**	**5,661.81**	**607.54**	**66.75**	**587.36**	**3,681.16**	**38.37**
Total area of Germany				**35,779.63**				

7.1.4 Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories

Germany reports in eight LULUCF categories (cf. Chapter 7.1.3). The following changes have been made with respect to the previous year:

- Aggregation of the Cropland category within a single category. Calculations for special and permanent crops are carried out on a proportional basis, but those categories are no longer listed as a sub-category, because no consistent georeferenced area data are available for them since 1990.
- Division of the Grassland category into the sub-categories Grassland (in the narrower sense) and Woody Grassland, including heath
- Division of the Wetlands category into the sub-categories Wetlands (terrestrial) and Waters
- Aggregation of the Settlements category within a single category.

Table 204: Correlation of the German reporting categories with the IPCC land-use categories

IPCC category	German LULUCF category
Forest land	Forest land
Cropland	Cropland
Grassland	Grassland (in the narrower sense) Woody Grassland
Wetlands	Wetlands (terr.) Waters
Settlements	Settlements
Other land	Other land

With the introduction of the sample-point grid system, the land-use definitions from the underlying data sources (Basis-DLM of ATKIS® and CORINE Land Cover; cf. Chapter 7.1.3.2) had to be correlated with these reporting categories. The existing system was adapted for that purpose.

In a first step, the object numbers from the Basis-DLM of ATKIS® were assigned to the above-listed IPCC categories. To that end, the previous year's system was adopted, with slight changes (Table 205). In the main, the changes involved are due to introduction of the sub-categories and to reclassification of object type 4106 "swamp, reeds" in the Grassland category – formerly, it was part of the Wetlands category – in the interest of time-series consistency. Analysis of land-use changes for object type 4106 "swamp, reeds" showed that such areas consist of extensively managed grassland areas.

In a next step, in the framework of expansion of the land-use-identification system, the land-cover classes in the CORINE Land Cover nomenclature were assigned to object types within the ATKIS®-Basis-DLM – and, thus, to the relevant IPCC categories (Table 205). In preparation of the land-use matrix, grid-point allocation is computerized; it is carried out fully automatically via dedicated programmes. In support of that purpose, the allocation key for this classification system is included in digital form, with the result that any given grid point can always be unambiguously allocated to an object-type-key number and, thus, to a specific land-use type and IPCC category, regardless of the data source being used.

Table 205: Allocation of main object-type index numbers and attributes in ATKIS® to IPCC land-use categories

ATKIS Object-type catalog			CORINE LAND COVER
Object number	**Object type**	**Description / attributes pursuant to ATKIS object-type catalog**	**Nomenclature code**
IPCC category: Forest land			
4107	Forest land	Deciduous, coniferous and mixed forest	311; 312; 313; 324
IPCC category: Cropland			
4101	Cropland	Area for cultivation of field crops (such as grain, legumes, root crops) and berries (such as strawberries)	211; 212
4103	Horticultural land	Area for cultivation of vegetables, fruit and flowers, and for growing of cultivated plants	242
4109	Specialised cultivation	Area for cultivation of certain plants (such as hops, grapes, orchards).	222
IPCC category: Grassland			
4102	Grassland	Meadows, pastures, greenery along transport infrastructure	231; 321
4104	Heath		322; 421
4106	Swamp, reeds	Water-saturated area that is intermittently inundated (de facto, extensively managed grassland).	411
4108	Woodlands	Area covered with individual trees, groups of trees, bushes, hedges and shrubs.	243
IPCC category: Wetlands			
4105	Peat bogs and fens	Uncultivated area whose top layer consists of peaty or decomposed plant remains.	412
5100	Waters	Such as dammed lakes, reservoirs, movable banks	511; 512; 423; 521; 522; 523
IPCC category: Settlements			
2100-2135	Structurally modified areas	Contiguously built-up areas with sizes of at least 10 ha or with at least 10 properties.	111; 112; 121; 131; 132
2201	Sports facilities	Area with structures and facilities intended to be used for (competitive) sports and by spectators. Sports facilities include "stadiums", "sports areas" – such as football pitches, tennis courts, ice-skating rinks – "shooting ranges", "swimming pools", "outdoor swimming pools" and "golf courses".	142
2202	Recreational facilities	Area with structures and facilities intended for recreational purposes. Recreational facilities include "open-air theaters", "open-air museum", "swimming pools, outdoor swimming pools", "zoos", "amusement parks" "safari parks", "game enclosures" and "drive-in movie theatres" and "outdoor movie theatres".	142
2213	Cemeteries		141
2227	Greenswards, parks	Large areas with trees, shrubs, grass areas, flower beds and/or paths, and that are intended primarily for recreation and as a means of urban beautification.	141
2228	Camping areas	142	
2300-2352	Buildings and other facilities		131; 133
3100-3205	Roads and railways		122
3301	Airports		124
3302	Airfields		No allocation
3400-3543	Ship-transport and related facilities	For example, ports, transmission masts, bridges, tunnels, piers	123
4110	Fallow land	Areas that for some time have not been used in accordance with their original purpose.	No allocation
4198	Glades		No allocation
IPCC category: Other land			
4120	Areas without vegetation	Areas without significant vegetation cover, as a result of special soil characteristics such as unprotruding rocks, sand or ice areas.	331; 332; 333; 334; 335
4199	Area currently undefined	Areas whose characteristics cannot currently be determined, in terms of allocation to object types.	No allocation

7.1.5 Soil carbon in mineral soils (5.A to 5.F)

Changes in carbon and nitrogen stocks in mineral soils are calculated as the difference between the relevant stocks prior to relevant measures and after such measures (the stock-change approach).

In mineral soils for which use does not change, it is assumed, in keeping with the IPCC Tier-1 method, that carbon inputs and extractions are of equal size, i.e. such systems are in balance. In agricultural soil use, the soil-cultivation and soil-management methods used do not change rapidly over large areas. Recent meta-studies (BAKER et al. 2007; LUO et al. 2010) have shown, for soil depths > 60 cm, that the type of soil cultivation used has no influence on the total carbon stocks in mineral soils.

The procedure used for the Grassland category is an exception to the Tier-1 method. That category has two sub-categories: cultivated grassland in the conventional sense, and woodlands that do not fall within the Forest land category as it is defined. The transition areas between those two sub-categories are treated like land-use changes.

In the stock-change method for determining carbon-stock changes in mineral soils, representative carbon stocks, area-weighted with respect to original substrate and climate region, are determined for mineral soils with soil depths to 30 cm, for each of the eight land-use categories defined for Germany. The manner in which the relevant values, and their uncertainties, are derived is described in Chapter 19.5.2.

For each land-use-change category, the carbon-stock changes in mineral soils as a result of land-use changes are calculated as the difference between the carbon stocks of the final-use category and the carbon stocks of the original category. Pursuant to IPCC Default (IPCC 1996b, 2003, 2006), the total changes are linearly distributed over a period of 20 years. The sum of all carbon-stock changes resulting from land-use changes in Germany's mineral soils is calculated, for a 20-year period, as follows:

$$\Delta C = \sum_{n=1}^{7} (C_{final} - C_{initial})$$

ΔC:	Change in carbon stocks as a result of land-use changes in mineral soils of an IPCC land-use category [Mg C $(20*a)^{-1}$]
C_{final}:	Final soil-carbon stocks [Mg C]
$C_{initial}$:	Initial soil-carbon stocks [Mg C]
n	Transition categories

The carbon stocks of mineral soils in the various land-use categories, and the carbon-stock changes derived from those stocks and used as emission factors, are shown in Table 206; the pertinent derivations are described in Chapter 19.5.2.

Table 206: Mean carbon stocks in Germany's mineral soils, by land use [Mg C ha^-1], and derived (e.g. therefrom) carbon-stock changes as a result of land-use changes

Mean carbon stocks in Germany's mineral soils								
	Forest land	**Crop-land**	**Grassland (i.t.n.s.)**	**Woody Grassland**	**Wetlands (terr.)**	**Waters**	**Settlements**	**Other land**
[Mg C ha^-1]	62.03	60.03	77.43	73.18	74.00		58.67	55.60
Carbon-stock change in 20 years [Mg C ha^-1 (20 a)^-1]								
Initial\final	**Forest land**	**Crop-land**	**Grassland (i.t.n.s.)**	**Woody Grassland**	**Wetlands (terr.)**	**Waters**	**Settlements**	**Other land**
Forest land		-2.00	15.40	11.15	11.97	0	-3.36	NO
Cropland	2.00		17.40	13.15	13.97	0	-1.35	NO
Grassland (i.t.n.s.)	-15.40	-17.40		-4.25	-3.43	0	-18.76	NO
Woody Grassland	-11.15	-13.15	4.25		0.82	0	-14.51	NO
Wetlands (terr.)	-11.97	-13.97	3.43	-0.82		0	-15.32	NO
Waters	0	0	0	0	0		0	NO
Settlements	3.36	1.35	18.76	14.51	15.32	0		NO
Other land	6.43	4.42	21.83	17.58	18.39	0	3.07	

Negative: Carbon losses; positive: Carbon sequestration; NO: not occurring

To determine the annual stock changes, one must divide the total stock change (Table 206) determined for the relevant transition category by 20. One thereby obtains a specific emission factor for the transition category (cf. Table 207). In keeping with the logical specifications for reporting, that factor is multiplied by the total area of the relevant transition category. The simplified version of the formula for that is as follows:

$$\Delta C = \sum_{n=1}^{7} \left(A_{LUC} * C_{EF\,spez} \right)$$

ΔC: Change in carbon stocks as a result of land-use changes in mineral soils of an IPCC land-use category [Mg C ha^-1 a^-1]

A_{LUC}: Area on which the land-use change has occurred [ha]

C_{EFspez}: Transition-category-specific, area-based rate of change in soil carbon stocks [Mg C ha^-1 a^-1]; negative: Carbon losses; positive: carbon sequestration

n: Transition categories

Table 207: Emission factors [Mg C ha^-1 a^-1] for determination of annual carbon-stock changes in Germany's mineral soils following land-use changes

Emission factors for mineral soils [Mg C ha^-1 a^-1]								
Initial\final	**Forest land**	**Cropland**	**Grassland (i.t.n.s.)**	**Woody Grassland**	**Wetlands (terr.)**	**Waters**	**Settlements**	**Other land**
Forest land		-0.100	0.770	0.558	0.598	0	-0.168	NO
Cropland	0.100		0.870	0.658	0.699	0	-0.068	NO
Grassland (i.t.n.s.)	-0.770	-0.870		-0.213	-0.172	0	-0.938	NO
Woody Grassland	-0.558	-0.658	0.213		0.041	0	-0.725	NO
Wetlands (terr.)	-0.598	-0.699	0.172	-0.041		0	-0.766	NO
Waters	0	0	0	0	0		0	NO
Settlements	0.168	0.068	0.938	0.725	0.766	0		NO
Other land	0.321	0.221	1.091	0.879	0.920	0	0.154	

Negative: carbon-stock losses

The area of the mineral soils in the transition categories was calculated as the difference between the relevant total areas and the areas covered by organic soils (Chapter 7.1.6).

7.1.6 Greenhouse-gas emissions from drained organic soils (5.A bis 5.F)

In Germany, nearly all organic soils are drained. Greenhouse emissions resulting from peat depletion are reported in the land-use categories Forest land, Cropland, Grassland and

Settlements (N_2O from drained organic soils is reported under Cropland and Grassland in CRF Sector 4.D).

In addition, emissions resulting from industrial peat extraction are reported in the land-use category Wetlands.

The few organic soils in Germany that are still in a "natural" state, and whose emissions do not have to be reported, are included in the land-use categories Other Land and Wetlands. An area of 16,786 ha that, in the Basis-DLM nomenclature is listed as object type 4106 "swamp, reeds", has been included in the Grassland category as a result of the type of use involved (cf. Chapter 7.1.4). Since the relevant lands have not been drained, and since they are used only on an irregular basis, no emissions are reported for them as well.

For both continuing use and land-use changes, CO_2 emissions from organic soils are calculated using the same emission factors. The emissions are calculated by multiplying the moor areas per sub-category by pertinent use-specific emission factors. For land-use changes, the emission factor for the final category is used right away:

$$EC_{orgsoil} = \sum_{n=1}^{7} (A_n * EF_n)$$

$EC_{orgsoil}$: Carbon emissions from organic soils in a land-use category [Gg C]
A_n: Moor area subject to a certain land use [kha]
EF_n: Land-use-specific emission factor [Mg C ha^{-1} a^{-1}]
n: Transition or no-change categories

7.1.6.1 Activity data: Determination of area sizes

The areas and distribution of organic soils have been documented via the 1:1,000,000-scale soil-survey map (BUEK 1000), with georeferencing. To that end, the following dominant soil associations have been surveyed:

LBA 6: primarily fens, often in association with fen gley soils, gleyed muck humus soils and gley soils; in part, transitional fens and podzolic gley soils (BGR 1995)

LBA 7: primarily raised-bog soils, with scattered pockets of gleyed muck humus soils, gley soils, fens and podzolic gley soils (BGR 1995)

Land use on bog areas is determined via a GIS. With such a system, the geometries of the LBA 6 and LBA 7 areas as shown in the BUEK 1000 (BGR 1997) are intersected with the ATKIS® data records from the year 2010. With that procedure, the organic-soil areas for each of the 8 land-use categories, in their final uses, were determined in a georeferenced format.

The land-use changes areas on organic soils were determined by intersecting the soil map with the ATKIS® data records from the years 2009 and 2010. For each transition category, the area percentage covered by organic soils, relative to the total area of the transition category in 2009/2010, was calculated. For all years since 1990, and for each transition category, these organic-soil area percentages were applied constantly to the total area of the transition category, as determined by the sampling-grid procedure. The area of the mineral soils in the transition categories was calculated as the difference between the relevant total areas and the areas covered by organic soils.

The areas of organic soils in the categories with no use changes were determined, beginning with the values for 2010, by adding the sums of the final areas for the relevant transition categories.

7.1.6.2 Emission factors: Determination of country-specific emission factors

Country-specific CO_2 emission factors for bogs were derived on a basis of values from the literature. In a CarboEurope study, BYRNE et al. (2004) report carbon emissions from organic grassland soils of 0.82 – 6.58 Mg C ha^{-1} a^{-1} and emissions from cropland soils of 1.09 – 10.6 Mg C ha^{-1} a^{-1}. At an average of 4.09 Mg C ha^{-1} a^{-1}, these values are too low, especially with regard to cropland, since the study was based primarily on data for boreal soils. MUNDEL (1976), GENSIOR & ZEITZ (1999), MEYER (1999) und AUGUSTIN (2001) report losses in grassland areas of 2.46 – 7.63 Mg C ha^{-1} a^{-1}, while HÖPER (2002) reports 4.6 – 16.5 Mg C ha^{-1} a^{-1}, with bogs under cropland listed at 10.6 – 16.5 Mg C ha^{-1} a^{-1}.

On the basis of those studies, in 2004 the following emission factors were determined for fens and raised bogs alike, via estimation by experts:

- Cropland: -11 Mg CO_2-C ha^{-1} a^{-1} [± 50 %]
- Cultivated grassland and settlements: -5 Mg CO_2-C ha^{-1} a^{-1}[± 50 %]

The most recent findings of the BMBF research project "Climate protection via bog protection" ("Klimaschutz durch Moorschutz") (DROESLER et al. 2011) indicate, for German bog areas under agricultural use, that while the pertinent emissions vary widely, the two types "raised bog" and "fen" differ virtually not at all when under the same use.

For example, CO_2-C emissions from bogs under cropland were measured at ca. 9 Mg CO_2-C ha^{-1} a^{-1}± 50 %, while on grassland a range of ca. 2 – 12 CO_2-C ha^{-1} a^{-1} was found, with an arithmetic mean over all variants and usage intensities (not weighted by area) of ca. 5 Mg CO_2-C ha^{-1} a^{-1} ± 50 % (DROESLER et al. 2011). These results confirm the factors on which the inventory has been based to date.

For organic soils under forest, and for woodlands not falling within the definition of "forest" (grassland woodlands), the IPCC default value was used:

- Forest / woodland: -0.68 Mg CO_2-C ha^{-1} a^{-1} [- 39.7 %; + 180.8 %]

7.1.7 Biomass (5.B to 5.F)

In the framework of German inventory preparation, the LULUCF categories 5.B – 5.F include only carbon dioxide (CO_2) removals and emissions resulting from land-use changes.

The stock change method is used to estimate CO_2 emissions and removals. On the basis of country-specific emission factors, the stock changes are determined separately for above-ground and below-ground biomass.

In the land-use categories Cropland, Grassland, Wetlands and Settlements, the C stocks resulting from planted wood biomass are reported completely in the year of the relevant land-use change. The reasons for this are as follows:

In Germany, the rotation periods for fruit trees and grapevines can vary widely (for fruit, the period is normally 10 – 15 years). When a new orchard is established, "ready trees" from nurseries are planted. During their years in such plantations, such trees add only small amounts of biomass, primarily through growth of trunk and root volume. As a rule, annual above-ground biomass growth is pruned, and thus biomass as a whole is close to balance. The situation is similar with grapevines and hedges, although the interval for hedges, at 10 - 12 years, is somewhat larger.

On-site burning of biomass is prohibited by law in Germany and thus is not reported. In the CRF tables, NO (not occurring) is entered.

The carbon-stock changes in biomass are estimated by subtracting the biomass carbon stock before land-use change from the stock after the conversion, with reference to the area affected by the change:

$$\Delta C_{Bio} = \sum_{n=1}^{7} \left(A_n * EF_{final} - A_n * EF_{initial} \right)$$

ΔC_{Bio}: Change in the biomass carbon stock for a given land-use category [Mg]
A_n: Area on which the land-use change has occurred [ha]
EF_{final}: Biomass carbon stock in final land use category [Mg ha^{-1}]
$EF_{initial}$: Biomass carbon stock in initial land use category [Mg ha^{-1}]
n: Transition categories

Biomass carbon stocks were calculated pursuant to GPG-LULUCF (IPCC, 2003). Chapter 7.1.3 provides a description of the relevant activity-data identification, while derivation of emission factors and their uncertainties is described in Chapter 19.5.3 and in the chapters for the individual land-use categories.

The biomass carbon stocks on cropland vary annually and are calculated for each year on the basis of harvest statistics. Therefore, the same data sources and algorithms are used as are used for calculating harvest residues in CRF Sector 4.D. The emission factors in Table 208 are obtained as the difference between the above-ground and below-ground biomass stocks.

Table 208: Emission factors [Mg C ha^{-1} a^{-1}] for determination of carbon-stock changes in the year of conversion, in above-ground and below-ground biomass, by type of land-use change, for the year 2010

Mean carbon stocks in above-ground and below-ground biomass								
	Forest[1]	**Cropland**	**Grassland (i.t.n.s.)**	**Woody Grassland**	**Wetlands (terr.)**	**Waters**	**Settlements**	**Other land**
[Mg C ha-1]	32.63	7.07	6.69	46.70	20.02	0	13.35	0
Emission factors for 2010, biomass [Mg C ha-1 a-1]								
Initial\final	**Forest**[2]	**Cropland**[3]	**Grassland (i.t.n.s.)**[3]	**Woody Grassland**[3]	**Wetlands (terr.)**[3]	**Waters**[3]	**Settlements**[3]	**Other land**[3]
Forest land		-25.6	-25.9	14.1	-12.6	-32.6	-19.3	-32.6
Cropland	3.8		-0.4	39.6	13.0	-7.1	6.3	-7.1
Grassland (i.t.n.s.)	3.8	0.4		40.0	13.3	-6.7	6.7	-6.7
Woody Grassland	1.8	-39.6	-40.0		-26.7	-46.7	-33.4	-46.7
Wetlands (terr.)	3.1	-13.0	-13.3	26.7		-20.0	-6.7	-20.0
Waters	4.1	7.1	6.7	46.7	20.0		13.3	0
Settlements	3.5	-6.3	-6.7	33.4	6.7	-13.3		-13.3
Other land	4.1	7.1	6.7	46.7	20.0	0	13.3	

Remark: The carbon stocks for forest land and cropland are chronologically variable, while those for the other land-use categories are constant

1) Carbon stocks, deforestation areas
2) Annual carbon-stock change over 20 years
3) One-time carbon-stock change

For calculation relative to conversion of forest land into other land uses (deforestation), the average value determined for deforestation areas in Germany, in the National Forest Inventory, was used as a basis for the relevant reporting year. For the relevant methods and value derivation, cf. Chapter 7.2.4.1.

Table 209: Time series for mean carbon stocks in biomass of deforestation areas [Mg ha^{-1}]

Year	Phytomass – carbon [Mg ha^{-1}] (EF 1)					
	Bio_{total}	Bio_{above}	Bio_{below}	Litter	Dead wood	Σ deforestation
1990	34.86	26.89	7.97	19.41	1.56	55.83
1991	34.86	26.89	7.97	19.37	1.65	55.88
1992	34.86	26.89	7.97	19.32	1.75	55.93
1993	34.86	26.89	7.97	19.28	1.84	55.98
1994	34.86	26.89	7.97	19.24	1.93	56.03
1995	34.86	26.89	7.97	19.19	2.03	56.08
1996	34.86	26.89	7.97	19.15	2.12	56.13
1997	34.86	26.89	7.97	19.10	2.21	56.18
1998	34.86	26.89	7.97	19.06	2.31	56.23
1999	34.86	26.89	7.97	19.02	2.40	56.28
2000	34.86	26.89	7.97	18.97	2.50	56.33
2001	34.86	26.89	7.97	18.93	2.59	56.38
2002	32.63	23.85	8.78	18.89	2.68	54.20
2003	32.63	23.85	8.78	18.84	2.78	54.25
2004	32.63	23.85	8.78	18.80	2.87	54.30
2005	32.63	23.85	8.78	18.75	2.96	54.35
2006	32.63	23.85	8.78	18.71	3.06	54.40
2007	32.63	23.85	8.78	18.67	3.15	54.45
2008	32.63	23.85	8.78	18.62	3.25	54.50
2009	32.63	23.85	8.78	18.58	3.34	54.55
2010	32.63	23.85	8.78	18.54	3.43	54.60

The uncertainty for the 2010 tree biomass value is 34.5 % (half of the 95 % confidence interval). The distribution is normal. With regard to the dead organic matter (dead wood and litter), the uncertainties are not symmetrically distributed: The lower bound is -55.7 %, and the upper bound is + 34.7 %, with regard to the measure of location.

7.1.8 Quality assurance

In May 2011, two workshops were carried out for the present inventory, for purposes of quality assurance in the framework of German inventory preparation. At those workshops, the new approaches and methodologies in German LULUCF reporting, pursuant to the KP and to the UN Framework Convention on Climate Change, were presented to, and discussed by, national and (subsequently) international experts and reviewers.

The aims of the workshop were to present, discuss and evaluate these approaches and methods; to review the scientific reliability and suitability of the underlying principles and data sources; and to share experience with a view to obtaining additional ideas for further improvement of the German inventory. All of the resulting criticism, ideas and suggestions were recorded in minutes (written record; cf. Chapter 19.5.5) and have entered into the ongoing inventory-preparation process. All of the participating reviewers indicated that the pertinent German approach is a suitable one.

7.2 Forest land (5.A)

7.2.1 *Source category description (5.A)*

CRF 5.A	Natural gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Forest land	**CO_2**	**L**	**T/T2**	**-73,408.0**	**(6.01%)**	**-25,060.6**	**(2.63%)**	**-65.86%**
Forest land	N_2O	-	-	60.4	(0.00%)	66.3	(0.01%)	9.74%
Forest land	CH_4	-	-	9.1	(0.00%)	3.2	(0.00%)	-64.82%

Natural gas	Method used	Source for the activity data	Emission factors used
CO_2	CS/Tier 2[59]	RS	CS
CH_4	Tier 1	RS	D
N_2O	Tier 1 / Tier 2	RS	D

The source categories Forest Land remaining Forest Land (5.A.1) und *Land converted to Forest Land* (5.A.2) are key categories for CO_2 emissions pursuant to GPG-LULUCF (IPCC, 2003).

Reporting in the category *Forest Land* covers CO_2 emissions / removals from / in mineral and organic soils, above-ground and below-ground biomass, litter, dead wood, forest fires and liming; in addition, it covers nitrous oxide emissions from forest fires, from drainage of organic soils, and from humus losses from mineral soils following land-use changes to cropland.

In 2010, the total emissions from forests amounted to -24,933 Gg CO_2 equivalents. Of those emissions, a total of -21,772 Gg CO_2 occurred via biomass stock increases, while -3,638 Gg CO_2 resulted from stock increases in dead wood and -593 Gg CO_2 resulted from stock increases in litter. Drainage of organic soils released a total of 675 Gg CO_2 equivalents, while emissions from mineral soils, in connection with conversion to forest land, amounted to 333 Gg CO_2. Liming produced additional emissions of 58 Gg CO_2, while emissions from forest fires amounted to 4 Gg CO_2 equivalents.

The time series for emissions from forests (cf. Figure 51 and Figure 52) highlight the fact that the sum of all greenhouse gas binding in forests in 2002 decreased abruptly. The reason for the jump is that relevant surveys in the BWI framework are carried out periodically. Additional details about this aspect are provided in Chapter 7.2.4.1.1.

In the category Forest Land, the most important factors for CO_2 removals are the pools biomass (76.12 %), dead wood (14.90 %) and litter (4.68 %). Pertinent sources occur via drainage, liming, forest fires and, in mineral soils, via conversions. Such sources account for only a very small share – 4.30 % – of the greenhouse gas balance for forests, however.

[59] The entry "CS/T2" refers to determination of changes in carbon stocks in biomass, dead wood and litter. Under Tier 1, changes in dead wood, litter and soil were estimated to be 0.

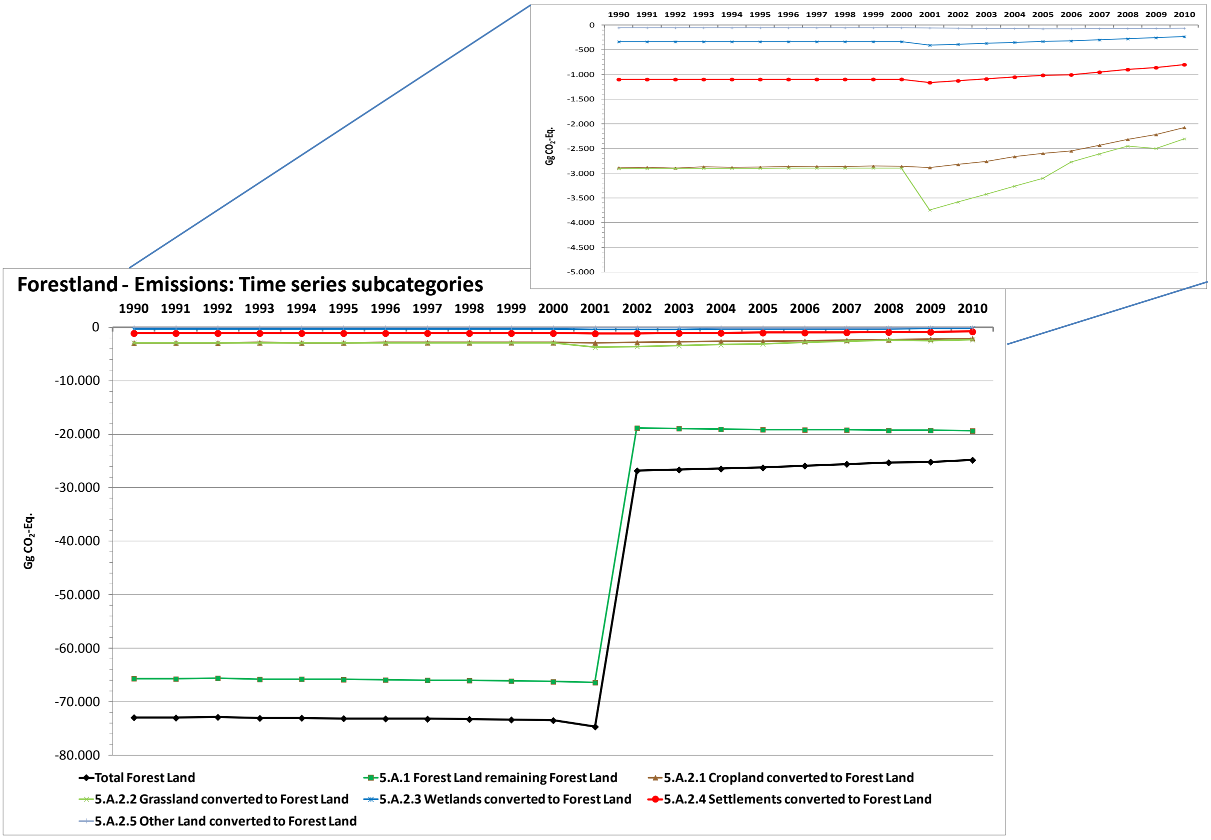


Figure 51: Greenhouse gas emissions [Gg CO_2-Eq.] from forests, as a result of land use and land-use changes, 1990 – 2010, by sub-categories

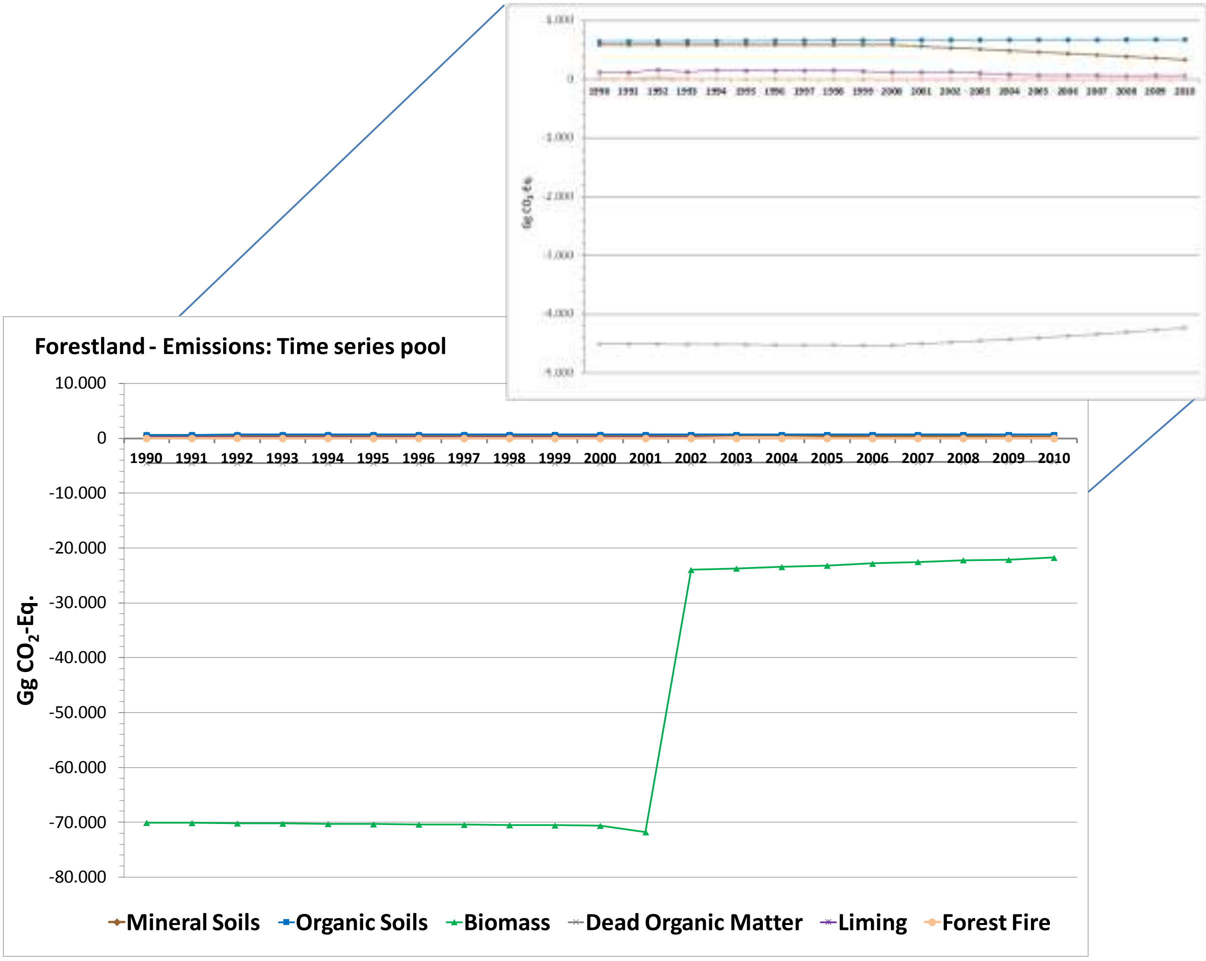


Figure 52: Greenhouse gas emissions [Gg CO_2-Eq.] from forests, as a result of land use and land-use changes, 1990 – 2010, by pools

In the Good Practice Guidance for Land use, Land-use Change and Forestry (GPG-LULUCF, IPCC, 2003), and in the official reporting tables, in the "Common Reporting Format" (CRF), for the greenhouse-gas inventories sent to the Climate Secretariat, the category "Forest Land" is divided into "Forest Land remaining Forest Land" (forest that remains forest during the period covered by the report) and "Land converted to Forest Land" (new forest established, via afforestation or natural succession, on areas previously used for other land use classes). It is important to note that relevant calculations are carried out on the basis of a 20-year transition time, and with a database beginning as of the year 1970 (cf. Chapter 7.1.3).

7.2.1.1 Forest Land remaining Forest Land (5.A.1)

Forest Land remaining Forest Land refers to the forest area that remains forest in the reporting year. It also includes areas that, after a 20-year period, are shifted from the category "Land converted to Forest Land" into the category Forest Land remaining Forest Land. The category Forest Land remaining Forest Land differs from the total forest area by not including Land converted to Forest Land, which is considered in a separate category (see Chapter 7.2.1.2).

7.2.1.2 Land converted to Forest Land (5.A.2)

Forest is established through succession, afforestation and reforestation; as soon as afforested areas are converted they start to accumulate carbon. . Pursuant to IPCC GPG-LULUCF (2003), Land converted to Forest Land remains for the duration of the transition period of 20 years in the conversion category and is subsequently transferred into Forest Land remaining Forest Land.

It must be remembered that the C stocks of previous land uses are deducted. Relevant information is provided in Chapters 7.3 through 7.7.

7.2.2 Information on approaches used for representing forest areas and on land-use databases used for inventory preparation (5.A)

The following data sources were used for determination of forest areas; determination of land-use changes that have occurred; estimation of the relevant emission factors for soil, biomass, litter and dead wood; for calculation of carbon stocks and stock changes at various times and over various periods; and for calculation of emissions from forest fires, fertilisation and drainage:

- National Forest Inventory 1 (Bundeswaldinventur; BWI 1)
- National Forest Inventory 2 (Bundeswaldinventur; BWI 2)
- Inventory Study 2008 (Inventurstudie; IS08)
- Datenspeicher Waldfonds (DSW)
- Forest Soil Inventory I (Bodenzustandserhebung im Wald I; BZE I)
- Forest Soil Inventory II (Bodenzustandserhebung im Wald II; BZE II)
- Soil-inventory data from the project BioSoil (BioSoil)
- GSE Forest Monitoring[60]: Inputs for national greenhouse-gas reporting (GSE FM-INT)
- Official topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem; ATKIS®;)
- CORINE Land Cover (CLC)
- Soil map for the Federal Republic of Germany 1:1,000,000 (Bodenübersichtskarte der Bundesrepublik Deutschland; BÜK 1000)
- Forest-fire statistics of the Federal Republic of Germany
- Fertiliser statistics of the Federal Statistical Office

7.2.2.1 National Forest Inventory, Inventory Study 2008 and Datenspeicher Waldfonds

The National Forest Inventory surveys the state of forests, and of forest production potential, on a large scale throughout Germany, using a standardised sampling procedure. The National Forest Inventory is a terrestrial sampling inventory that uses permanently marked sample points in a 4 km x 4 km basic grid whose resolution, at the request of the Länder, has been increased on a regional basis[61]. The first National Forest Inventory (BWI I) covered only the territory of the Federal Republic of Germany, in its pre-1990 borders, and West Berlin. It was carried out in the period 1986 to 1989 (sample year 1987). The second National Forest Inventory (BWI II) was carried out in the period 2001 to 2003 (sample year 2002), as a repeat

[60] GSE =GMES Services Elements
GMES = Global Monitoring for Environment and Security
[61] Further information: http://www.bundeswaldinventur.de

inventory in the old German Länder and as a first inventory in the new German Länder (BMVEL, 2001; BMELV, 2005).

In 2008, data on the state of forests as of the beginning of the Kyoto-Protocol commitment period were collected on a sub-sample of the National Forest Inventory that consisted of an 8 km x 8 km grid. In the main, the methods used for that so-called "2008 Inventory Study" (Inventurstudie 2008; IS08) are the same as those used for the National Forest Inventory (SCHWITZGEBEL et al. 2009, BMELV 2010).

The Datenspeicher Waldfonds (DSWF) database contains complete-coverage forestry-management data for the territory of the former GDR through 1993. Those data were collected at periodic intervals, annually revised in connection with growth models and updated in keeping with completion and change reports of that country's forest operations (BMELF, 1994).

7.2.2.2 Forest Soil Inventory (BZE and BioSoil)

Carbon emissions from forest soils have been estimated via the stock-changes method (IPCC 2003) by using data from three soil surveys, BZE I, BioSoil and BZE II. The Forest Soil Inventory I (BZE I) was carried out from 1987 to 1992, BioSoil was carried out from 2006 to 2007 and the Forest Soil Inventory II (BZE II) was carried out from 2006 to 2008. In all three inventories, samples were taken of both total organic layer, referred to in the following as "litter", pursuant to IPCC (2003), and of mineral soils. The data for the three inventories were collected by the Länder.

In the BZE I (WOLFF & RIEK 1996) and BZE II (WELLBROCK et al. 2006), forest soils throughout Germany were sampled within an 8 km x 8 km grid. In the sampling procedure, at each grid point, eight satellite samples were taken, within a 10 m radius around a central excavation with an exposed soil profile. For the BZE I, there were 1800 grid points; for the BZE II, there were 2000. The primary reason for the increase in the number of grid sampling points, from one inventory to the next, is that for the second it became possible to access areas which had been closed for the first (for which no access permits were available; for example, various former military exercise grounds were opened up).

In the period during which the BZE II was carried out, the BioSoil survey (UNECE 2006), covering 425 points in a 16 km x 16 km grid, was also carried out. The sampling and analysis methods for that survey were similar to those used in the BZE II. For the most part, corresponding grid points for the three inventories all lay, in each case, within a 30 m radius. For some 400 points, a systematic grid shift with respect to the BZE I occurred.

While for the BZE I a database is now available with some 1800 points for which carbon stocks for litter and the mineral soil (0 – 30 cm) have been calculated (WOLFF & RIEK 1996), the Länder have not yet completed transmitting BZE II survey data to a joint national database. For the BZE II, data from some 1400 grid points are available for calculation of carbon stocks. With the additional availability of the BioSoil data records, it became possible to calculate carbon stocks at some 1490 grid points for the years 2006 and 2007. Relevant analyses, and assessment in co-operation with Länder experts, have not yet been completed.

7.2.2.3 Additional activity data

Additional relevant activity data include

- GSE Forest Monitoring: Inputs for national greenhouse-gas reporting for the new German Länder
- Official topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem; ATKIS®;)
- CORINE Land Cover (CLC)

Details relative to these data are described in Chapter 7.1.3.2.1.

7.2.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.A)

7.2.3.1 The definition of forest under the National Forest Inventory

The basis for reporting consists of the definition of forest used by the National Forest Inventory (Bundeswaldinventur (BWI); BMVEL, 2001):

"Forest" within the meaning of the BWI is any area of ground covered by forest vegetation, irrespective of the information in the relevant cadastral survey or similar records. The term forest also refers to cutover or thinned areas, forest tracks, firebreaks, openings and clearings, forest glades, feeding grounds for game, timber yards / lumberyards, forest aisles for conduction, further areas linked to and serving the forest including areas with recreation facilities, overgrown heaths and moorland, overgrown former pastures, alpine pastures and rough pastures, as well as areas of dwarf pines and green alders. Heaths, moorland, pastures, alpine pastures and rough pastures are considered to be overgrown if the natural forest cover has reached an average age of five years and if at least 50 % of the area is covered by forest. Forested areas of less than 1,000 m^2 located in farmland or in developed regions, narrow thickets less than 10 m wide, Christmas tree and decorative brushwood cultivations and parkland belonging to residential areas shall not constitute forest within the meaning of the BWI. Watercourses up to 5 m wide do not break the continuity of a forest area.

At the same time, in a departure from the BWI definition of forest, areas that the BWI counts as forest, but places in the forest category "non-forest ground", i.e. because they are not wooded, were not taken into account in calculation of carbon stocks and carbon-stock changes. In the Federal Forest Inventory, short rotation coppices were included as forest. But since short rotation coppices do not count as forest within the German definition of forest used for greenhouse gas reporting, such data are excluded via filtering of BWI data (via the "silvicultural system" criterion) and therefore are not included in greenhouse-gas reporting.

Pursuant to IPCC GPG-LULUCF (2003), Land converted to Forest Land remains in the conversion category for at least 20 years and is subsequently included in Forest Land remaining Forest Land. For afforestation areas, data for the period as of 1970 are taken into account.

7.2.3.2 Determination of forest area and of relevant changes

Activity data for the LULUCF sector are derived with a sampling system that is used consistently for all land-use categories. In this system, land uses, as obtained from various data sources, are assigned to sample points, for certain time periods. For the present purpose, that technique was used to prepare a land-use matrix for the period 1990 to 2010. A detailed description of the procedure is provided in Chapter 7.1.3. The activity data for the forest categories Forest Land remaining Forest Land and Land converted to Forest Land are summarised in Table 210.

Table 210: Forest area, forest land remaining forest land and conversions from other land-use categories to forest land, from 1990 through 2010

Year	Forest area [ha]	Forest Land remaining Forest Land (5.A.1) [ha]	Cropland converted to forest (5.A.2.1) [ha]	Grassland (i.t.n.s.) converted to forest (5.A.2.2) [ha]	Woody Grassland converted to forest (5.A.2.2) [ha]	Wetlands (terr.) converted to forest (5.A.2.3) [ha]	Waters converted to forest (5.A.2.3) [ha]	Settlements converted to forest (5.A.2.4) [ha]	Other land converted to forest (5.A.2.5) [ha]
1990	10,766,646	10,204,916	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1991	10,779,590	10,217,861	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1992	10,792,535	10,230,806	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1993	10,805,479	10,243,750	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1994	10,818,424	10,256,695	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1995	10,831,368	10,269,639	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1996	10,844,313	10,282,584	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1997	10,857,257	10,295,528	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1998	10,870,202	10,308,473	178,940	173,280	103,734	27,924	1,799	73,067	2,985
1999	10,883,146	10,321,417	178,940	173,280	103,734	27,924	1,799	73,067	2,985
2000	10,896,091	10,334,362	178,940	173,280	103,734	27,924	1,799	73,067	2,985
2001	10,902,166	10,358,844	174,786	167,273	98,687	26,688	1,729	70,945	3,214
2002	10,908,241	10,383,327	170,631	161,265	93,640	25,452	1,659	68,824	3,442
2003	10,914,316	10,407,809	166,477	155,258	88,593	24,217	1,589	66,702	3,671
2004	10,920,391	10,432,292	162,323	149,250	83,545	22,981	1,519	64,580	3,900
2005	10,926,466	10,456,775	158,169	143,243	78,498	21,745	1,449	62,459	4,129
2006	10,928,856	10,481,479	151,541	136,035	74,612	20,349	1,393	59,435	4,012
2007	10,931,245	10,506,183	144,912	128,828	70,727	18,953	1,336	56,410	3,896
2008	10,933,634	10,530,887	138,284	121,620	66,841	17,556	1,279	53,386	3,780
2009	10,933,737	10,557,935	129,882	113,305	61,704	16,160	1,189	49,932	3,631
2010	10,933,840	10,584,982	121,480	104,989	56,567	14,764	1,099	46,477	3,482

7.2.4 Methodological issues (5.A)

7.2.4.1 Biomass

7.2.4.1.1 Forest land remaining forest land

For the old German Länder, and for the period until 2002, relevant data are available from two national forest inventories (referenced to the dates 1 October 1987 and 1 October 2002). Between BWI I and II, C stocks increased by 1.35 MgC ha^{-1} a^{-1} in the forests of the old German Länder. The increase in stocks is a result of low use, in comparison to growth. For the new German Länder, data from the National Forest Inventory II (BWI II) were compared with data from the Datenspeicher Waldfonds (DSWF) database, given the lack of an initial inventory comparable to BWI I. The comparison showed a marked net C-stock increase of 2.52 MgC ha^{-1} a^{-1}. From 2002, data for stock-change calculations throughout Germany are available from the BWI II and the Inventory Study 2008 (IS08). On the basis of that data, a C-stock increase of 0.44 MgC ha^{-1} a^{-1} was calculated for Germany.

Nonetheless, the sink effect of managed forests has decreased significantly as a result of forest management. The relevant reasons include a near doubling of the annual cut. In the first inventory period (1987 – 2002), for example, an average of about 47.9 million m³ (cubic meters of standing timber) were harvested per year in the old German Länder, while some 89.0 million m³ were harvested in the 2002 – 2008 inventory period. Despite the increase in the annual cut, harvests are still, in sum below the relevant CO_2 uptake.

Logging statistics for Germany as a whole show a similar trend – although they differ from forest inventory values (cf. DIETER & ENGLERT 2005) –, with an average of 39 million m³ (Efm = cubic meters of harvested timber, i.e. with bark and cutting losses deducted)[62] in the period 1991 – 2001 and an average of 56 million m³ (Efm) in the period 2002 – 2010 (cf. Table 211 and Figure 54).

Table 211: Raw-wood production pursuant to logging statistics of the Federal Statistical Office

Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Raw-wood production (millions of m³ u.b.)	39.1	35.6	34.3	37.1	40.0	37.0	38.2	39.1	37.6	53.7
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Raw-wood production (millions of m³ u.b.)	39.5	42.4	51.2	54.5	56.9	62.3	76.7	55.4	48.1	54.4

Figure 53 shows the carbon stocks for the three inventory dates. The data for 1987 and 1993 have been derived from the BWI I or the DSWF; data for 2002 have been taken from the BWI II; and data for 2008 have been derived from the IS08. These figures, which take account of both forest land remaining forest land and land converted to forest land, also highlight the increase in forest carbon stocks.

Overall, the forests of the Federal Republic of Germany are thus a net sink for carbon.

[62] The wood mass in standing trees is given in cubic meters of standing timber. A cubic meter of harvested timber is equivalent to a cubic meter of standing timber less the losses incurred in wood harvesting and grading.

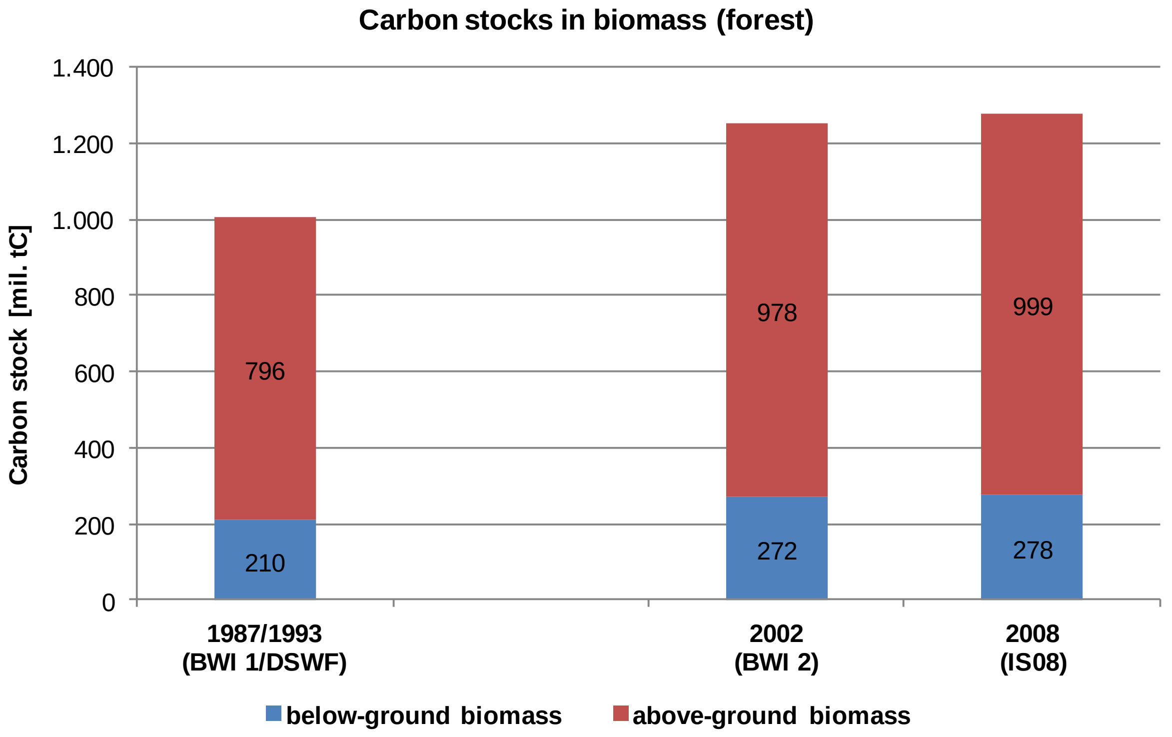


Figure 53: Carbon stocks in below-ground and above-ground biomass, in forest, in the years 1987/1993, 2002 and 2008

Changes in biomass carbon stocks are calculated via the "stock-change method" (IPCC 2003, p. 3.24). Systematic use of this IPCC GPG method (Tier 2) leads to an average country-specific emission factor per period. Such emission factors differ from one period to the next. The reasons for the large difference between the average country-specific emission factors of the periods 1990-2001 and 2002-2008 are described in the paragraph above. As is apparent, use of this method results in so-called "jumps" or "fluctuations" in an inventory year (cf. Chapter 7.2.1 Figure 51).

The reasons for the change include increased wood use in the 2002-2008 inventory period. Figure 54 shows the relationship between wood use and biomass changes.

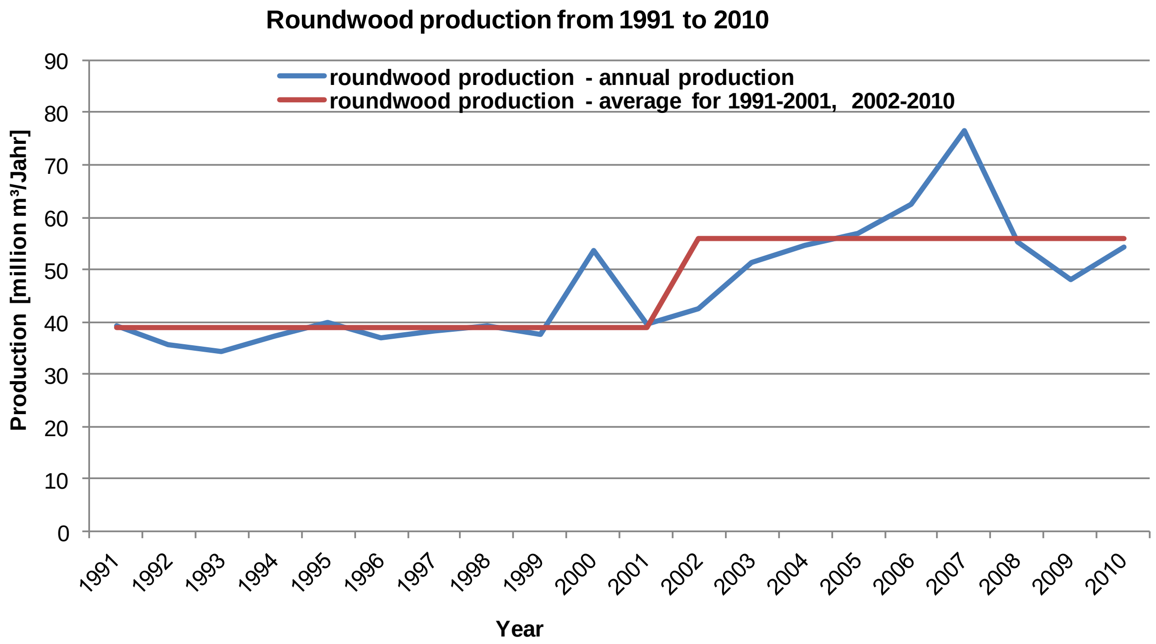


Figure 54: Raw-wood production in forests – annually and for the periods 1991 to 2001 and 2002 to 2010

A second reason for the change is that gross growth of forests has changed as a result of changes in forests' age structures (cf. Figure 55). German forests are aging, and thus additions through growth are expected to slow. That effect cannot be quantified, however, due to a lack of data for all of Germany for the period prior to 2002. This situation will change when the results of BWI III (2012) become available.

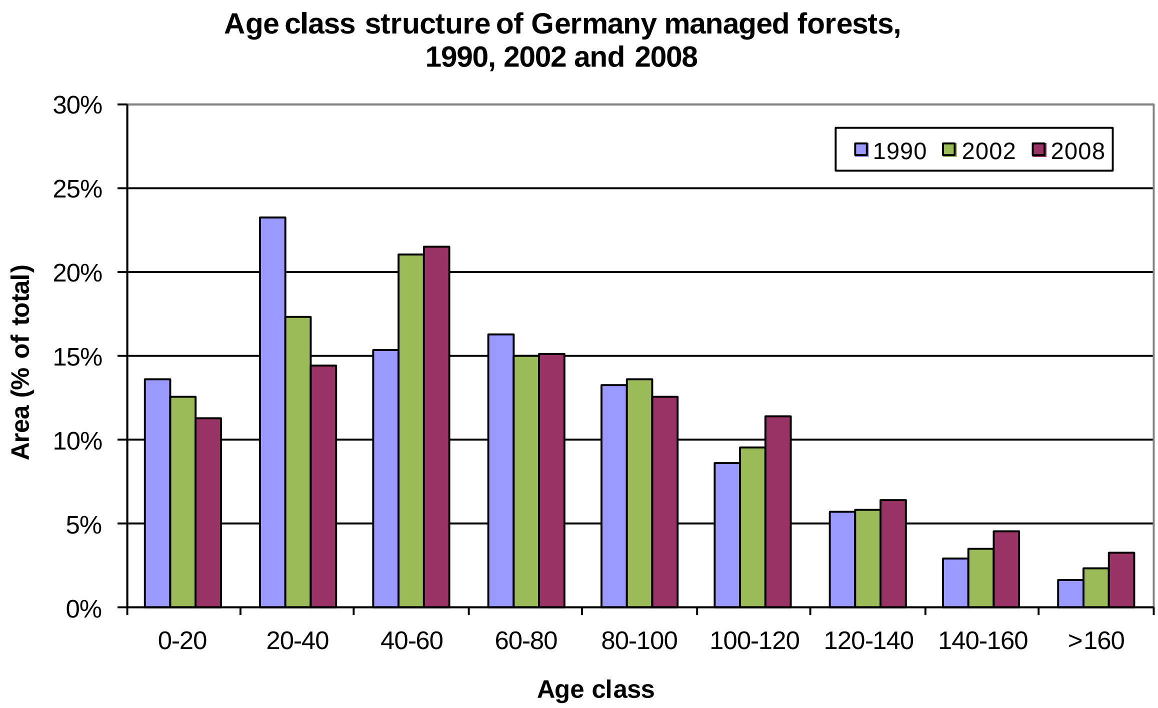


Figure 55: Age-class structure of forests in Germany as of the years 1990, 2002 and 2008

7.2.4.1.2 Land converted to Forest Land

To obtain emission factors for Land converted to Forest Land an individual-tree calculation was carried out on the basis of the BWI I and BWI II inventories. Only trees in the old German Länder were taken into account, since the BWI I inventory was carried out only there. The carbon stocks were calculated for each area on which conversion from a given land use to forest land took place, and then all the resulting stocks were combined within the "Land converted to Forest Land" category. The stocks of earlier-use categories were deducted – and thus taken into account.

Since it was not possible, for the new German Länder, to derive wood stocks for Land converted to Forest Land directly from comparison of two inventories, the relevant values for the old German Länder were used.

The biomass stocks at the end of the 2002 vegetation period represent the increase in stocks in biomass throughout the entire period under consideration since 1987. That increase in stocks was linearly interpolated/extrapolated throughout the period 1990 to 2010. The C-stock increase, for the entire afforested area, is 4.15 MgC ha^{-1} a^{-1} for each year. It must be remembered that afforested areas remain in this land-use category for 20 years. On the areas added each year, the C-stock losses from previous uses must be taken into account; those losses are immediately assessed as emissions. In Table 212, the C stocks from previous uses for all land-use categories have been combined, weighted by area (cf. also Chapter 7.1.7).

Table 212: Carbon stocks from previous uses, as an area-weighted average of all previous-use categories

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
C stocks [MgC ha^{-1}]	15.36	15.44	15.30	15.54	15.40	15.47	15.54	15.59	15.55	15.62	15.58
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	
C stocks [MgC ha^{-1}]	8.45	8.19	7.87	8.61	8.43	16.33	16.45	16.64	10.01	9.77	

In the Inventory Study 2008 , no cluster screening – which is normally aimed, for example, at identifying clusters on new forest land – was carried out. For this reason, no new-forest areas were identified. In addition, no samples with individual-tree data were available for the period from 2002 (BWI II) through 2008 (IS08). Values for that period were calculated via extrapolation of data from the BWI I and BWI II surveys. To determine net growth on new forest areas in the period from 2002 through 2008, plots with status "… Land converted to Forest Land" in the period 1990-2001 were used. That net growth amounted to 4.95 MgC ha^{-1} a^{-1}. As mentioned above, it was not possible to take Land converted to Forest Land as of 2002 into account, and thus this net-growth figure does not include those areas' growth. For this reason, this update value was not included in reporting.

7.2.4.1.3 Derivation of individual-tree biomass

For calculation of carbon stocks, data from BWI I (some 230,000 measured trees) were used for the old German Länder as of the 1987 sampling year. For the new German Länder, data on forest management plans through 1993 are available in aggregated form, in the Datenspeicher Waldfonds database, that can be used for calculations of C stocks. The BWI II survey, in which some 377,000 trees were measured, provides the database for the 2002 sampling year for Germany. Those data sources provide such a good basis for calculating estimated C-stock changes that it was preferable to use the stock-change method instead of the default method (IPCC, 2003: p. 3.24). The BWI data have been supplemented with repeat-survey data for some 83,000 trees, from the Inventory Study 2008.

Forest inventories yield volume data that often emphasise usable dimensions (volume). For purposes of greenhouse-gas reporting, data on carbon mass in trees is required, however. Consequently, the biomass of a given tree is estimated via a step-by-step procedure – for example, via biomass functions that can be applied to measured inventory data. These functions directly yield tree dry masses, usually with the input quantities diameter at breast height (DBH) and height (H). In a second step, the so-determined biomass is multiplied by its carbon content, to obtain the entire C mass in the relevant individual tree. Unfortunately, findings from biomass studies carried out to date are based on small numbers of samples; or have been obtained from trees growing in other climate zones (Scandinavia, Siberia, North America); and/or represent only local growth and site circumstances and applicable management options. Use of such data would thus produce distorted biomass estimates. For this reason, a procedure was applied (PISTORIUS et. al., 2006) whereby the raw-wood volume, as determined in the inventory, is converted into the above-ground tree volume. The above-ground tree volume includes branches and, for evergreen trees, the leaf organs. To estimate tree wood volumes from raw-wood volumes, regression equations are used that describe the relationship between the above-ground raw-wood volume and the above-ground tree wood volume. These volume-expansion functions were derived from the tables of Grundner & Schwappach (1952), which are based on an extensive database comprising

71,051 trees. In spite of its age, that database is still assumed to be the most suitable database for Germany at present.

In a next step, the above-ground biomass of individual trees was estimated by multiplying the raw-wood volume by the applicable volume density. Density data from KOLLMANN (1982), for specific tree-species groups, were used for that purpose. Since those data include statistics relative to applicable value ranges, they support error analysis via triangular distribution. With this method, the greater volume densities found in branches (HAKKILA, 1972) can be taken into account, since the difference between tree-wood volume and raw-wood volume correlates with branch mass. That separation was carried out for the densities pursuant to KOLLMANN (1982).

The below-ground living biomass was taken into account via stock-mass relationships. To that end, the above-ground biomass, broken down by tree species, was aggregated to hectare values for each random-sample point. The resulting values were multiplied with the IPCC default values (IPCC, 2003, Table 3A.1.8), to derive root biomass.

For use of the stock-change method, the relevant living biomass was divided into the categories of raw-wood volume, branch-wood volume and root mass. Above-ground volumes were converted into masses using specific volume densities for the various tree species in question. Equation 10 and Equation 11 for C-stock determination via the stock-change method were thus converted, pursuant to PISTORIUS et al. (2006), into the form exhibited by Equation 12. The first term of that equation (raw wood, branch wood) was applied to each tree, and the results were aggregated to obtain values for entire stands. The stand values, broken down by tree-species groups, were used to derive the below-ground biomass for the second term of Equation 12.

Equation 10

$$\Delta C = (C_{t2} - C_{t1}) / (t_2 - t_1)$$

Equation 11

$$C = (D * rd * BEF) * (1 + R) * CF$$

Equation 12

$$C = (D * rd_{stamm} + D * rd_{ast} * (VEF - 1)) * (1 + R) * CF$$

where:

C	= carbon stocks
t	= time at which an inventory is taken
D	= raw-wood volume
rd_{stamm}	= stem bulk density
rd_{ast}	= branch bulk density
BEF	= biomass-expansion factor
VEF	= volume-expansion factor[63]
R	= root / shoot ratio

[63] The biomass-expansion factor (BEF) is used here in keeping with IPCC. In the literature, the term "BEF" is used in a variety of very different ways. For this reason, in the following, the term "volume-expansion factor" (VEF) is used, which describes the relationship "above-ground volume / raw-wood volume".

CF	= carbon fraction

7.2.4.1.4 Conversion into above-ground individual-tree biomass

The raw-wood volume D of each individual tree is derived using the BWI-volume function, which depends on the parameters diameter at breast height (DBH), tree height (H) and diameter at a height of 7 m (D7). The raw-wood volume D is converted to biomass (in tonnes) via bulk-density values rd_{stem} for each relevant tree-species group. The bulk-density values are derived via the formula:

Equation 13

$$r = r_0 (1 - \beta_V / 100)$$

where:

r	= bulk density
r_0	= raw density
β_V	= volume-loss measure

Those values depend on the volume-loss measures and raw densities given in KOLLMANN (1982). The raw densities - given in KOLLMANN (cf. Table 213) - also include the raw-density ranges and their average values for the most important tree species. The aforementioned ranges provide the basis for deriving the error framework which results from conversion of raw-wood volume into biomass. Table 213 lists bulk densities pursuant to IPCC and KNIGGE & SCHULZE (1966) by way of comparison. While those figures are comparable to those given by KOLLMANN (1982), they do not yield error data.

Table 213: Bulk densities *rd* in [g/cm³], as given by IPCC (2003), KOLLMANN (1982) and KNIGGE & SCHULZ (1966)

Genus	Species	Stem (IPCC)	Branch (IPCC)	Stem (Kollmann)	Branch (Kollmann)	Knigge & Schulz (branch and stem)	βV [%] (Kollmann)
Picea	**Abies**	0.40	0.54	0.38	0.51	0.38	11.9
Picea	**(other)**	0.40	0.54	0.38	0.51	0.38	11.9
Pinus	**sylvestris**	0.42	0.56	0.43	0.58	0.43	12.1
Pinus	**Strobus**	0.32	0.43	0.43	0.58	0.43	12.1
Pinus	**(other)**	0.42	0.56	0.43	0.58	0.43	12.1
Abies	**Alba**	0.40	0.54	0.36	0.49	0.37	11.5
Abies	**(other)**	0.40	0.54	0.36	0.49	0.37	11.5
Pseudotsuga	**menziesii**	0.45	0.60	0.41	0.56	0.41	11.9
Larix	**Decidua**	0.46	0.62	0.49	0.66	0.49	11.4
Larix	**kaempferi**	0.49	0.66	0.49	0.66	0.49	11.4
Thuja	**spec.**	0.31	0.42	0.38	0.51	0.38	11.9
Tsuga	**spec.**	0.42	0.56	0.38	0.51	0.38	11.9
Coniferous trees	**(other)**	0.40	0.54	0.38	0.51	0.38	11.9
Fagus	**sylvatica**	0.58	0.64	0.56	0.61	0.55	17.9
Quercus	**Robur**	0.58	0.62	0.57	0.61	0.56	12.2
Quercus	**Petraea**	0.58	0.62	0.57	0.61	0.56	12.2
Fraxinus	**excelsior**	0.57	0.60	0.56	0.60	0.56	13.2
Carpinus	**Betulus**	0.63	0.69	0.64	0.70	0.56	18.8
Acer	**spec.**	0.52	0.57	0.52	0.57	0.56	11.5
Tilia	**spec.**	0.43	0.47	0.42	0.46	0.56	12.1
Robinia	**pseudoacacia**	0.58	0.64	0.65	0.71	0.56	11.5
Ulmus	**spec.**	0.51	0.54	0.56	0.59	0.56	14.9
Castanea	**Sativa**	0.48	0.51	0.56	0.59	0.56	11.4
Betula	**spec.**	0.51	0.56	0.53	0.58	0.38	13.2
Alnus	**spec.**	0.45	0.49	0.43	0.47	0.38	17.9
Populus	**spec.**	0.35	0.38	0.35	0.39	0.38	13.7
Salix	**spec.**	0.45	0.49	0.46	0.51	0.38	13.7
Prunus	**spec.**	0.49	0.54	0.56	0.61	0.38	12.6
Deciduous trees	**(other)**	0.58	0.64	0.56	0.61	0.38	13.7

The raw-wood volume D was expanded to the above-ground tree wood volume B via the functions published in PISTORIUS et al. (2006) for derivation of volume-expansion factors (*VEF*). As used, the functions have the form

Equation 14

$$VEF = B / D = (a + bD) / D$$

The parameters a and b for calculation of *VEF* are listed in Table 214.

Table 214: Models for deriving volume-expansion factors

Model	a	b
Birch	0.017493	1.121933
Beech, age to 60	0.011942	1.207371
Beech, age 61 to 100	0.008184	1.196184
Beech, age at least 101	0.030255	1.128104
Oak	0.101879	1.051529
Alder	0.004825	1.068903
Spruce, age to 60	0.036697	1.148143
Spruce, age at least 61	0	1.177947
Pine, age to 80	0.009946	1.156659
Pine, age at least 81	0.036883	1.076103
Fir, age to 80	0.019457	1.168262
Fir, age 81 to 120	0	1.228069
Fir, age at least 121	0	1.219492
Larch	0.063265	1.057712

The difference between tree wood volume and raw-wood volume is defined as branch wood. Due to the stresses it is subject to, branch wood is denser than trunk wood. Differentiation of categories makes it possible to use branch-wood densities that differ from raw-wood densities. The necessary data were derived by analogy to HAKKILA (1972), who divides trees by physiological groups – into conifers, ring-porous deciduous trees and diffuse-porous deciduous trees. Table 215 shows average values for 8 conifers, 8 ring-porous deciduous trees and 4 diffuse-porous deciduous trees. A relationship for these physiological tree-species groups was derived, and the basic densities pursuant to KOLLMANN (1982) were correspondingly increased.

Table 215: Wood densities for branch wood

	Stem wood [g/cm³]	Branch wood [g/cm³]	Ratio, Branch density / stem density
Conifers	0.36	0.49	1.34
Diffuse-porous deciduous trees	0.49	0.54	1.1
Ring-porous deciduous trees	0.54	0.57	1.06

The above-ground biomass Bo for a given individual tree, therefore, is obtained as the sum of the raw-wood biomass and the branch-wood biomass, via the following equation:

Equation 15

$$B_o = D * rd_{stamm} + D * (\frac{a + bD}{D} - 1) * rd_{ast}$$

Trees with less than 7 cm DBH

In the National Forest Inventory, the numbers of trees with DBH of less than 7 cm are tallied in sampling circles, and grouped into separate size classes. The mean individual-tree volumes for such size classes are known from studies carried out by the FVA Baden-Württemberg (an institute for forest trials and research): trees shorter than 50 cm have an average volume of 0.0002 m^3; trees > 50 cm height and < 7 cm DBH have an average volume of 0.001 m^3. Tree volumes are converted into biomass via multiplication by the bulk densities listed in Table 213.

7.2.4.1.5 Conversion into below-ground biomass

In contrast to derivation of above-ground biomass, the root dry substance was not calculated via a volume and the bulk density; instead, it was estimated directly from the above-ground biomass. Dry-root substance was estimated using the root/shoot ratio, at the stand level, with values from Table 3A.1.8 IPCC (2003) (cf. Table 216). To obtain stand values, the above-ground biomass, differentiated by tree-species groups, was up-scaled to the hectare level for each sampling point, and then the below-ground biomass was derived. An advantage of the IPCC table is that it gives the standard error for estimates.

The below-ground biomass can also be calculated via root-biomass functions. Because root studies are so difficult to carry out, few relevant functions are available. For example, DIETER & ELSASSER 2002 published a function for estimating root biomass. In the main, this function is based on data, for temperate forests, of CAIRNS et al. (1997), KURZ et al. (1996) and VOGT et al. (1996). They achieved a random-sampling set of 272 root studies. However, the function of DIETER & ELSASSER (2002) was not used, because no error information for that function was given. A calculation comparing the function of DIETER & ELSASSER (2002) and the IPCC values is presented by DUNGER et al. (2010c).

Table 216: Root/shoot-ratio at the plantation level, pursuant to IPCC (2003)

Vegetation type	Above-ground biomass [t ha^{-1}]	Average root / shoot ratio	Standard error	Lower range	Upper range
Coniferous trees, plantations	50	0.46	0.21	0.21	1.06
	50-150	0.32	0.08	0.24	0.50
	150	0.23	0.09	0.12	0.49
Oak forest	70	0.35	0.25	0.20	1.16
Other deciduous tree species	75	0.43	0.24	0.12	0.93
	75-150	0.26	0.10	0.13	0.52
	150	0.24	0.05	0.17	0.30

7.2.4.1.6 Conversion of individual-tree biomass to carbon

For conversion of biomass to C stocks, the IPCC default value of 0.5 (IPCC, 2003, Equation 3.2.3) was used. WIRTH et al. (2004) report that the differences between compartments, within one and the same tree species, are larger than the differences between tree species. They obtain a range of 0.50 to 0.56 gC g^{-1} in conifers. The relative standard error for carbon content in wood is given by BURSCHEL et al. (1993) as 1 to 2 %; WEISS et al. (2000) use 2 %. Overall, therefore, 0.5 gC g^{-1}, with a relative standard error of ±2 %, seems appropriate as a good assumption for mean C content.

7.2.4.1.7 Procedures for scaling up to relevant states in 1987, 2002, 2008

This section presents the procedures for scaling up the values "raw-wood stocks", "biomass" and "carbon", in the context of an underlying stratified cluster sampling, for a given time. Stratification is required, since some Länder have increased the density of their sampling grid, the so-called "sampling strata". The relevant states for the years 1987, 2002 and 2008 were calculated. The up-scaling procedures for different domains (Germany, various regions (old/new Länder) and different LULUCF/ARD categories) are identical.

The National Forest Inventory is designed on a basis of cluster sampling. The smallest sampling unit is the cluster, with four cluster points (sample points). Along the boundaries of the inventory area, or of sampling strata, incomplete clusters, of varying sizes, will be found, i.e. the number of sample points (cluster points in forest and non-forest) within such clusters can vary between 1 and 4. For each cluster c located within a stratum *l*, the local density (*Y*) must be calculated first:

Equation 16

$$Y_{lc} = \frac{\sum_{m=1}^{M} I_{l,c,m} Y_{l,c,m}}{M_{l,c}}$$

where $M_{l,c}$ = number of sampling points in cluster c in stratum *l*. The estimator of means, with respect to forest and non-forest, for stratum *l* is then obtained as follows:

Equation 17

$$\hat{\bar{Y}}_l = \frac{\sum_{c_l=1}^{C_l} M_{l,c} Y_{lc}}{\sum_{c_l=1}^{C_l} M_l}$$

The estimator of means throughout all sampling strata ($\hat{Y}_{st}$) is the mean of the individual stratum estimators, weighted with the area proportions for the various strata:

Equation 18

$$\hat{\bar{Y}}_{st} = \sum_{l=1}^{L} \hat{\bar{Y}}_l \frac{\lambda(U_{l)}}{\lambda(U)}$$

The estimator of the total is obtained by multiplying the estimator of means throughout all strata by the total area *λ(U)*.

Equation 19

$$\hat{Y}_{st} = \hat{\bar{Y}}_{st} \lambda(U)$$

The (forest-) area-related mean estimator is defined as the quotient or ratio estimator ($\hat{R}_{st}$); it is obtained as follows:

Equation 20

$$\hat{R}_{st} = \frac{\hat{Y}_{st}}{\lambda(U_{Wald})}$$

7.2.4.1.8 Up-scaling procedures for obtaining changes between 1987 and 2002, and between 2002 and 2008 (derivation of stock changes via the "stock-change method")

For calculation of the changes between two time points, the "continuous forest inventory" (CFI) method was used, i.e. for up-scaling only those cluster points were used that were included at both times. The change estimate is thus based on the difference between the two status estimators. At the stratum level, the total change is estimated as follows:

Equation 21

$$\hat{G}_l = \hat{Y}_l^{(t_2)} - \hat{Y}_l^{(t_1)}$$

The total change throughout all strata is estimated in the manner used in Equation 18. The estimated total change is calculated via Equation 19. The change in the area-related mean estimator is determined via:

Equation 22

$$\hat{G}_{R_{st}} = \hat{R}_{st}^{(t_2)} - \hat{R}_{st}^{(t_1)}$$

7.2.4.1.9 Interpolation of time periods, to obtain annual-change estimates

The National Forest Inventory (BWI; Bundeswaldinventur) is carried out periodically. Consequently, annual rates of change – "emission factors" – have to be obtained via interpolation between two points in time. For the time periods between BWI I (sample year 1987) and BWI II (sample year 2002) and the Inventory Study 2008, linear interpolation was carried out at the level of the LULUCF and ARD classes. The emission factor EF for a LULUCF class is thus defined as the quotient of the area-related mean estimator and the number of years *a* within the relevant inventory interval:

Equation 23

$$EF = \hat{R}_{st}^{(t_1,t_2)} / a$$

A linear trend was also chosen in cases in which change estimates had to be extrapolated beyond an inventory period.

7.2.4.2 Dead wood

7.2.4.2.1 Forest land remaining forest land

The C stocks in dead wood were calculated with data of the BWI II (BMELV 2005) survey and the Inventory Study 2008. The terrestrial survey used for BWI II included only fallen dead wood with a thicker-end diameter of at least 20 cm, standing dead wood with a diameter of at least 20 cm at breast height (DBH), and trunks with either a height of at least 50 cm or a cut-surface diameter of at least 60 cm (BMVEL 2001). In keeping with requirements for climate reporting, in the Inventory Study 2008 the survey threshold for dead-wood objects was reduced to a diameter of at least 10 cm at the thicker end (BMELV 2010). In both forest inventories, trees were sub-divided into three main tree-species groups: conifers, deciduous trees (except for oaks) and oaks. In addition, dead wood was classified into a total of four decomposition-level categories (BMELV 2010, BMVEL 2001).

For purposes of reporting pursuant to IPCC (2003), the applicable dead-wood-stock relationship between the 10 cm and 20 cm survey limits was determined from the data collected in the Inventory Study. Under the assumption that that relationship was the same at the time of BWI II, the dead-wood stocks from the 10 cm survey limit upward were estimated for the year 2002. The biomass of the dead wood stocks from BWI II (2002) and the Inventory Study (2008), for the various relevant decomposition classes, was determined with the wood density figures pursuant to FRAVER et al (2002) for conifers, and with the wood density figures pursuant to MÜLLER-USING & BARTSCH (2009) for deciduous trees. To calculate the wood density of deciduous wood, the dead-wood objects in the deciduous (other than oak) and oak tree-species groups were combined. The annual C-stock change in dead wood was calculated pursuant to Equation 24 (IPCC 2003, Equation 3.2.12). It amounts to about 0.09375 MgC ha^{-1} a^{-1}.

Equation 24

$$\Delta C_{FF_{DW}} = \frac{A * \left(B_{t_2} - B_{t_1}\right)}{T} CF$$

where:

ΔC_{FFDW} =	Annual change in carbon stocks in dead wood, on forest land remaining forest land
A =	Area of forest land remaining forest land
B_{t1} =	Dead-wood stocks at time t_1 for forest land remaining forest land
B_{t2} =	Dead-wood stocks at time t_2 (previous time) for forest land remaining forest land
T=(t_2-t_1) =	Time period between the two estimates
CF =	Carbon conversion factor (standard value = 0.5)

7.2.4.2.2 Land converted to Forest Land

On Land converted to Forest Land (0-20 years), no creditable accumulation of dead wood takes place, since the dead-wood objects produced on such land tend to have diameters smaller than 10 cm. Pursuant to the guidelines for climate reporting, the survey threshold for dead-wood objects is a diameter of at least 10 cm. The BWI II data indicate that the mean DBH of a 20-year-old stand is no more than 10 cm, throughout all tree species. For this reason, for the entire report period, no dead wood is reported on Land converted to Forest Land, and NO (not occurring) is entered at the corresponding locations in the CRF tables.

7.2.4.3 Litter

7.2.4.3.1 Forest land remaining forest land

The calculation of C-stock changes in the soil and in litter is based on data from national forest-soil inventories (BZE I and BZE II) and on the BioSoil inventory data. Carbon-stock changes did not differ significantly from zero in the period from 1990 (BZE I) to 2006 (BZE II / BioSoil) (cf. Chapter 7.2.4.3.4); for this reason, a change of 0 MgC ha^{-1} a^{-1} is assumed. The same assumption was made for the period 2007 to 2010. In the CRF tables, NO (not occurring) is thus entered for that category.

7.2.4.3.2 Land converted to Forest Land

Carbon stocks in litter were calculated on the basis of status data from the BZE I, BZE II and BioSoil inventories. According to those calculations, the mean carbon stocks in litter, referenced to 1990 (BZE I), were 19.41 MgC ha^{-1}, and, referenced to 2006 (BZE II/BioSoil) 18.71 MgC ha^{-1} (cf. Chapter 7.2.4.3.3). For the period 1991 to 2005, the mean carbon stocks in litter are obtained via interpolation; for the period as of 2007 they are obtained via extrapolation and used as a basis for calculating afforestation areas (cf. Table 217).

Table 217: Implied emission factors for litter for land converted to forest land

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
IEF [MgC ha^{-1}]	0.48525	0.48416	0.48306	0.48197	0.48088	0.47978	0.47869	0.47759	0.47650	0.47541	0.47431
Jahr	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
IEF [MgC ha^{-1}]	0.47322	0.47213	0.47103	0.46994	0.46884	0.46775	0.46666	0.46556	0.46447	0.46338	

Litter forms only gradually in afforested areas. It was assumed that it takes 40 years for average carbon stocks to form in litter. The annual carbon-stock increase in litter is obtained by dividing the mean carbon stocks for the year in question by the number of years required for those mean carbon stocks to form. Those values are confirmed by standard values for carbon storage in litter, and by standard values for the time periods required for a new balance to form, pursuant to IPCC (2006) and PAUL et al. (2009).

7.2.4.3.3 Derivation of carbon stocks in litter

Sampling of litter was carried out by taking samples at satellite points, using sampling frames of various sizes. The litter was considered to comprise all dead organic cover with a fraction < 20 mm. For some 80 % of points, the fraction > 20 mm was also included in the litter sample. Organic carbon concentrations in the litter were measured via comparable methods. The following relationship is relevant: total carbon (C_{ges}) is equal to organic carbon (C_{org}) ($[C_{ges}]=[C_{org}]$). In each case, the carbon stocks in litter are calculated from the area of the sampling frame, and from the weight and organic concentration of the relevant litter. A more detailed description of the relevant methodological aspects is provided by KÖNIG et al. 2005.

All points available from the BZE I, BZE II and BioSoil surveys, along with information as to the forest type concerned in each case, entered into calculation of litter carbon stocks. All values that were either smaller or larger than twice the standard deviation ($x \pm 2\sigma$) were considered to be outliers and were deleted. From the values of the remaining data points for the BZE I (n = 1724) and BZE II / BioSoil (n = 1341) surveys, it was possible to calculate carbon stocks separately for deciduous, coniferous and mixed forest (cf. Table 218). The mean C stocks given by the two inventories were calculated as a weighted mean from the carbon stocks for the three forest types concerned. The applicable weights were obtained from the forest types' area shares of the total forest area, as given by CORINE land-use data for 1990 and 2006, and from the regional densities of the inventory networks. The mean C stocks for the samples were 19.41 ± 0.33 Mg ha^{-1}, for BZE I, and 18.71 ± 0.44 Mg ha^{-1}, for BZE II/BioSoil. As country-specific values for litter, those values replace the recommended standard value in IPCC (2003) as the basis for calculating CO_2 emissions from litter in connection with deforestation (cf. Chapter 11.3.1.1.4) and carbon sequestration in litter in connection with afforestation (cf. Chapter 7.2.4.3.2).

Table 218: Carbon stocks in litter in German forests, as determined in the BZE I and BZE II / BioSoil inventories, along with the pertinent standard error

Forest type	Carbon stocks (BZE I) [Mg/ha]	Carbon stocks (BZE II/BioSoil) [Mg/ha]
Deciduous forest	9.53 ± 0.43	7.69 ± 0.42
Mixed forest	16.85 ± 0.73	14.75 ± 0.86
Coniferous forest	24.65 ± 0.48	24.30 ± 0.67
Total forest	**19.41 ± 0.33**	**18.71 ± 0.44**

7.2.4.3.4 Derivation of carbon-stock changes in litter in the period from 1990 (BZE I) to 2006 (BZE II/Biosoil)

The sampling plots entering into calculation of carbon stocks were analysed as unpaired samples. With a two-sided t-test for unpaired samples, it was tested whether the carbon stocks at the two inventory times differed. Each sampling plot was assigned a weight consisting of the area percentage for the relevant stratum and the regional network density. The average difference was -0.044 ± 0.035 MgC ha^{-1} a^{-1}. The value did not deviate significantly from zero.

For Forest Land remaining Forest Land, no transfer into the CRF tables was carried out, since the results are provisional and since no significant changes were calculated.

For Land converted to Forest Land, annually decreasing factors for litter accumulation were calculated from the C stocks given by BZE I / BZE II and the average difference (cf. Chapter 7.2.4.3.2 and Table 217).

7.2.4.4 Mineral soils

7.2.4.4.1 Forest land remaining forest land

Carbon stocks, and carbon-stock changes, in mineral soils were up-scaled on the basis of the national forest soil inventories (BZE I and BZE II) and of the BioSoil inventory data (cf. Chapter 7.2.2.2). The data from the second soil inventory are currently being evaluated. With a view to analysing whether the soil is a C source, changes in mineral soils were calculated, with the existing data, for both inventories. The relevant methods are described in detail in chapters 7.2.4.4.3 and 7.2.4.4.4. From the results, which are still provisional, and which include only part of the relevant data, a C source was ruled out. Because the results are provisional, they have not been included in the CRF tables with respect to category 5.A.1 (Forest Land remaining Forest Land).

7.2.4.4.2 Land converted to Forest Land

For Land converted to Forest Land, the carbon-stock changes in mineral soils were calculated in keeping with the procedure in Chapter 7.1.5. The calculated mean emission factors (implied emission factors), which are summarised in Table 219, are oriented to annual carbon-stock changes in mineral soils in connection with land-use changes leading to Forest Land (Land converted to Forest Land), over a change period of 20 years.

Table 219: Emission factors for mineral soils in connection with land-use changes leading to Forest (Land converted to Forest Land)

Time period [year]	1990-2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
IEF [MgC ha^{-1} a^{-1}]	-0.30407	-0.30096	-0.29763	-0.29407	-0.29024	-0.28611	-0.28459	-0.28291	-0.28105	-0.27901	-0.27666

7.2.4.4.3 Derivation of carbon stocks and carbon-stock changes

Mineral soil was sampled at depths of relevance for the national inventory report; at most BZE points, this involved depth ranges of 0-5 cm, 5-10 cm and 10-30 cm. In a few cases, samples were taken on a horizon basis. In the BioSoil inventory, samples were taken at depth ranges of 0-5 cm, 5-10 cm, 10-20 cm and 20-40 cm.

As part of sampling, the fine-earth bulk density (TRD_{fb}), the coarse-fragment content (GBA) and the organic-carbon concentration (C_{org}) were determined using comparable methods (KÖNIG et al. 2005). The fine-earth bulk density was determined via volume-adapted sampling, for different depth ranges; to some extent, estimated values based on soil profiles were used (WOLFF & RIEK 1996, WELLBROCK et al. 2006). Where fine-earth bulk-density data is lacking, existing relevant values from other inventories have been used. That procedure has also been applied to obtain coarse-fragment content values, which are needed for calculation of the TRD_{fb} and fine-earth stocks.

In carbonate-containing soils, the organic-carbon concentration (C_{org}) in fine soils was measured with respect to the inorganic-carbon concentration (C_{anorg}) ($[C_{org}] = [C_{ges}] – [C_{anorg}]$). In non- carbonate-containing soils, the relationship $[C_{org}] = [C_{ges}]$ applies.

The carbon stocks were calculated from the stocks for the individual depth layers. To that end, it was necessary first to translate horizon-based data into depth-layer sections. This was accomplished, in each case, by calculating the carbon stocks in a given depth layer, with stocks weighted in accordance with the thicknesses of overlapping sections and their carbon stocks. This was also carried out for the different depth layer, 20-40 cm, used by the BioSoil inventory.

An area-referenced approach, with strata formation, was used for calculation of carbon stocks and of their changes between the two inventory times. The basis for formation of area-relevant strata consisted of the 72 legend units used in the national soil map "Bodenübersichtskarte der Bundesrepublik Deutschland 1:1.000.000" (BÜK 1000). That source describes the dominant soil types, and parent material for soil formation, pursuant to the German soil system (AG BODEN 1994) and FAO legend (FAO 1990). Since the classes concerned differed in the number of sampling points they contained, the various dominant soil units were aggregated into new dominant soil groups. This increased the basic totality for each class, thereby increasing the pertinent statistical significance. The groups formed were oriented to comparable soil types, to substrate type and parent material and to texture and lime content. All in all, 20 new dominant soil groups, with their pertinent parent material, were then available for area-referenced evaluation (cf. Table 220). The inventory plots were allocated to the dominant soil groups on the basis of data, collected in the inventories, relative to the parent material and any layering of that material, to soil type, to horizon sequences and to soil texture.

Table 220: Combined legend units on the basis of the BÜK 1000 soil map

Abb.	Dominant soil groups, by substrate type, soil texture and lime content
1	Alluvial soils / gley soils from loamy to clayey alluvial sediments
2	Podzolic soils from sandy terrace or riverine deposits
3	Various soils from partly calcareous, sandy-loamy high-flood and alluvial sediments
4	Pseudo-gleyed soils from sandy to loamy sediments overlying boulder clay
5	Various soils from sandy sediments overlying boulder clay
6	Podzolic soils from dry, oligotrophic sands
7	Brown earths from nutrient-rich sands
8	Various soils from loess or loess-loam, partly overlying various rocks
9	Various soils from mixed sand and loess or loess-loam
10	Various soils from scree overlying calcareous, marl and dolomite rock, alternating with terra fusca from silty-clayey redeposited products of limestone weathering
11	Brown earth and terra fusca from redeposited products of weathering of calcareous, marl and dolomite rock, and rendzina from limestone
12	Pelosol – brown earth / pelosol-pseudogley from weathering products of marl and clay rocks
13	Brown earth from marl rocks and calcareous rubble
14	Brown earth from alkiline and intermediary magmatic rock
15	Brown earth from acidic magmatic and metamorphic rock
16	Podzolic soils from hard clayey and silty slates with fractions of greywacke, sandstone, siltstone, quarzite and phyllite
17	Podzolic and groundwater-affected soils from loess mixed with crystalline slates, sandstone, quarzite and acidic to intermediary magmatic rock
18	Podzolised brown earth from low-alkilinity quarzitic sandstones and conglomerates
19	Various soils alternating tightly with clay slate, greywacke, limestone, and loess-loam overlying various rocks
20	Soils of different alpine elevations, from limestone and dolomite, and from non-calcareous silicate rocks

A total of 1631 plots from the BZE I inventory, and 1493 plots from the BZE II inventory / BioSoil inventory, were used. For 997 points for which assignment to a dominant soil group was possible, the data were available as paired samples, i.e. samples in which it was possible to correlate each BZE I point with exactly one BZE II point or one BioSoil point. Once the carbon stocks for each dominant soil group, and for the different inventory times, had been plotted against each other in a linear regression, it was possible to identify outliers via residual analysis. A relevant example is presented in Figure 56 (on the left). Studentised residuals were used to eliminate outliers that seemed inconsistent with the rest of the data (cf. Figure 56 (on the right)). In addition, a "hat matrix" was generated, for identification of "leverage" points that represent outliers within the independent variable (cf. Figure 56 (right)) (WEISBERG 2005).

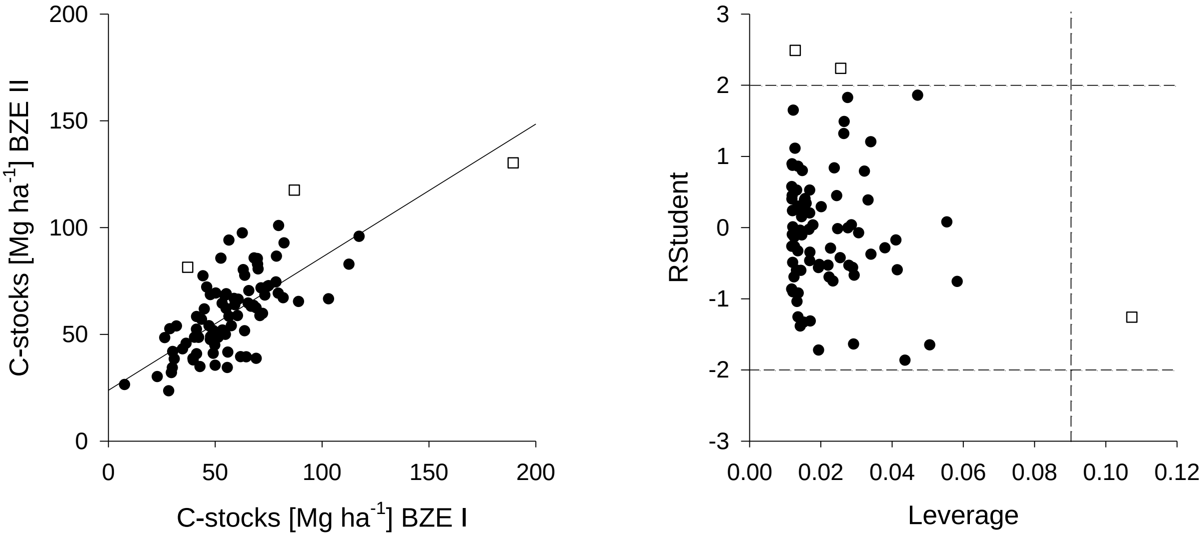


Figure 56: Regression between carbon stocks (0-30cm) as shown by BZE II / BioSoil data and the BZE I data (left), and outliers identified via residuals analysis with studentized residuals and "high-leverage" points (right), with regard to the example of the new dominant soil group "spodic luvisols / spodic-dystric podzoluvisols from sandy sediments overlying boulder clay" .

Some Länder shifted the grid between the BZE I and BZE II inventories, and thus a total of 485 BZE I plots and 441 BZE II plots for which assignment to a dominant soil group was possible were available as unpaired samples. Carbon stocks for those plots were calculated via formation of mean values for each dominant soil group. Outliers for each class were detected via double standard deviation (x ± 2 σ) and then removed. In addition, organic soils were excluded. Then, the mean carbon stocks for each dominant soil group were correlated with the relevant annual differences. After elimination of the outliers, a total of 393 points from the BZE I survey, and 397 points from the BZE II survey / BioSoil inventory, were left.

To permit area-weighted calculation of carbon-stock changes, the forest areas on the new dominant soil groups were determined as percentage shares of Germany's total forested area. In each case, it proved possible to correlate a forest area with the mean carbon-stock change for a dominant soil group. That, in turn, made it possible to calculate the average annual change in organic carbon for Germany, taking account of the new dominant soil groups' shares of total relevant area.

7.2.4.4.4 Results of derivation of carbon stocks and carbon-stock changes

On the basis of the area-weighted approach, the carbon stocks of Germany's mineral soil, to a depth of 30 cm, amounted to 57.24 Mg ha^{-1} at the time of the BZE I inventory, and to 62.03 Mg ha^{-1} at the time of the BZE II / BioSoil inventories. Those figures translated into annual increases of 0.32 ± 0.04 MgC ha^{-1}. A variance analysis (type III - ANOVA) showed that the differences between the two inventories were significant ($p<0.001$). Both the rate of change and the total stocks lie within a range that other authors have already estimated for central Europe. Estimates of annual carbon sequestration in the root zone range from 0.1 Mg ha^{-1} a^{-1} (NABUURS & SCHELHAAS 2002) to 0.9 Mg ha^{-1} a^{-1} (SCHULZE et al. 2000). Most of the values given in the literature are based on model-based up-scaling, and they take the soil's entire root zone into account (LISKI et al. 2002; DE VRIES et al. 2006). In comparison to those studies, the present effort was able to draw on considerably more measurement plots, arrayed within a finer grid. Those data represent a more valid sample, one that supports conclusions for Germany that are more reliable and that have a complete-coverage focus.

For nearly all dominant soil groups, carbon stocks, broken down by classes, were estimated to be higher at the time of the BZE II / BioSoil inventories than they had been at the time of the BZE I inventory (cf. Table 221). In addition, carbon stocks were higher in soils with high clay content than they were in soils with high sand content. The reasons for this are discussed in, for example, SIX et al. (2002) and BARITZ et al. (2010). Evaluation of the time series between the BZE I and BZE II / BioSoil inventories shows greater annual changes in carbon stocks especially in sandy dominant soil groups of the North German lowlands. For example, the annual relevant rate of change for the dominant soil groups 2, 5, 6 and 7 was greater than 0.6 MgC ha^{-1} a^{-1}. On the other hand, PRIETZEL et al. (2006) put carbon sequestration, in the upper 30 cm, at 0.2 Mg ha^{-1} a^{-1} on sandy locations and at 0.4 Mg ha^{-1} a^{-1} on loamy locations. Smaller positive changes in carbon stocks, ranging between 0.1 and 0.6 Mg ha^{-1} a^{-1}, were found in over half of all classes formed. A marked decrease in C stocks, between the two inventory times, was seen in class 11.

Table 221: Carbon stocks at the time of the BZE I inventory and at the time of the BZE II inventory, and annual rates of carbon-stock change, in the newly formed dominant soil units; and correlated forest areas

	Carbon stocks (BZE I) [MgC ha^{-1}]			Carbon stocks (BZE II) [MgC ha^{-1}]			Share of forest area [ha]	Rate of change in carbon stocks [MgC ha^{-1} a^{-1}]
DSU	**n**	**MV**	**SE**	**n**	**MV**	**SE**		**MV**
1	21	79.7	4.1	25	82.2	3.0	3.4	0.26
2	47	45.1	0.9	57	54.4	1.3	6.7	0.60
3	17	63.8	4.2	22	61.1	5.3	1.2	-0.11
4	106	64.5	1.9	88	63.7	2.3	7.0	-0.02
5	67	47.6	1.4	64	58.1	1.5	6.8	0.71
6	134	52.1	2.1	129	64.4	2.9	9.1	0.80
7	27	28.1	1.7	27	37.2	2.8	2.3	0.66
8	76	53.6	1.0	61	60.8	1.3	6.9	0.50
9	14	47.5	4.7	14	54.9	5.7	1.6	0.52
10	71	76.0	2.3	71	76.5	2.4	4.9	0.03
11	33	76.5	3.4	40	68.2	1.8	2.9	-0.53
12	42	54.7	1.8	45	59.9	2.6	3.4	0.32
13	11	54.4	6.1	18	66.1	4.9	1.9	0.76
14	19	57.1	4.6	19	63.0	4.6	1.4	0.36
15	153	60.7	1.4	133	62.7	1.5	8.9	0.14
16	130	58.4	0.6	145	60.5	0.5	13.5	0.12
17	15	58.0	3.9	15	72.3	5.0	1.8	0.97
18	151	55.2	1.4	169	56.8	1.3	12.5	0.10
19	23	51.1	2.2	23	53.6	2.2	2.3	0.17
20	30	74.4	0.1	26	92.9	0.1	1.6	1.03

(DSU = dominant soil units, n = number of soil samples, MV = mean value, SE = standard error)

7.2.4.5 Organic soils

7.2.4.5.1 Forest Land remaining Forest Land

The areas covered by organic soils were determined via a georeferencing procedure, with overlaying of BÜK 1000 and ATKIS® data (cf. also Chapter 7.1.6). In estimation of differences in carbon stocks in organic soils, the IPCC (2003) values from Table 3.2.3 were used for CO_2, while the values from Table 3a.2.1 were used for N_2O. For that process, it is assumed that all organic sites are affected by drainage[64] and that the drainage is solely responsible for the changes. For organic soils, carbon emissions of 0.68 MgC ha^{-1} a^{-1}, and methane emissions of 0.6 kg N_2O-N ha^{-1} a^{-1}, were used.

7.2.4.5.2 Land converted to Forest Land

For all Land converted to Forest Land, as for Forest Land remaining Forest Land, it is assumed that drainage applies (cf. Chapter 7.1.6). For organic soils under Land converted to Forest Land, carbon emissions of 0.68 MgC ha^{-1} a^{-1}, and nitrous oxide emissions of 0.6 kg N_2O-N ha^{-1} a^{-1}, were thus used. Those annual emissions are being reported for all years since the relevant conversions.

7.2.4.6 Other greenhouse-gas emissions from forests

No nitrogen fertilisation in forests takes place in Germany. In CRF Table 5(I), therefore, this activity has been marked "NO" (not occurring).

7.2.4.6.1 Liming

Figures for CO_2 emissions from liming of forest soils are provided in category 5.G (Other). They range from 162.37 Gg a^{-1} (1992) to 52.35 Gg a^{-1} (2008), and show a decreasing trend (cf. Figure 57). For 2010, the pertinent CO_2 emissions amount to 58.29 Gg a^{-1}.

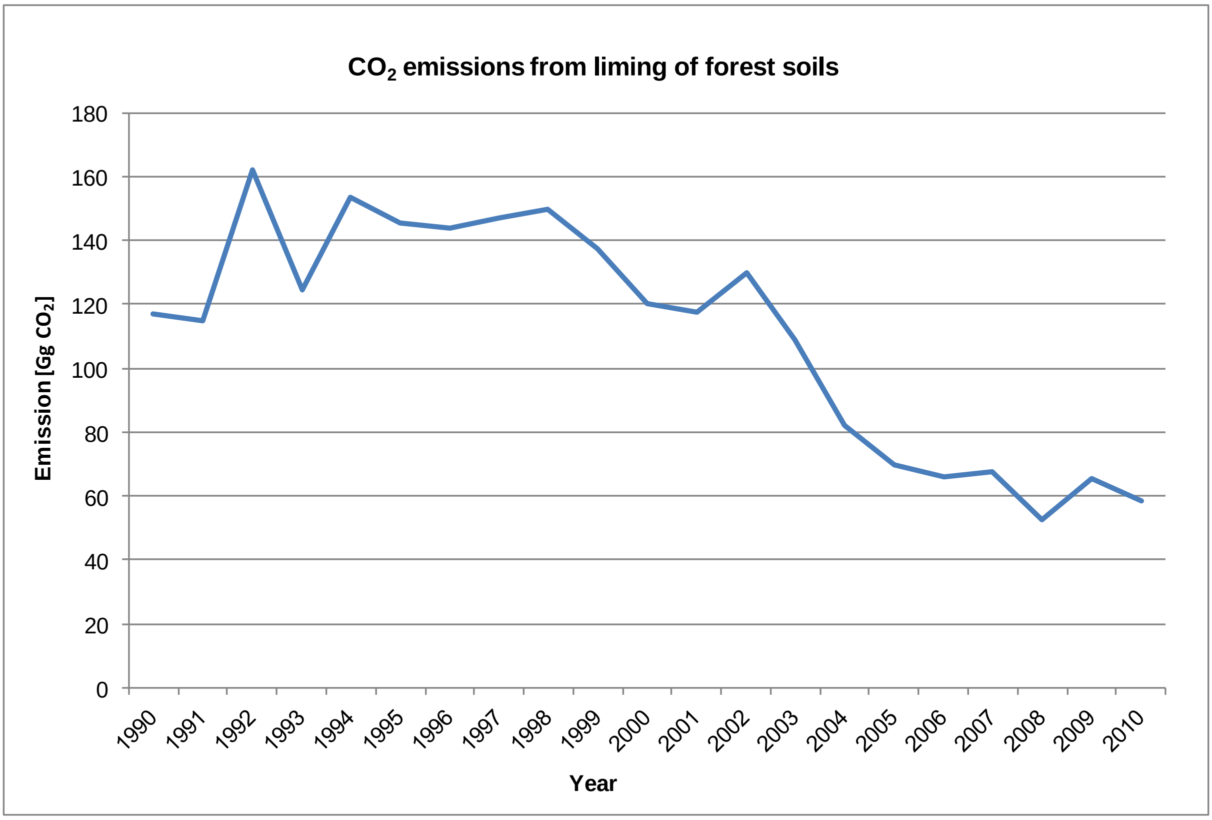


Figure 57: Emissions from liming of forests

The liming data were derived from the total-fertilisers calculation. They describe producers' and importers' deliveries to wholesalers and end users (STATISTISCHES BUNDESAMT,

[64] Since no figures are available relative to the areas covered by undrained organic soils, a conservative approach is taken whereby all of the organic soil is assumed to be drained.

Fachserie 4, Reihe 8.2). For the calculation, the amount of fertiliser applied was assumed to be the same as the amount sold. The relevant emissions were derived using equation 3.3.6 from IPCC GPG-LULUCF (2003: p. 3.80). Additional information is presented in Chapter 7.3.4.5.

7.2.4.6.2 Forest fires / wildfires

While in other countries "prescribed burning" is an accepted method for clearing land or for managing ecosystems, no prescribed/controlled burning of biomass is carried out in Germany's managed forests. In keeping with Germany's climatic situation, and with measures taken in Germany to prevent wildfires, such fires tend to be rather seldom. This conclusion is confirmed by relevant wildfire statistics (BLE, 2011) and their data on areas affected by wildfires (cf. Figure 58). The mean area affected annually by wildfires, in the period 1990 – 2010, was 885 ha. In some years, unseasonably high summer temperatures have resulted in larger burn areas. This was the case, for example, in 1996 and 2003. An unusually large burn area, about 4,908 ha, was measured in 1992, which had an extremely warm summer.

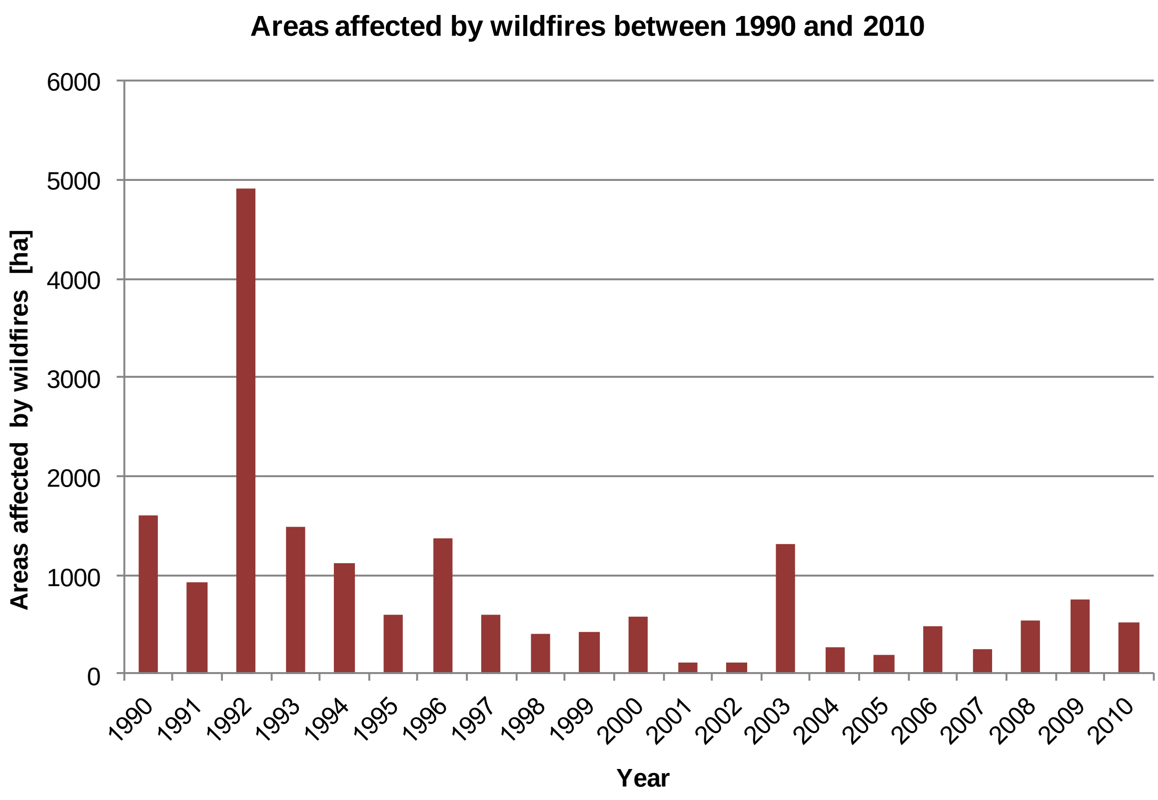


Figure 58: Areas affected by wildfires between 1990 and 2010 (pursuant to BLE, 2011) [areas in hectares]

Along with CO_2, wildfires release a range of other greenhouse gases (CO, CH_4, N_2O and NO_x). The CO_2 emissions resulting from biomass combustion have already been taken into account as part of changes of biomass stocks (CRF Sector 5.A.1 Forest land remaining Forest Land), via the "stock-change method". For this reason, they are listed as "IE" (included elsewhere). Emissions of other greenhouse gases were calculated with Equation 25 (IPCC 2003, Equation 3.2.20).

Equation 25

$$L_{fire} = A*B*C*D*10^{-6}$$

where:

L_{fire} = Quantity of greenhouse gas [t] released via fire
A = Wildfire burn area [ha]
B = Mass of fuel present on the relevant site (biomass) [kgTM ha^{-1}]
C = Combustion efficiency
D = Emission factor [$g(kgTM)^{-1}$]

The data on areas affected by wildfires in the period 1990 to 2010 have been taken from the wildfire statistics maintained by the Federal Agency for Agriculture and Food (BLE; Waldbrandstatistik – BLE 2011). The mean above-ground biomass for each year between 1990 and 2010 was derived via linear extrapolation and interpolation, using the data of the BWI II (National Forest Inventory II) and the Inventory Study 2008. Pursuant to the expert assessment carried out by KÖNIG (2007), 80 % of the wildfires in Germany remain on the ground surface and 20 % rise into tree crowns. In accordance with Table 3A.1.12 (IPCC 2003), a combustion efficiency (mass loss via direct combustion) of 0.15 was used for fires remaining on the ground surface, and an efficiency of 0.45 was used for fires rising into tree crowns. The emission factors for CH_4 and N_2O were taken from Table 3A.1.16 (IPCC 2003).

Germany suffers relatively little wildfire damage in terms of burn area, and thus the relevant CH_4 and N_2O gas emissions are low. With the exception of 1992, the pertinent CH_4 emissions range between 34 and 433 Gg, and the N_2O emissions range between 0.5 and 6.7 Gg. Those emissions levels were exceeded in 1992 (CH_4: 1.33 Gg, N_2O: 20.7 Mg), as a result of that year's unusually large burn area, which stemmed from that year's extremely warm summer. The complete time series for greenhouse gases resulting from wildfires is shown in Table 222.

Table 222: Greenhouse gases emitted as a result of wildfires, in the period 1990-2010

Year	Above-ground biomass [Mg ha^{-1}]	Wildfire burn area [ha]	Emitted gases [Mg]	
			CH_4	N_2O
1990	180.7	1,606	433	6.7
1991	181.4	920	249	3.9
1992	182.1	4,908	1,333	20.7
1993	182.9	1,493	407	6.3
1994	183.6	1,114	305	4.7
1995	184.4	592	163	2.5
1996	185.1	1,381	381	5.9
1997	185.9	599	166	2.6
1998	186.6	397	110	1.7
1999	187.4	415	116	1.8
2000	188.1	581	163	2.5
2001	188.8	122	34	0.5
2002	189.6	122	34	0.5
2003	190.3	1,315	373	5.8
2004	191.1	274	78	1.2
2005	191.8	183	52	0.8
2006	192.6	482	138	2.1
2007	193.3	256	74	1.1
2008	194.1	539	156	2.4
2009	194.8	757	220	3.4
2010	195.6	522	152	2.4

7.2.4.6.3 Drainage

No area data are available with regard to drainage of mineral soils. It may be assumed that no drainage occurs on mineral soils. For this reason, the entry for N_2O emissions from mineral soils is "NO" (not occurring).

Information about drainage of organic soils, with regard to both CO_2 and N_2O, is provided in Chapter 7.2.4.5.

7.2.4.6.4 Land-use changes from forest land to cropland

The manner in which N_2O emissions from land-use changes leading to cropland, on mineral soils, are estimated is described in Chapter 7.3.4.3. The N_2O-N emissions for land-use changes from forest land to cropland are 0.08345 kg ha^{-1} a^{-1} for the period 1990 to 2010.

For organic soils, N_2O emissions in the agricultural sector are reported under 4.D. In the CRF tables, IE (included elsewhere) is entered for that category (cf. also Chapter 7.3.4.4).

7.2.5 Uncertainties and time-series consistency (5.A)

Various uncertainties have to be taken into account in calculation of carbon stocks. The actual uncertainties, however, can only be approximated, with the help of pragmatic approaches.

With the available data, the following uncertainties can be quantified:

- Uncertainties in estimation of areas affected by land-use changes
- Uncertainties in estimation of above-ground and below-ground biomass
- Uncertainties in estimation pertaining to litter and mineral soils

The uncertainties described in the following chapters enter into a total-error budget for the LULUCF sector that is presented in Chapter 19.5.4.

With regard to the uncertainties in the carbon-conversion factor, we call attention to Chapter 7.2.4.1.6. A comprehensive statistical study of the measurement errors in the Inventory Study 2008 found that such errors can be neglected (DUNGER et al. 2010c).

When aggregated, error estimates (U) for values (1,..,*i…I*) propagate themselves in two different ways. When two values are added or subtracted, the error propagation is additive (cf. Equation 26).

Equation 26

$$U = \frac{\sqrt{\sum_i (U_i x_i)^2}}{\sum_i x_i}$$

where:

U	= Total uncertainty
U_i	= Uncertainty for target value
x_i	= Quantity of target value

On the other hand, when two values are multiplied or divided, the errors for the two values propagate themselves multiplicatively (cf. Equation 27).

Equation 27

$$U = \sqrt{\sum_i (U_i)^2}$$

7.2.5.1 Uncertainties in estimation of areas affected by land-use changes

The new, sample-based system for surveying land-use changes has made it possible, for the first time, to calculate the sampling errors for each LULUCF category and KP category, per year (cf. Table 223). The sampling error is calculated in keeping with the formulae in Chapter 7.2.5.2.4 "Sampling errors". Once validation has been completed, all other error sources can be ruled out (cf. also Chapter 7.1.3.3). All areas have been entered significantly.

Table 223: Sampling error (SE) in area estimation for LULUCF classes between 1990 and 2010

LULUCF category / year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Forest land remaining forest land	0.67	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Conversion of forest land to cropland	7.02	7.02	7.02	7.02	7.02	7.02	7.02	7.02	7.02	7.02	7.02	6.97	6.92	6.89	6.87
Conversion of forest land to grassland	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.94	2.88	2.82	2.78	2.75
Conversion of forest land to wetlands	13.49	13.49	13.49	13.49	13.49	13.49	13.49	13.49	13.49	13.49	13.49	13.20	13.33	13.79	14.48
Conversion of forest land to settlements	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.57	11.16	10.84	10.60	10.43
Conversion of forest land to other land	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
KP deforestation	17.52	17.52	17.52	17.52	17.52	17.52	17.52	17.52	17.52	17.52	17.52	17.42	17.27	17.10	16.90
Conversion of cropland to forest land	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.97	4.74	4.56	4.42	4.33
Conversion of grassland to forest land	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.37	2.35	2.34	2.34
Conversion of wetlands to forest land	14.77	14.77	14.77	14.77	14.77	14.77	14.77	14.77	14.77	14.77	14.77	14.60	14.46	14.35	14.27
Conversion of settlements to forest land	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.80	10.38	10.05	9.78	9.57
Conversion of other land to forest land	44.93	44.93	44.93	44.93	44.93	44.93	44.93	44.93	44.93	44.93	44.93	36.68	32.26	29.88	28.63
KP afforestation	15.47	15.47	15.47	15.47	15.47	15.47	15.47	15.47	15.47	15.47	15.47	15.49	15.50	15.49	15.49
LULUCF category / year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**									
Forest land remaining forest land	0.68	0.68	0.68	0.68	0.68	0.68									
Conversion of forest land to cropland	6.86	6.85	6.84	6.83	6.82	6.81									
Conversion of forest land to grassland	2.74	2.68	2.65	2.63	2.61	2.61									
Conversion of forest land to wetlands	15.32	14.35	13.60	13.03	13.03	13.03									
Conversion of forest land to settlements	10.32	10.05	9.85	9.71	9.62	9.56									
Conversion of forest land to other land	nd	nd	nd	nd	nd	nd									
KP deforestation	16.70	16.68	16.67	16.67	16.66	16.66									
Conversion of cropland to forest land	4.26	4.19	4.14	4.11	4.10	4.09									
Conversion of grassland to forest land	2.34	2.30	2.27	2.25	2.25	2.25									
Conversion of wetlands to forest land	14.21	14.15	14.09	14.04	14.04	14.04									
Conversion of settlements to forest land	9.41	9.30	9.21	9.14	9.10	9.08									
Conversion of other land to forest land	28.02	27.77	27.55	27.37	27.37	27.37									
KP afforestation	15.48	15.51	15.55	15.62	15.63	15.64									

(nd = not defined[65])

7.2.5.2 Uncertainties in estimation of above-ground and below-ground biomass

7.2.5.2.1 Conversion of raw-wood volume into tree wood volume

The natural variability of above-ground tree allometry has not been included. This error cannot be calculated, since the original figures of Grundner & Schwappach (1952) are not available. The trees with which they obtained their figures grew between 1750 and 1900, and it is not possible to identify relevant allometric differences resulting from changes in environmental conditions, and in management, that have occurred since then. The tables

[65] There are no areas in the land-use category Other Land

contain only already smoothed values, and thus the actual variance is systematically underestimated. This error consideration thus calculates only the error for conversion of raw-wood volume into tree wood volume. The standard deviation of the residuals of the models is shown in Table 224:

Table 224: Relative standard error of volume-expansion models

Model	Mean (tree wood) [m³]	Standard deviation (residuals) [m³]	Relative standard error [%]
Oak	4.69	0.19	4.10
Birch	0.69	0.01	1.09
Alder	0.69	0.01	0.91
Beech, age to 60	0.36	0.02	5.47
Beech, age 61 to 100	1.25	0.05	4.06
Beech, age at least 101	2.67	0.07	2.57
Spruce, age to 60	0.45	0.05	11.28
Spruce, age at least 61	3.60	0.16	4.55
Pine, age to 80	0.60	0.02	3.08
Pine, age at least 81	2.11	0.07	3.27
Fir, age to 80	0.89	0.06	6.22
Fir, age 81 to 121	3.53	0.26	7.50
Fir, age at least 121	6.98	0.62	8.94
Larch	3.21	0.07	2.22

Table 225 shows the uncertainties that arise in the volume expansion. It includes only the uncertainties for cases in which C stocks can be directly estimated.

Table 225: Uncertainties arising in the volume expansion

LULUCF category	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest Land remaining Forest Land	2.99	2.84	2.18	2.90	1.70	1.70	1.76	1.71
Conversion of forest land to cropland	2.12	–	–	–	–	–	–	–
Conversion of forest land to grassland	2.81	–	–	–	–	–	–	–
Conversion of forest land to settlements	2.14	–	–	–	–	–	–	–
Conversion of forest land to wetlands	3.08	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	2.11	–	–	–	–	–	–
Conversion of grassland to forest land	–	2.07	–	–	–	–	–	–
Conversion of settlements to forest land	–	2.00	–	–	–	–	–	–
Conversion of wetlands to forest land	–	1.04	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–
KP afforestation	–	2.70	–	–	–	–	–	–
KP deforestation	2.14	2.45	–	–	2.23	–	1.93	–

7.2.5.2.2 Bulk densities for specific tree-species groups

The bulk densities for wood vary from tree species to tree species – and within one and the same tree. KOLLMANN (1982) gives variation ranges for raw densities. With the help of those variation ranges, the standard deviation can be estimated pursuant to SACHS (1984). For left-leaning and right-leaning distributions (approximations of triangular distributions) of bulk densities, distributions that are actually seen in trees (BOSSHARD 1984; KOLLMANN 1982), the range is divided by 4.2. It was not possible to take account of the error arising in conversion of raw density into bulk density, since no relevant data are available. In this case, it was assumed that this error would not affect the bulk-density range.

Table 226: Relative standard error in estimates of bulk densities

Tree species	Mean raw density	Minimum raw density	Maximum raw density	Standard error estimated	se [%]
Beech	0.68	0.49	0.88	0.09	13.66
Douglas fir	0.47	0.32	0.73	0.10	20.77
Oak	0.65	0.39	0.93	0.13	19.78
Larch	0.55	0.40	0.82	0.10	18.18
Common ash[66]	0.65	0.41	0.82	0.10	15.02
Spruce	0.43	0.30	0.64	0.08	18.83
Pine	0.49	0.30	0.86	0.13	27.21
Poplar[67]	0.41	0.37	0.52	0.04	8.71
Fir	0.41	0.32	0.71	0.09	22.65

For tree-species groups that are relatively unimportant in terms of numbers, including deciduous trees with high life expectancies (4.4 % of total standing-timber volume) and deciduous trees with low life expectancies (5.2 %), the values for ash and poplar were used. Table 227 shows the uncertainties that arise in the volume expansion. It includes only the uncertainties for cases in which C stocks can be directly estimated.

[66] Including other long-lived deciduous species
[67] Including other short-lived deciduous species

Table 227: Uncertainties arising in connection with use of bulk densities

LULUCF classes	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest Land remaining Forest Land	9.19	8.63	8.16	13.87	12.31	12.41	7.14	6.86
Conversion of forest land to cropland	13.70	–	–	–	–	–	–	–
Conversion of forest land to grassland	8.65	–	–	–	–	–	–	–
Conversion of forest land to settlements	7.92	–	–	–	–	–	–	–
Conversion of forest land to wetlands	24.49	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	8.05	–	–	–	–	–	–
Conversion of grassland to forest land	–	7.76	–	–	–	–	–	–
Conversion of settlements to forest land	–	6.83	–	–	–	–	–	–
Conversion of wetlands to forest land	–	6.65	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–
KP afforestation	–	6.96	–	–	–	–	–	–
KP deforestation	8.21	9.23	–	–	24.46	–	8.93	–

7.2.5.2.3 Derivation of below-ground biomass

The only available sources for the standard error for root-biomass calculation were the tables pursuant to IPCC GPG-LULUCF (2003) (cf. Table 216). That source also uses quantity-weighted error up-scaling. To carry out error propagation by sums (IPCC, 2000: Equation 6.3), the sums of the above-ground mass calculations were computed for each stratum of the table 225. This made it possible to derive the total errors for conifers, oak and other deciduous trees (broadleaves). Table 228 shows the values for the state in which it was possible to estimate C stocks directly.

Table 228: Uncertainties arising in use of root/shoot relationships

LULUCF classes	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest Land remaining Forest Land	25.37	23.86	23.10	–	26.24	26.13	19.15	18.48
Conversion of forest land to cropland	32.36	–	–	–	–	–	–	–
Conversion of forest land to grassland	24.19	–	–	–	–	–	–	–
Conversion of forest land to settlements	22.43	–	–	–	–	–	–	–
Conversion of forest land to wetlands	32.34	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	29.27	–	–	–	–	–	–
Conversion of grassland to forest land	–	26.61	–	–	–	–	–	–
Conversion of settlements to forest land	–	25.24	–	–	–	–	–	–
Conversion of wetlands to forest land	–	17.95	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–
KP afforestation	–	24.79	–	–	–	–	–	–
KP deforestation	23.09	22.51	–	–	35.27	–	19.20	–

An advantage of the IPCC root-biomass calculation is that it also yields the standard error for the estimation – in contrast to other methods, such as those presented in the studies of DIETER & ELSASSER (2002). The values entered into the CRF tables were derived pursuant to IPCC (2003).

7.2.5.2.4 Sampling error

The National Forest Inventory uses cluster sampling. It thus includes only a random set of samples, rather than a basic totality of samples. The sampling elements themselves, as well as the mean and total values estimated on the basis of the sampling elements chosen, are subject to variance. The variance can serve as a tool for assessing the precision of the estimated target values. The variance of a measured value in stratum *l* is estimated via the following relationship:

Equation 28

$$v\left\langle \hat{\bar{Y}}_l \right\rangle = \frac{1}{c_l(c_l - 1)} \sum_{c_l=1}^{C_l} \left(\frac{M_{l,c}}{E\left\langle M_{l,c} \right\rangle}\right)^2 (Y_{l,c} - \hat{\bar{Y}}_l)^2$$

where:

v	= Variance
Y	= Target value
c	= Number of clusters

E	= Expected value
M	= Number of points per cluster

The variance of the overall mean, throughout all strata, is defined as follows:

Equation 29

$$v\left\langle \hat{\hat{Y}}_{st} \right\rangle = \sum_{l=1}^{L} (\frac{\lambda(U_l)}{\lambda(U)})^2 v\left\langle \hat{\hat{Y}}_l \right\rangle \approx \sum_{l=1}^{L} (\frac{n_l}{n})^2 v\left\langle \hat{\hat{Y}}_l \right\rangle$$

With

$$n = \sum_{l=1}^{L} n_l = \sum_{l=1}^{L} c_l E\left\langle M_{l,c} \right\rangle = \sum_{c_{l=1}}^{C_l} M_{l,c}$$

The estimated variance of the change $v\left\langle \hat{\hat{G}}_l \right\rangle$ between two inventories whose sampling elements were repeatedly surveyed is calculated as follows:

Equation 30

$$v\left\langle \hat{\hat{G}}_l \right\rangle = v\left\langle \hat{\hat{Y}}_l^{(2)} \right\rangle + v\left\langle \hat{\hat{Y}}_l^{(1)} \right\rangle - 2 r_{y^2 y^1} \sqrt{v\left\langle \hat{\hat{Y}}_l^{(2)} \right\rangle} \sqrt{v\left\langle \hat{\hat{Y}}_l^{(1)} \right\rangle}$$

With $r_{y^2 y^1} = \frac{s_{y^2 y^1}}{s_{y^2 y^1}}$ as a correlation coefficient and:

Equation 31

$$s_{y^2 y^1} = \frac{1}{c_l (c_l - 1)} \sum_{c_{l=1}}^{C_l} (\frac{M_{lc}}{E\left\langle M_{l,c} \right\rangle})^2 (Y_{lc}^{(2)} - \hat{\hat{Y}}_l^{(2)})(Y_{lc}^{(1)} - \hat{\hat{Y}}_l^{(1)})$$

The variance of the area-related mean estimator (ratio estimator) $v\left\langle \hat{R}_{st} \right\rangle$ from $\hat{\hat{Y}}_{st} / \hat{\hat{X}}_{st}$ is estimated as follows:

Equation 32

$$v\left\langle \hat{R}_{st} \right\rangle = \frac{1}{(\hat{\hat{X}}_{st})^2} \sum_{l=1}^{L} w_l^2 \frac{\sum_{c_{l=1}}^{C_l} (\frac{M_{lc}}{E\left\langle M_{l,c} \right\rangle})^2 (y_{lc} - \hat{R}_{st} x_{lc})^2}{c_l (c_l - 1)}$$

where:

w_l	= Stratum weight of stratum l
X_{st}	= Target value

The variance in the change of a ratio estimator ($v\left\langle \hat{\hat{G}}_{R_{st}} \right\rangle$) is defined as follows:

Equation 33

$$v\left\langle \hat{\hat{G}}_{R\,st} \right\rangle = v\left\langle \hat{R}_{st}^{(2)} \right\rangle + v\left\langle \hat{R}_{st}^{(1)} \right\rangle - 2\,\mathrm{cov}\left\langle \hat{R}_{st}^{(2)}, \hat{R}_{st}^{(1)} \right\rangle$$

where:

$$\mathrm{cov}\left\langle \hat{R}_{st}^{(2)}, \hat{R}_{st}^{(1)} \right\rangle = \frac{1}{\hat{\hat{X}}_{st}^{(2)} \hat{\hat{X}}_{st}^{(1)}} \sum_{l=1}^{L} \left(\frac{\lambda(U_l)}{\lambda(U)} \right)^2 \frac{1}{n_{2,l}\left(n_{2,l} - 1\right)}$$

$$\sum_{x \in F_1 \cap s_2} \left(\frac{M(x)}{E(M(x))} \right)^2 \left(d_c^{(2)}(x) - \hat{\hat{d}}_l^{(2)}\right)\left(d_c^{(1)}(x) - \hat{\hat{d}}_l^{(1)}\right)$$

where

$$d_c^{(2)}(x) = (Y_c^{(2)}(x) - \hat{R}_{st}^{(2)} X_c^{(2)}(x))$$

and

$$\hat{\hat{d}}_l^{(2)} = \frac{1}{n_{2,l}} \sum_{x \in F_1 \cap s_2} \left(Y_c^{(2)}(x) - \hat{R}_{st}^{(2)} X_c^{(2)}(x) \right)$$

with $d_c^{(1)}(x)$ and $\hat{\hat{d}}_l^{(1)}$ having the corresponding values.

The estimation procedures presented here can be used to calculate, on the basis of the National Forest Inventory, the precision of biomass estimates for each LULUCF category in which such estimates are made.

Since C-stock calculation for the new German Länder was possible only with the method pursuant to BURSCHEL et al. 1993, taking account of data in the publication: "Der Wald in den neuen Bundesländern" ("The Forest in the New German Länder", BMELF, 1994), the procedure for the old German Länder can be adopted here only partially. On p. 9 of that publication, the following statement about errors relative to stocks is made: "The stocks of the sub-area were determined, in the framework of the forest-management procedure, with a mean standard error of ± 12.5 %." Under the assumption that that error has systematically propagated itself throughout the up-scaling, one may assume a value of ± 12.5 % for the relevant tree-species groups.

Table 229: Sampling error for above-ground biomass

LULUCF category	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest Land remaining Forest Land	1.07	1.04	2.34	12.50	3.91	3.84	2.01	2.00
Conversion of forest land to cropland	55.12	–	–	–	–	–	–	–
Conversion of forest land to grassland	45.42	–	–	–	–	–	–	–
Conversion of forest land to settlements	18.73	–	–	–	–	–	–	–
Conversion of forest land to wetlands	69.85	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	26.46	–	–	–	–	–	–
Conversion of grassland to forest land	–	15.37	–	–	–	–	–	–
Conversion of settlements to forest land	–	20.90	–	–	–	–	–	–
Conversion of wetlands to forest land	–	28.42	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–
KP afforestation	–	10.47	–	–	–	–	–	–
KP deforestation	16.33	44.95	–	–	77.30	–	39.03	–

Table 230: Random-sampling error for below-ground biomass

LULUCF category	Old German Länder			New German Länder			Germany	
	Error, 1987 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 1993 [%]	Error, 2002 [%]	Error, 2008 [%]	Error, 2002 [%]	Error, 2008 [%]
Forest land remaining forest land	1.05	1.03	2.18	12.50	3.84	3.80	1.98	1.97
Conversion of forest land to cropland	55.59	–	–	–	–	–	–	–
Conversion of forest land to grassland	43.11	–	–	–	–	–	–	–
Conversion of forest land to settlements	18.49	–	–	–	–	–	–	–
Conversion of forest land to wetlands	64.93	–	–	–	–	–	–	–
Conversion of forest land to other land	–	–	–	–	–	–	–	–
Conversion of cropland to forest land	–	25.41	–	–	–	–	–	–
Conversion of grassland to forest land	–	14.80	–	–	–	–	–	–
Conversion of settlements to forest land	–	20.93	–	–	–	–	–	–
Conversion of wetlands to forest land	–	28.31	–	–	–	–	–	–
Conversion of other land to forest land	–	–	–	–	–	–	–	–
KP afforestation	–	10.23	–	–	–	–	–	–
KP deforestation	16.01	2.45	–	–	77.86	–	38.50	–

7.2.5.3 Uncertainties in estimation pertaining to litter and mineral soils

7.2.5.3.1 Sampling error

In soil sampling, proper separation of litter and mineral soil can present a problem, since the transition between the two compartments cannot always be unambiguously identified. This problem becomes all the more important in light of the fact that carbon concentrations in litter are considerably higher than they are in mineral soil below the litter. In sampling, imprecise or improper separation of litter from mineral soil can thus have major impacts on the carbon stocks measured in a relevant horizon or depth layer.

7.2.5.3.2 Small-scale variability

Due to the high spatial variability in litter and mineral soil, and because carbon stocks maintain spatial continuity only over short distances, sampling of carbon stocks in such compartments is subject to a high degree of uncertainty. For litter in a beech forest, SCHÖNING et al. (2006) calculated stocks of 4.0 MgC ha^{-1}, with a variation coefficient of 38 %. In mineral soil (0 - 36 cm), they found carbon stocks of 64.0 Mg ha^{-1}, with variation coefficients between 30 % and 43 %. Similar values were recorded by LISKI (1995). He showed that different carbon stocks under a spruce site, and within a given horizon, were spatially independent as of a separation of 8 m.

7.2.5.3.3 Representativeness of points within strata

One problem in analysing samples in accordance with dominant soil units resulted from the different degrees to which classes were represented. Small classes lack statistical validity with respect to a major basic totality. Where no comparison between BZE I and BZE II / BioSoil data was possible, as a result of a lack of pertinent data, it was not possible to include the relevant forested dominant-soil-unit area in the calculation. In addition, it was not possible to have all dominant soil units represented, since some are found only on small areas of Germany's territory. All in all, as a result of these difficulties, 4.3 % of the forest area was not taken into account in this context.

7.2.5.3.4 Database

For about half of all sampled points from the second inventory, complete data sets are not yet available. For this reason, the present results, which of course do not take account of the lacking data, cannot be seen as a final result of the evaluation.

7.2.5.3.5 Sampling error

In calculation of the sampling error with regard to stock changes in litter and mineral soil, paired and unpaired samples were differentiated, and stratification of mineral soils was taken into account. The variance of the mean stocks in stratum l, and of the unstratified total sample with n_l sampling points, was calculated as follows:

Equation 34

$$v\left\langle \overline{Y}_l \right\rangle = \frac{1}{n_l(n_l - 1)} \sum_{j=1}^{n_l} (Y_{lj} - \overline{Y}_l)$$

For paired samples, the variance of the mean stock changes in stratum l, between times t_1 and t_2, was calculated via:

Equation 35

$$v\left\langle \overline{G}_l \right\rangle = v\left\langle \overline{Y}_{lt_2} \right\rangle + v\left\langle \overline{Y}_{lt_1} \right\rangle - 2r_{y^2y^1}\sqrt{v\left\langle \overline{Y}_{lt_2} \right\rangle}\sqrt{v\left\langle \overline{Y}_{lt_1} \right\rangle}$$

With

$$r_{y^2y^1} = \frac{s_{y^2y^1}}{s_{y^2y^1}}$$

and

$$s_{y^2y^1} = \frac{1}{n_l(n_l - 1)} \sum_{j=1}^{n_l} (Y_{ljt_2} - \overline{Y}_{lt_2})(Y_{ljt_1} - \overline{Y}_{lt_1})$$

For unpaired samples, the variance of stock changes was calculated via:

Equation 36

$$v\left\langle \overline{G}_l \right\rangle = v\left\langle \overline{Y}_{lt_2} \right\rangle + v\left\langle \overline{Y}_{lt_1} \right\rangle$$

The total variance, throughout all strata, was estimated, taking account of the area shares w_l / w for strata, as follows:

Equation 37

$$\nu\langle\overline{Y}\rangle \approx \sum_{l=1}^{L}\left(\frac{w_l}{w}\right)^2 \nu\left[\overline{Y}_l\right]$$

and with

Equation 38

$$\nu\langle\overline{G}\rangle \approx \sum_{l=1}^{L}\left(\frac{w_l}{w}\right)^2 \nu\left[\overline{G}_l\right]$$

The carbon-stock changes for litter were calculated on the basis of unpaired samples, with stratification. A sampling error of 0.034 Mg ha^{-1}, or 77 %, was obtained. In calculation of carbon-stock changes in mineral soil, the overall sample was divided into a paired sample set and an unpaired sample set. In addition, stratification, in keeping with the applicable dominant soil units and the two sample sub-sets, was carried out. Overall, the sampling error for mineral soils amounted to 0.041 Mg ha^{-1}, or 13 %.

7.2.5.4 Time-series consistency

A time series is consistent if it is consistent within itself, is meaningful and has no internal contradictions. All of the time series concerned are consistent. While some time series contain "jumps", for methodological reasons, such jumps result from the available data, i.e. they do not constitute contradictions with regard to time-series consistency.

7.2.6 Category-specific QA / QC and verification (5.A)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Quality assurance for ATKIS® and BÜK 1000 input data, and for wildfire statistics, is the responsibility of the respective data administrators.

For the first time, extensive error analysis was carried out for the LULUCF sector, and an attempt was made to quantify all existing sources of error. That error analysis includes all error calculations relative to the forest sector, for biomass, dead wood, litter and mineral soils. In Chapter 19.5.4, a total-error budget is presented that summarises the results of error analysis.

7.2.6.1 Biomass and dead wood

The estimates of carbon stocks in the biomass and dead wood pools, at the various relevant times, and the estimates of carbon-stock changes are based on up-scaling that was carried out at the Institute of Forest Ecology and Forest Inventory of the Johann Heinrich von

Thünen Institute (vTI-WOI), using data from the National Forest Inventories and from the Inventory Study 2008. With regard to the quality assurance developed for the Federal Forest Inventory, we call attention to the literature for the Federal Forest Inventory (BMELV 2005). In work carried out independently of the vTI-WOI's calculations, the C stocks and C-stocks changes for biomass were calculated with a programme developed under PostGreSQL. The results of the two sets of calculations agree.

7.2.6.2 Litter and mineral soils

In order to achieve a consistent standard of laboratory analysis in analysis of sampling carried out in the framework of the BZE and BioSoil surveys, ring analysis was initiated. To that end, all laboratories underwent a quality test carried out by the Gutachterausschuss Forstliche Analytik ("forestry analysis auditors' committee" (BLUM & HEINBACH 2006, 2007). To ensure the comparability of the applicable laboratory methods, only laboratories that participated successfully in the ring analysis were permitted to carry out relevant analysis. Ring analysis was also carried out at the European level, with German participation (COOLS et al. 2006).

To harmonise laboratory measurements and topographical surveys, rules for determining relevant parameters were defined, in the framework of the BZE II survey, for participating laboratories. This was done with a view to preventing any discrepancies resulting from use of different analysis equipment or methods (KÖNIG et al 2005, WELLBROCK et al. 2006). Previous ring analyses served as the basis for certifying laboratories for relevant analysis. A similar approach was taken with regard to field sampling. On the basis of various preliminary studies, suitable sampling methods were defined and specified, and described in a field-sampling manual (WELLBROCK et al. 2006).

7.2.6.3 Comparison with results of neighbouring countries

A comparison of carbon-stock changes in living biomass (cf. Table 231) shows that Germany has the highest values in the "land converted to forest land" categories and, thus, the largest carbon stocks. Similarly high carbon stocks in these categories were achieved by the Netherlands, followed by Poland, the UK and Belgium. In the category Forest Land remaining Forest Land, on the other hand, Germany ranks in the lower part of the range. Even lower carbon stocks occur only in Switzerland. The highest carbon stocks in this category occur in the Netherlands and in Austria.

In the dead organic matter category (cf. Table 232), Germany's carbon stocks in the "land converted to forest land" categories are similar to those of Denmark and France. Austria shows the highest carbon stocks in these conversion categories. In the area Forest Land remaining Forest Land, Germany occupies a mid-range position. The largest carbon stocks in that category occur in Denmark, the UK, Switzerland and France, while the smallest are found in the Netherlands, Austria and Belgium.

In the area of mineral soils (cf. Table 233), Germany exhibits the highest carbon losses in conversions to forest land, as a result of its relatively large losses from grassland and wetlands. Denmark also has losses in these categories. Low carbon stocks, on the other hand, occur in France, the UK and the Czech Republic, while the largest stocks are found in Poland, Austria and Belgium. At present, Germany does not report any figures in the area Forest Land remaining Forest Land.

No comparison was carried out in the area of carbon losses in organic soils, due to a lack of data on such losses in neighbouring countries.

Table 231: Carbon-stock changes in living biomass, in various countries (Germany, for 2010; other countries, for 2009)

Country	Forest land remaining forest land [MgC ha^{-1} a^{-1}]	Land converted to forest Land [MgC ha^{-1} a^{-1}]	Cropland converted to forest land [MgC ha^{-1} a^{-1}]	Grassland converted to forest land [MgC ha^{-1} a^{-1}]	Wetlands converted to forest land [MgC ha^{-1} a^{-1}]	Settlements converted to forest land [MgC ha^{-1} a^{-1}]	Other land converted to forest land [MgC ha^{-1} a^{-1}]
AUT	1.17	0.97	1.18	1.18	1.18	-0.27	1.18
BEL	0.59	2.30	2.23	2.31	2.27	2.26	2.42
CHE	0.10	0.20	1.27	0.18	0.10	0.73	0.20
CZE	0.84	1.85	1.85	1.85	1.85	1.85	NA
DNK	0.99	0.59	0.53	0.83	0.72	NA	0.66
FRA	0.77	1.23	1.62	1.16	1.16	1.38	1.17
GBR	0.52	2.54	2.44	2.56	IE	2.48	NO
GER	**0.43**	**4.12**	**4.12**	**4.12**	**4.15**	**4.09**	**4.15**
NLD	1.70	3.25	3.25	3.25	3.25	3.25	3.25
POL	0.85	2.58	2.58	2.58	NO	NO	NO

Source: UNFCCC 2011

Table 232: Carbon-stock changes in dead organic mass, in various countries (Germany, for 2010; other countries, for 2009)

Country	Forest land remaining forest land [MgC ha^{-1} a^{-1}]	Land converted to forest Land [MgC ha^{-1} a^{-1}]	Cropland converted to forest land [MgC ha^{-1} a^{-1}]	Grassland converted to forest land [MgC ha^{-1} a^{-1}]	Wetlands converted to forest land [MgC ha^{-1} a^{-1}]	Settlements converted to forest land [MgC ha^{-1} a^{-1}]	Other land converted to forest land [MgC ha^{-1} a^{-1}]
AUT	0.04	0.75	0.75	0.75	0.75	0.75	0.75
BEL	0.06	NO	NO	NO	NO	NO	NO
CHE	0.15	0.10	0.01	0.10	0.13	0.07	0.13
CZE	NO	NA,NO	NO	NO	NO	NO	NA
DNK	0.35	0.49	0.49	0.49	0.49	NA	0.49
FRA	0.13	0.33	0.51	0.29	0.49	0.40	0.42
GBR	0.19	0.09	0.10	0.09	IE	0.09	0.09
GER	**0.09**	**0.46**	**0.46**	**0.46**	**0.46**	**0.46**	**0.46**
NLD	0.03	NE	NE	NE	NE	NE	NE
POL	NO				NO	NO	NO

Source: UNFCCC 2011

Table 233: Carbon-stock changes in mineral soils, in various countries (Germany, for 2010; other countries, for 2009)

Country	Forest land remaining forest land [MgC ha^{-1} a^{-1}]	Land converted to forest Land [MgC ha^{-1} a^{-1}]	Cropland converted to forest land [MgC ha^{-1} a^{-1}]	Grassland converted to forest land [MgC ha^{-1} a^{-1}]	Wetlands converted to forest land [MgC ha^{-1} a^{-1}]	Settlements converted to forest land [MgC ha^{-1} a^{-1}]	Other land converted to forest land [MgC ha^{-1} a^{-1}]
AUT	NO	1.35	2.27	0.22	3.80	3.16	3.81
BEL	0.58	0.80	2.31	0.59	-0.28	0.00	0.00
CHE	IE,NO	NO	NO	NO	NO	NO	NO
CZE	NO	0.16	0.49	0.04	NO	NO	NA
DNK	NA	-0.16	-0.11	-0.22	0.40	NA	-0.22
FRA		0.06	0.80	-0.05		0.04	
GBR	0.27	0.14	0.30	0.11	IE	0.25	0.18
GER	No.	-0.26	0.10	-0.69	-0.53	0.17	0.32
NLD	NE	NE	NE	NE	NE	NE	NE
POL	0.53	1.98	2.31	0.73	NO	NO	NO

Source: UNFCCC 2011

7.2.7 Category-specific recalculations (5.A)

As a result of recommendations made in the In-Country Review 2010 (UNFCCC, 2011), recalculation of the land-area matrix for the entire LULUCF sector was required. The new matrix for the forest land sector is shown in Chapter 7.2.3.2. The changes in the areas lead to changes in the relevant correlated emissions. No attempt was made to compare the current activity data to those of the previous year since, as a result of the introduction of *transition time* with values as of 1970, the data do not lend themselves to such comparisons.

7.2.7.1 Forest land remaining forest land

All changes in emissions of the pools organic soils, biomass and dead wood, with respect to the 2010 Submission, result from changes in activity data (cf. Chapter 7.1.3). Table 234 presents a comparison of emissions as reported in the present submission and emissions as reported in the previous year's submission. The reason for the change in the drainage category is that an erroneous emission factor was used in the 2011 Submission. Instead of the emission factor for N_2O, the emission factor for N_2O-N (= 0.600 kg ha^{-1}) was used. That error has been corrected in the 2012 Submission. The correct emission factor for N_2O is 0.943 kg ha^{-1}.

Table 234: Comparison of emissions [Gg CO_2], as reported in the 2012 and 2011 Submissions, from Forest Land remaining Forest Land (5.A.1)

[Gg CO_2 eq a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total 2012	**-66,062.950**	**-66,122.421**	**-66,181.771**	**-66,241.000**	**-66,300.107**	**-66,359.091**	**-66,417.952**	**-66,476.689**	**-66,535.303**	**-66,593.791**
Total 2011	**-70,944.168**	**-70,899.805**	**-70,855.447**	**-70,811.092**	**-70,766.742**	**-70,722.396**	**-70,678.055**	**-70,633.717**	**-70,589.384**	**-70,545.056**
Organic soils, 2012	497.298	499.519	501.740	503.961	506.182	508.403	510.624	512.845	515.066	517.287
Organic soils, 2011	581.806	582.679	583.549	584.415	585.277	586.135	586.989	587.838	588.684	589.526
Biomass, 2012	-63,110.688	-63,168.191	-63,225.573	-63,282.833	-63,339.972	-63,396.988	-63,453.881	-63,510.650	-63,567.295	-63,623.816
Biomass, 2011	-67,788.594	-67,747.568	-67,706.542	-67,665.516	-67,624.491	-67,583.465	-67,542.439	-67,501.413	-67,460.388	-67,419.362
Dead wood, 2012	-3,507.857	-3,512.306	-3,516.756	-3,521.205	-3,525.655	-3,530.105	-3,534.554	-3,539.004	-3,543.453	-3,547.903
Dead wood, 2011	-3,780.782	-3,778.384	-3,775.986	-3,773.588	-3,771.189	-3,768.791	-3,766.393	-3,763.995	-3,761.596	-3,759.198
N_2O from drainage, 2012	58.297	58.557	58.817	59.078	59.338	59.599	59.859	60.119	60.380	60.640
N_2O from drainage, 2011	43.402	43.467	43.532	43.597	43.661	43.725	43.789	43.852	43.915	43.978
[Gg CO_2 eq a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total 2012	**-66,652.155**	**-66,796.996**	**-19,263.832**	**-19,291.896**	**-19,319.883**	**-19,347.791**	**-19,377.507**	**-19,407.152**	**-19,436.726**	**-19,478.931**
Total 2011	**-70,500.731**	**-70,456.411**	**-20,699.398**	**-20,684.873**	**-20,670.352**	**-20,655.835**	**-20,641.322**	**-20,626.814**	**-20,612.309**	**-20,597.809**
Organic soils, 2012	519.508	523.409	527.310	531.211	535.111	539.012	542.836	546.660	550.484	554.706
Organic soils, 2011	590.364	591.199	592.029	592.855	593.677	594.496	595.311	596.121	596.928	597.732
Biomass, 2012	-63,680.211	-63,820.995	-16,283.773	-16,307.779	-16,331.708	-16,355.559	-16,381.055	-16,406.480	-16,431.835	-16,469.460
Biomass, 2011	-67,378.336	-67,337.310	-17,583.588	-17,572.349	-17,561.110	-17,549.871	-17,538.632	-17,527.393	-17,516.154	-17,504.915
Dead wood, 2012	-3,552.352	-3,560.768	-3,569.184	-3,577.599	-3,586.015	-3,594.431	-3,602.923	-3,611.415	-3,619.906	-3,629.204
Dead wood, 2011	-3,756.800	-3,754.402	-3,752.004	-3,749.605	-3,747.207	-3,744.809	-3,742.411	-3,740.013	-3,737.614	-3,735.216
N_2O from drainage, 2012	60.900	61.358	61.815	62.272	62.729	63.187	63.635	64.083	64.531	65.027
N_2O from drainage, 2011	44.041	44.103	44.165	44.226	44.288	44.349	44.410	44.470	44.530	44.590

7.2.7.2 Land converted to Forest Land

Via the new method, new emission factors were derived for mineral soils. Further pertinent information is provided in Chapter 7.1.5. In the biomass category as well, the change in methods produced new emission factors – in this case, for the relevant previous uses (cf. Chapter 7.1.7). The emission factors for the litter category were adjusted to take account of the expanded BZE II / BioSoil database (cf. Chapter 7.2.4.3). All changes in emissions, in addition to the aforementioned adjustments of emission factors, are also the result of use of changed activity data (cf. Chapter 7.1.3). Table 235 compares the current values to the previous year's relevant values.

Table 235: Recalculation of emissions [Gg CO_2 equivalents], as reported in the 2012 and 2011 Submissions, from land-use changes leading to forest land (5.A.2)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**-7286.756**	**-7276.503**	**-7289.315**	**-7262.454**	**-7273.734**	**-7264.995**	**-7254.873**	**-7248.217**	**-7249.443**	**-7240.039**
Total, 2011	**934.199**	**695.809**	**423.929**	**152.048**	**-119.832**	**-391.712**	**-663.592**	**-935.472**	**-1207.352**	**-1479.232**
Mineral soils, 2012	587.377	587.377	587.377	587.377	587.377	587.377	587.377	587.377	587.377	587.377
Mineral soils, 2011	-4.034	-8.069	-12.103	-16.137	-20.171	-24.206	-28.240	-32.274	-36.308	-40.343
Organic soils, 2012	87.026	87.026	87.026	87.026	87.026	87.026	87.026	87.026	87.026	87.026
Organic soils, 2011	2.902	5.803	8.705	11.607	14.509	17.410	20.312	23.214	26.116	29.017
Biomass, 2012	-6961.703	-6953.702	-6968.767	-6944.159	-6957.691	-6951.205	-6943.336	-6938.933	-6942.411	-6935.260
Biomass, 2011	968.057	763.526	525.504	287.483	49.461	-188.560	-426.582	-664.603	-902.625	-1,140.646
Litter, 2012	-999.457	-997.204	-994.952	-992.699	-990.446	-988.193	-985.941	-983.688	-981.435	-979.182
Litter, 2011	-32.726	-65.452	-98.178	-130.904	-163.630	-196.357	-229.083	-261.809	-294.535	-327.261

[Gg CO_2 a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total, 2012	**-7242.305**	**-8260.724**	**-7984.099**	**-7709.624**	**-7397.890**	**-7118.630**	**-6720.643**	**-6366.785**	**-6011.502**	**-5897.210**
Total, 2011	**-1751.113**	**-2022.993**	**-2294.873**	**-2566.753**	**-2838.633**	**-3110.513**	**-3407.110**	**-3804.262**	**-3840.091**	**-4109.391**
Mineral soils, 2012	587.377	562.499	537.620	512.742	487.863	462.985	438.830	414.676	390.522	361.868
Mineral soils, 2011	-44.377	-48.411	-52.445	-56.480	-60.514	-64.548	-68.582	-72.617	-76.651	-80.685
Organic soils, 2012	87.026	83.761	80.497	77.232	73.968	70.703	66.902	63.100	59.299	55.057
Organic soils, 2011	31.919	34.821	37.723	40.624	43.526	46.428	49.330	52.231	55.133	58.035
Biomass, 2012	-6939.779	-7964.247	-7693.523	-7424.803	-7118.675	-6844.873	-6459.087	-6117.250	-5773.809	-5674.125
Biomass, 2011	-1,378.668	-1,616.689	-1,854.711	-2,092.732	-2,330.754	-2,568.775	-2,831.513	-3,194.807	-3,196.778	-3,432.219
Litter, 2012	-976.929	-942.737	-908.692	-874.795	-841.046	-807.444	-767.288	-727.311	-687.514	-640.011
Litter, 2011	-359.987	-392.713	-425.439	-458.165	-490.891	-523.617	-556.343	-589.070	-621.796	-654.522

7.2.8 Category-specific planned improvements (5.A)

7.2.8.1 Land-use changes

A sample-based information system was introduced for determination of area data throughout the entire LULUCF sector. With the data available for the relevant years, each sample point can be assigned a land-use category, tied to a quality level. The land-use categories for each year have been derived from such assignations. In addition, records have been kept of the number of points that are considered validated as a result of agreement with respect to LULUCF categories, on the various quality levels. The percentage of points in 1990 that have not yet been validated is still high. Plans call for that percentage to be considerably improved via integration of new data sources (in particular, 1990 maps derived from ColorInfraRed data) (cf. also Chapter 7.1.3.3).

The National Forest Inventory 3 (Bundeswaldinventur 3; BWI 3) that is currently being carried out will add, to the sample-based information system, an important database for determination of activity data. The results are expected to make it possible, in 2013, to estimate the areas and land-use changes for all categories of conversion from and to forest land, and for forest land remaining forest land, for the period 2002 through 2012. The high quality of the pertinent data is expected to make highly precise conclusions possible with regard to forest land areas and pertinent changes.

7.2.8.2 Litter and mineral soils

Still-lacking Länder data records are to be collected for purposes of future evaluations. To date, it has been possible to calculate carbon stocks for only about 75% of the BZE II survey points. Inclusion of the currently lacking data will make it possible to carry out evaluations on a basis that is statistically more reliable. The approach chosen, involving dominant soil units, offers potential for more-detailed evaluation, since the analyses have not yet taken account of covariables (texture, precipitation, temperature, inclination, exposition). Furthermore, the BÜK map data are currently being revised. They will soon be published with a higher level of precision (scale of 1:200.000).

Evaluation of the data relative to changes in organic carbon in the upper 30 cm of mineral soil shows that sandy soils in particular, soils whose distribution is concentrated in northern Germany, have accumulated carbon since the BZE I survey. A study is already underway, with regard to the BZE, to determine the reasons for the carbon increase. A comparison with a regional soil inventory carried out on long-term study areas (KONOPATZKY 2009) indicates that the changes have taken place primarily in recent years. On the other hand, a study carried out in the framework of the BZE has concluded that significant changes of carbon stocks in mineral soil take at least 10 years to become apparent in surveys (MELLERT et al. 2007). It is thus necessary to determine the relevant rate of change via a follow-on inventory. The time at which that inventory is to be carried out will not be decided until after the BZE II inventory has been evaluated.

7.3 Cropland (5.B)

7.3.1 Source category description (5.B)

CRF 5.B	Natural gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Cropland	**CO_2**	**L**	**T/T2**	**28,761.1**	**(2.35%)**	**28,272.8**	**(2.96%)**	**(-1.70%)**
Cropland	N_2O	-	-	199.4	(0.02%)	185.2	(0.02%)	(-7.17%)

Natural gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	RS/NS	CS[68]
N_2O	CS/Tier 1	RS/NS	D

The source category *Cropland* (5.B) is a key category of CO_2 emissions in terms of emissions level and trend.

[68] The entry "CS/M" refers to determination of changes in stocks in biomass and in soil. Under Tier 1, changes in dead wood and litter were estimated to be 0.

Reporting in the *Cropland* category covers emissions / removals of CO_2 from/in mineral and organic soils, from/in above-ground and below-ground biomass and from liming. It also includes nitrous oxide emissions from humus losses from mineral soils, following land-use changes leading to cropland. Burning of fields and crop residues is prohibited by law in Germany and thus is not reported (NO).

In 2010, the total emissions from cropland amounted to 28,458 Gg CO_2 equivalents. Of that amount, 25,104 Gg CO_2 consisted of emissions from agriculturally used bogs; 1,388 Gg CO_2 were released from mineral soils, as the result of conversions leading to cropland; and 135 Gg CO_2 were released from biomass, as the result of conversions leading to cropland. Decomposition of dead wood and litter in connection with deforestation produced emissions of 8 Gg CO_2. An additional 1,638 Gg CO_2 was released as a result of liming. While this total refers non-specifically to all agricultural lands, it was assigned wholly to cropland cultivation (cf. Chapter 7.3.4.5). N_2O releases as a result of humus losses from mineral soils, following land-use changes leading to cropland, amounted to 185 Gg CO_2 equivalents.

The time series for emissions from cropland (cf. Figure 59 and Figure 60, and Table 242 and Table 243, in Chapter 7.3.7) highlight the fact that total greenhouse-gas emissions from cropland have been stagnating. In 2010, for example, only a small decrease, 504 Gg CO_2 equivalents (-1.74 %), occurred with respect to the base year.

Increases in emissions from organic soils (791 Gg CO_2 ≙ 3.3 %) and from liming (479 Gg CO_2 ≙ 41 %) were more than offset by decreases in emissions from biomass (-1,336 Gg CO_2 ≙ -91 %), from dead organic matter (-328 Gg CO_2 ≙ -98 %) and from mineral soils (CO_2: -97 Gg CO_2 ≙ -6.5 %; N_2O: -14 Gg CO_2 equivalents ≙ -7.2 %). The marked decrease in emissions from losses of biomass and dead organic matter is due especially to a decrease in deforestation.

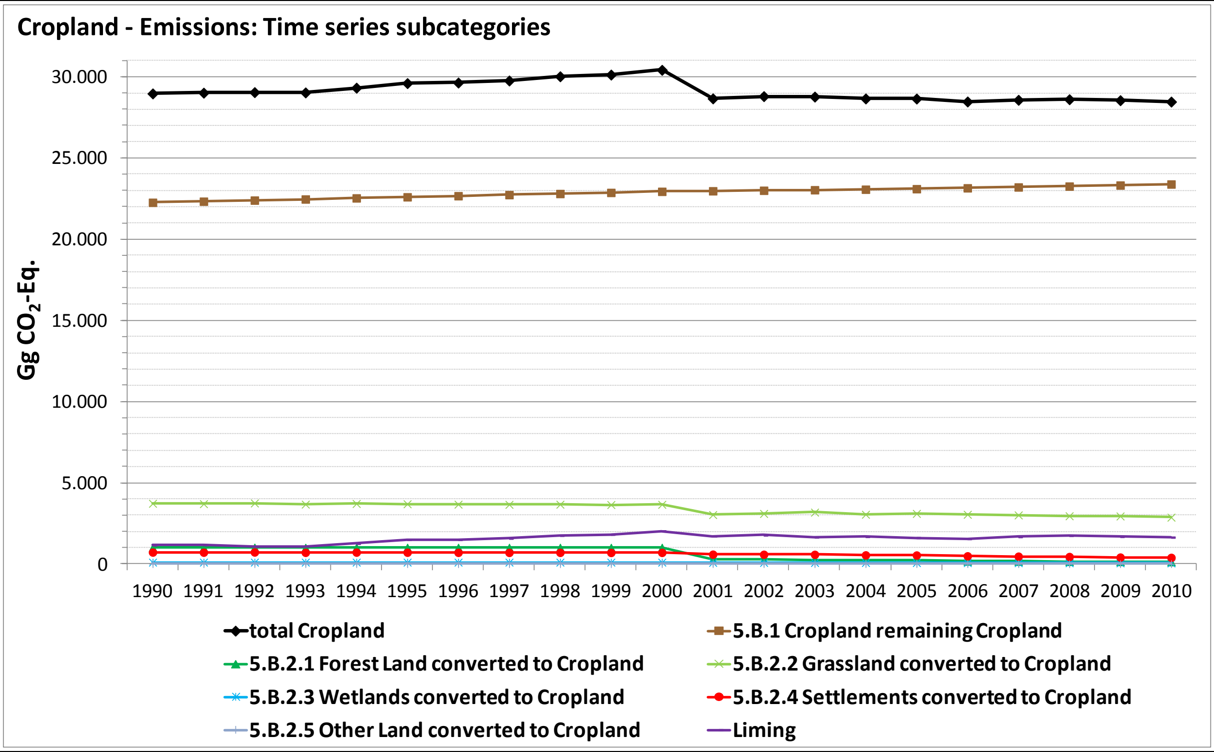


Figure 59: Greenhouse gas emissions [Gg CO_2-Eq.] from cropland, as a result of land use and land-use changes, 1990 – 2010, by sub-categories

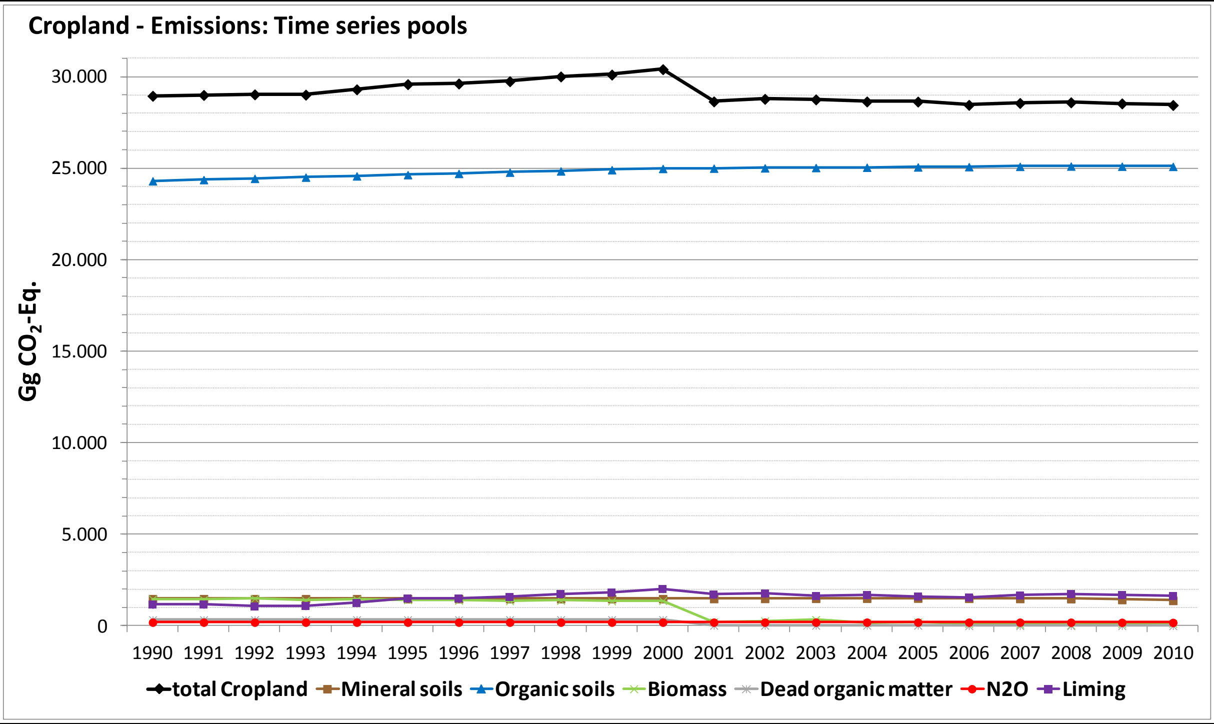


Figure 60: Greenhouse gas emissions [Gg CO_2-Eq.] from cropland, as a result of land use and land-use changes, 1990 – 2010, by pools

7.3.2 Information on approaches used for representing land areas and on land-use databases used for the inventory(5.B)

Cf. Chapter 7.1.3.

7.3.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.B)

Cf. Chapter 7.1.4.

7.3.4 Methodological issues (5.B)

7.3.4.1 Data sources

Annual crops

- Statistisches Bundesamt, Fachserie 3, Reihe 3, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung und pflanzliche Erzeugung (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, agricultural soil use and crop cultivation; various years)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.2.1, Land- und Forstwirtschaft, Fischerei, Wachstum und Ernte – Feldfrüchte (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, growth and harvests – crops; various years)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.1.2, Land- und Forstwirtschaft, Fischerei,– Bodennutzung der Betriebe (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries – soil use by sectoral operations; various years)
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 - Agriculture, Forestry and Other Land Use (IPCC 2006)
- "Ordinance on application of fertilisers, soil additives, culture substrates and plant additives according to the principles of good practice in fertilization (Ordinance on Fertilisation – Düngeverordnung (DüV))“ (Ordinance on Fertilisation in the version as promulgated 27 February 2007 (Federal Law Gazette I, p. 221), last amended by Article 18 of the Act of 31 July 2009 (Federal Law Gazette I p. 2585).

Cultivation of fruit trees, wine grapes and Christmas trees

- "Obstanbau, Weinanbau und Weihnachtsbaumkulturen in Deutschland" ("Fruit cultivation, viticulture and Christmas-tree cultures in Germany") interim report in the research project "Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Wäldern“ (Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth") (PÖPKEN 2011)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.1.4, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung – Baumobstflächen – 2007 (Federal Statistical Office, Fachserie 3, Reihe 3.1.4, agriculture and forestry, fisheries, agricultural soil use – fruit tree cultivation – 2007)

7.3.4.2 Biomass

7.3.4.2.1 Carbon stocks in the biomass of perennial arable crops

The carbon stocks in the biomass of perennial arable crops have been recalculated on the basis of national data. The relevant database, applicable individual factors and methods are described in Chapter 19.5.3.1. Table 236 shows the results, namely the carbon stocks for land with perennial arable crops.

Table 236: Area-weighted mixed value for carbon stocks [Mg ha^{-1}] of perennial arable crops (± half of the 95 % confidence interval)

Perennial crops	Carbon stocks [Mg C ha^{-1}]		
	Bio_{total}	$Bio_{above-ground}$	$Bio_{below-ground}$
Cropland: Perennial crops	11.73 ± 2.90	8.73 ± 2.24	2.99 ± 1.30

7.3.4.2.2 Carbon stocks in the biomass of annual arable crops

The carbon stocks in the above-ground and below-ground biomass of annual arable crops are calculated annually on the basis of the Federal Statistical Office's harvest statistics. Mean carbon stocks, weighted by area and harvest, and referenced to the area of annual arable crops and horticultural crops, are then calculated from those stocks.

The basis for determination of the mean carbon stocks for field crops consists of the data on harvests and area under cultivation for a total of 65 field crops. These include:

- Winter wheat, spring wheat, rye, triticale, maslin, winter barley, spring barley, oats, mixed grains other than maslin, grain maize
- Field peas, broad beans
- Potatoes, sugar beets, fodder beets
- Winter oilseed rape
- Clover, alfalfa, grass, silage maize
- Cauliflower, broccoli, Chinese cabbage, kale, kohlrabi, Brussels sprouts, red cabbage, white cabbage, savoy, oak-leaf lettuce, iceberg lettuce, endive, lamb's lettuce, head lettuce, lollo lettuce, radicchio, romana lettuce, arrugula, other lettuce types, spinach, rhubarg, asparagus, celery, fennel, celeriac, horseradish, carrots, radishes, (larger) radishes, red beets, pickling cucumbers, slicing cucumbers, edible pumpkins, zucchini, sweet corn, bush beans, broad beans, runner beans, split peas, peas, bunching onions, onions, parsley, leeks, chives

Pursuant to RÖSEMANN et al. (2011), for grassland and cropland, the dry biomass of individual plant parts is derived from harvest data, using relevant ratios and water-content data (obtained from various sources).

For calculation of biomass carbon stocks, an average carbon content of 45 % by weight – instead of with the IPCC default value (50 % by weight) – was assumed, since OSOWSKI et al. (2004) give carbon contents of 44 – 48 % by weight for plants in central Europe and since PÖPKEN (2011), in her studies of cultivated trees (carried out for the German inventory), also found average values of 45 to 46 % by weight. The relevant results for annual arable and horticultural crops are shown in Table 237.

Table 237: Area-referenced carbon stocks [Mg C ha^{-1}] of cropland with annual vegetation (± half of the 95 % confidence interval)

Year	Carbon stocks [Mg C ha^{-1}] Cropland$_{annual}$		
	Bio$_{total}$	Bio$_{above-ground}$	Bio$_{below-ground}$
1990	6.03 ± 0.48	4.84 ± 0.37	1.19 ± 0.32
1991	6.27 ± 0.50	5.07 ± 0.38	1.21 ± 0.32
1992	5.81 ± 0.46	4.71 ± 0.36	1.10 ± 0.29
1993	6.57 ± 0.52	5.32 ± 0.40	1.25 ± 0.33
1994	6.15 ± 0.49	4.97 ± 0.38	1.18 ± 0.31
1995	6.35 ± 0.51	5.14 ± 0.39	1.21 ± 0.32
1996	6.60 ± 0.52	5.35 ± 0.40	1.24 ± 0.33
1997	6.73 ± 0.54	5.46 ± 0.41	1.27 ± 0.34
1998	6.62 ± 0.53	5.37 ± 0.40	1.25 ± 0.33
1999	6.84 ± 0.54	5.56 ± 0.42	1.29 ± 0.34
2000	6.70 ± 0.53	5.45 ± 0.41	1.25 ± 0.33
2001	6.99 ± 0.56	5.67 ± 0.43	1.31 ± 0.35
2002	6.45 ± 0.51	5.25 ± 0.40	1.21 ± 0.32
2003	5.82 ± 0.46	4.75 ± 0.36	1.07 ± 0.29
2004	7.32 ± 0.58	5.95 ± 0.45	1.36 ± 0.36
2005	6.96 ± 0.55	5.64 ± 0.42	1.32 ± 0.35
2006	6.56 ± 0.52	5.30 ± 0.40	1.26 ± 0.33
2007	6.84 ± 0.54	5.54 ± 0.42	1.31 ± 0.35
2008	7.33 ± 0.58	5.92 ± 0.45	1.40 ± 0.37
2009	7.51 ± 0.60	6.08 ± 0.46	1.43 ± 0.38
2010	7.01 ± 0.56	5.67 ± 0.43	1.35 ± 0.36

7.3.4.2.3 Total carbon stocks in cropland biomass

The total biomass in cropland is calculated as area-weighted annual carbon stocks, pursuant to Equation 39.

Equation 39:

$$EF_{crop} = (EF_{wood} * A_{wood} + EF_{annual} * A_{annual}) / (A_{wood} + A_{annual})$$

The values shown in Table 238 are used as a basis for all calculations relative to biomass in connection with land-use changes in the cropland and horticultural-land sectors.

Table 238: Area-weighted mixed value for carbon stocks [Mg C ha^{-1}] in the biomass of cropland in Germany (± half of the 95 % confidence interval)

Year	Carbon stocks [Mg C ha^{-1}] Cropland$_{annual}$		
	Bio_{total}	$Bio_{above-ground}$	$Bio_{below-ground}$
1990	6.11 ± 0.48	4.89 ± 0.36	1.22 ± 0.32
1991	6.35 ± 0.50	5.12 ± 0.38	1.23 ± 0.32
1992	5.89 ± 0.46	4.77 ± 0.36	1.12 ± 0.29
1993	6.64 ± 0.52	5.37 ± 0.40	1.28 ± 0.33
1994	6.23 ± 0.49	5.03 ± 0.37	1.20 ± 0.31
1995	6.43 ± 0.51	5.20 ± 0.39	1.23 ± 0.32
1996	6.67 ± 0.53	5.40 ± 0.40	1.27 ± 0.33
1997	6.80 ± 0.54	5.51 ± 0.41	1.30 ± 0.34
1998	6.70 ± 0.53	5.42 ± 0.40	1.28 ± 0.33
1999	6.92 ± 0.54	5.60 ± 0.42	1.31 ± 0.34
2000	6.78 ± 0.53	5.50 ± 0.41	1.28 ± 0.33
2001	7.06 ± 0.56	5.72 ± 0.43	1.34 ± 0.35
2002	6.53 ± 0.51	5.30 ± 0.40	1.23 ± 0.32
2003	5.89 ± 0.46	4.80 ± 0.36	1.10 ± 0.29
2004	7.38 ± 0.58	5.99 ± 0.45	1.39 ± 0.36
2005	7.03 ± 0.55	5.68 ± 0.42	1.34 ± 0.35
2006	6.63 ± 0.52	5.34 ± 0.40	1.28 ± 0.33
2007	6.91 ± 0.54	5.58 ± 0.42	1.33 ± 0.35
2008	7.38 ± 0.58	5.96 ± 0.44	1.42 ± 0.37
2009	7.57 ± 0.60	6.12 ± 0.46	1.45 ± 0.38
2010	7.07 ± 0.56	5.70 ± 0.43	1.37 ± 0.36

7.3.4.3 Mineral soils

No significant change in carbon stocks in mineral soils is listed for areas under permanent cultivation. This is supported by regional evidence from 140 long-term observation sites (FORTMANN, H., P. RADEMACHER, H. GROH & H. HÖPER (in press): Stoffgehalte und –vorräte im Boden und deren Veränderungen; GeoBerichte des LBEG; BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT (LfL) (2007): 20 Jahre Boden-Dauerbeobachtung in Bayern, Teil 3: Entwicklung der Humusgehalte zwischen 1986 und 2007; Schriftenreihe, 10, Freising-Weihenstephan). The manner in which CO_2 emissions resulting from conversions leading to cropland are calculated is described in Chapter 7.1.5, while the pertinent emission factors are described in Table 240 (Chapter 7.3.5), and derivation of the emission factors is described in Chapter 19.5.2. Table 239 shows the annual emission factors, averaged over all land-use categories, for conversions leading to cropland.

Table 239: Annual emission factors, averaged over all land-use categories, for conversions leading to cropland [MgC ha^{-1} a^{-1}]

Implied emission factor for mineral soils - cropland [MgC ha^{-1} a^{-1}]											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
IEF	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	
IEF	-0.57	-0.58	-0.59	-0.60	-0.60	-0.61	-0.62	-0.63	-0.63	-0.64	

The N_2O emissions resulting from conversions of land to cropland (CRF Table 5 (III)) were determined pursuant to IPCC GPG (2003). To that end, the carbon-stock changes determined for the various individual land-use-change areas were divided by the mean, area-weighted C/N ratios for the pertinent soils, in order to obtain the absolute changes in soil nitrogen stocks. Those stock changes were then tallied with the IPCC default value of 0.0125

Mg N_2O-N per Mg N (IPCC GPG 2003). The so-obtained N_2O emission factors, and their uncertainties, are shown in Table 240 (Chapter 7.3.5). The C/N ratios were derived from the dominant-profile data of the BÜK 1000 n 2.3 soil map (BGR 2011). The nitrous oxide emissions are also subject to transition-time considerations; like the carbon-stock changes, they are distributed over 20 years.

7.3.4.4 Organic soils

The annual emissions following land-use changes are calculated with the same procedure used for emissions from cropland remaining cropland. The procedure for calculating CO_2 emissions from organic soils that result from land use and land-use changes, and the procedure for deriving the pertinent emission factors, are described in Chapter 7.1.6.

N_2O emissions from organic soils are reported as part of the "Agriculture" sector, under 4.D.1.5 "Cultivation of Histosols". To prevent double-counting, N_2O emissions from organic soils that result from conversions to cropland are listed in the LULUCF tables with the notation key "IE".

7.3.4.5 Liming

Emissions from liming are calculated from the total quantities of lime fertiliser applied. Fertiliser lime includes all carbonates of calcium and magnesium, either as pure substances or as additives. Reporting thus covers emissions from dissolving of calcium carbonate, mixed carbonates, carbonated lime, residual lime and calcium ammonium nitrate.

The quantities of lime applied are derived from the product quantities sold within the country, under the assumption that lime fertiliser is applied in the year in which it is sold. The product-quantity figures are taken from official statistics (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 8.2). They list solely the fertiliser quantity corresponding to the total sum of relevant lime, as well as – in aggregated form – the percentage of the total quantity of lime that is sold to the forestry sector. As part of inventory-related estimation, it is assumed that the quantity of lime fertiliser applied to forests is equivalent to the forestry sector's percentage share of the total quantity sold. Lime quantities not explicitly assigned to the forestry sector are reported completely in the cropland category.

In fertiliser statistics, all lime-containing fertilisers, including magnesium carbonates, are reported as CaO. The relevant CO_2 emissions are derived from such statistics stoichiometrically.

In calcium ammonium nitrate, the nitrogen fraction is assumed to account for 27 %. As a result, ammonium nitrate accounts for 77.1 % and calcium carbonate accounts for 22.9 %. Here as well, the CO_2 emissions are determined stoichiometrically.

Because the CO_2 emissions are derived stoichiometrically from the relevant lime quantities, the pertinent uncertainties – also with regard to the emission factors – are equal to 0.

7.3.5 Uncertainties and time-series consistency (5.B)

The uncertainties for emission factors and activity data were determined in accordance with the publication Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000). Additional relevant information is provided in

Chapter 19.5.4. Table 240 shows the uncertainties in the emission factors for the cropland sector, broken down by pools and sub-categories.

Table 240 highlights the fact that distributions based on natural processes tend not to be symmetric, and thus have to be described with log-normal distributions. For example, the distribution functions for emission factors in the cropland sector tend to be log-normal. The standard normal distributions seen for biomass values are exceptions. The uncertainties for those values are also the smallest of all relevant uncertainties, and the boundaries are at half of the 95 % confidence interval.

The uncertainties for the activity data, the areas, are shown in Table 339 in Chapter 19.5.4. Those uncertainties have a normal distribution, and half of the 95 % confidence interval, in the cropland sector, falls within the range 0.5 – 74 %. For system-related reasons, the sampling error with the grid-point approach depends on the sample size, and thus on the relevant sub-category's share of the total area (cf. Chapter 7.1.3). Consequently, in the cropland sector major uncertainties are seen only for those sector sub-categories whose share of the total cropland area is < 0.1 %. Area-weighted derivation of a total uncertainty for the area data in the cropland category yields a value of 0.55 %.

Table 339 in Chapter 19.5.4 shows that, in the cropland sector, and in terms of total emissions, emissions from organic soils have an especially significant share of national LULUCF emissions. Emissions from mineral soils and, especially, those occurring in connection with biomass, have only a small share.

The uncertainties for liming emissions have a log-normal distribution; the lower boundary is -0.5 % of the location scale, and the upper boundary is + 3.5 % of that scale. The uncertainty arises via the circumstance that the quantities of lime sold to the forestry sector are recorded as sum totals, i.e. are not broken down by lime type. The range of results that emerges is in keeping with the maximum possible shifting (of types) that can occur within such totals. The survey for determination of activity data is an exhaustive statistical survey. It is required by law, and all surveyed parties are required to provide the relevant information. As a result, the activity data may be considered complete, and subject to no statistical uncertainties. The emission factor is obtained via stoichiometric recalculations and thus also holds no further uncertainties.

Table 240: Uncertainties of emission factors [in % of location scale] used for calculation of GG emissions from Germany's croplands in 2010, broken down by pools and sub-categories; positive: C sink or N_2O emissions; negative: C source

Cropland **Land use$_{before}$** **Mineral soils CO_2-C**[69]	**Area** **Land use$_{after}$**	**Emission factor** **[Mg C ha^{-1} a^{-1}]**	**Boundaries** **upper** **[%]**	 **lower** **[%]**
Forest land	**Cropland**	-0.10	35	26
Grassland (in the narrower sense)	**Cropland**	-0.87	49	30
Woody Grassland	**Cropland**	-0.66	51	28
Wetlands (terr.)	**Cropland**	-0.70	37	28
Waters	**Cropland**	0.00	51	33
Settlements	**Cropland**	0.07	49	28
Other land	**Cropland**	0.22	52	27
Mineral soil N_2O-N[70]		**[kg N_2O-N ha^{-1} a^{-1}]**	**[%]**	**[%]**
Forest land	**Cropland**	0.08	88	84
Grassland (in the narrow sense)	**Cropland**	0.86	94	85
Woody Grassland	**Cropland**	0.67	95	85
Wetlands (terr.)	**Cropland**	0.57	88	85
Organic soil		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
	Cropland	-11.00	50	50
Biomass[71]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	**Cropland**	-25.56	29	29
Grassland (in the narrow sense)	**Cropland**	0.39	13	13
Woody Grassland	**Cropland**	-39.63	171	60
Wetlands (terr.)	**Cropland**	-13.04	113	40
Waters	**Cropland**	7.07	8	8
Settlements	**Cropland**	-6.34	113	40
Other land	**Cropland**	7.07	8	8
Dead organic matter[72]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	**Cropland**	-21.97	35	56

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2010.

7.3.6 *Category-specific QA / QC and verification (5.B)*

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Internally, data processing is checked via comparisons of cross sums. Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators.

An intra-European comparison of the implied emission factors shows – especially when the large pertinent uncertainties and broad scattering of reported values are taken into account (cf. Chapter 7.3.5) – that the country-specific values for Germany exhibit no conspicuous differences from those of Germany's neighbours in terms of order of magnitude. Germany

[69] Calculation for 20-year period
[70] Calculation for 20-year period
[71] Calculation only for the first year following the pertinent land-use change
[72] Calculation only for the first year following the pertinent land-use change

uses the largest emission factor for CO_2 from drainage of organic soils under cultivation. The value used in Germany, which has been derived from national measurements, reflects the fact that use / drainage intensity is much higher in Germany than it is in Germany's neighbours. In the case of land-use changes leading to cropland, involving organic soils, the same emission factor applies, immediately, that applies for cropland remaining cropland.

In the German inventory, carbon-stock changes in mineral soils, biomass and dead organic matter (only for conversions from forest land to cropland) are taken into account only in connection with land-use changes leading to cropland; they are not taken into account in connection with cropland remaining cropland. The C losses from mineral soils and biomass, as shown in the German calculations, are lower than the corresponding European average, but would fall within the middle range of neighbouring countries' implied emission factors. The C losses from dead organic matter reflect forest lands' share of lands under conversion.

Nitrous oxide emissions are calculated as the result of soil carbon losses. The German emission factor is slightly higher than the European average. That said, it must be noted that nitrous oxide from mineral soils is not taken into account in some Member States, and that Denmark and Sweden clearly take a wider perspective on nitrous oxide (i.e. do not solely consider nitrous oxide emissions from mineral soils).

Table 241: Comparison of implied emission factors (IEF) of different cropland-sector pools in Europe

Implied emission factors (IEF) NIR 2009	**Cropland remaining cropland**	**Conversions to cropland**			
	Organic soils	**Mineral soils**	**Biomass**	**Dead org. matter**	**Nitrous oxide**
	Mg C ha^{-1}				**kg N_2O-N ha^{-1}**
Austria	NO	-1.06	0.042	-0.040	1.06
Belgium	NO	-1.83	-0.091	NO	NE
Czech Republic	NO	-0.35	-0.091	-0.002	0.39
Denmark	-8.33	0.18	-0.069	-0.035	7.41
France	0.00	-0.84	-0.169	-0.015	-0.78
Netherlands	IE	NE	-0.705	-0.228	NE
Poland	-1.00	NA,NO,NE	NA,NO,NE	NA,NO,NE	NA,NE
Sweden	-3.73	-0.36	-0.362	-0.091	2.50
Switzerland	-9.52	-0.21	-0.076	-0.001	0.56
UK	-1.95	-0.60	-0.008	IE,NO	0.25
European Union (15)	-7.35	-0.80	-0.073	-0.008	0.56
European Union (27)	-5.20	-0.83	-0.079	-0.010	0.58
Germany, 2009	**-11.00**	**-0.63**	**-0.047**	**-0.0035**	**0.64**
Germany, 2010	**-11.00**	**-0.64**	**-0.058**	**-0.0037**	**0.64**

Positive: C sink or N_2O emissions; negative: C source or N_2O storage

7.3.7 Category-specific recalculations (5.B)

For this year's report, the data for the entire report period, 1990 – 2010, have been largely recalculated (and are so presented) to take account of the transition in the reporting system. For the first time, a time series for emissions in connection with dead organic matter, and as a result of deforestation, is being provided. With the methods changes, all the requirements that emerged from the 2010 in-country review have been implemented (Chapter 7.1.2). The recalculation was required as a result of the change made in the procedure for determining the land-use-change matrix (cf. Chapter 7.1.3), and it was needed because a transition time of 20 years was used, for the first time, for the entire LULUCF sector. What is more, the calculation method for determination of emissions from mineral soils, resulting from land-use changes, was changed, and nearly all emission factors for the categories 5.B – 5.F (except those for organic soils) were changed. As a result of the numerous changes that have been made, the emissions as reported in 2011 cannot be compared directly with those as reported in 2012 (Table 242 and Table 243).

Table 242: Comparison of emissions [Gg CO_2], as reported in 2012 and 2011, from cropland remaining cropland (5.B.1)

[Gg a^{-1} CO_2 equiv.]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**22,256**	**22,323**	**22,391**	**22,458**	**22,526**	**22,594**	**22,661**	**22,729**	**22,796**	**22,864**
Total, 2011	**21,565**	**21,645**	**21,724**	**21,804**	**21,884**	**21,964**	**22,044**	**22,123**	**22,203**	**22,283**
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2011	-58	-58	-58	-58	-58	-58	-58	-58	-58	-58
Organic soils, 2012	22,256	22,323	22,391	22,458	22,526	22,594	22,661	22,729	22,796	22,864
Organic soils, 2011	22,105	22,185	22,264	22,344	22,424	22,504	22,584	22,663	22,743	22,823
Biomass, 2012	0	0	0	0	0	0	0	0	0	0
Biomass, 2011	-482	-482	-482	-482	-482	-482	-482	-482	-482	-482
[Gg a^{-1} CO_2 equiv.]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**22,931**	**22,964**	**22,996**	**23,029**	**23,061**	**23,093**	**23,147**	**23,200**	**23,253**	**23,317**
Total, 2011	**22,363**	**22,442**	**22,522**	**22,602**	**22,681**	**22,761**	**22,921**	**22,308**	**23,219**	**22,999**
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2011	-58	-58	-58	-58	-58	-58	-21	-38	33	-22
Organic soils, 2012	22,931	22,964	22,996	23,029	23,061	23,093	23,147	23,200	23,253	23,317
Organic soils, 2011	22,903	22,982	23,062	23,142	23,221	23,301	23,491	23,112	23,407	23,391
Biomass, 2012	0	0	0	0	0	0	0	0	0	0
Biomass, 2011	-482	-482	-482	-482	-482	-482	-549	-766	-221	-370

Positive: emissions; negative: sink

Table 243: Comparison of emissions [Gg CO_2], as reported in 2012 and 2011, from land-use changes leading to cropland (5.B.2)

[Gg a^{-1} CO_2 equiv.]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**5,546**	**5,512**	**5,578**	**5,473**	**5,532**	**5,505**	**5,472**	**5,454**	**5,470**	**5,440**
Total, 2011	**6,622**	**6,622**	**6,622**	**6,622**	**6,621**	**6,621**	**6,621**	**6,621**	**6,621**	**6,620**
Mineral soils, 2012	1,484	1,484	1,484	1,484	1,484	1,484	1,484	1,484	1,484	1,484
Mineral soils, 2011	6,238	6,238	6,238	6,238	6,238	6,238	6,238	6,238	6,238	6,238
Organic soils, 2012	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057
Organic soils, 2011	374	374	374	374	374	374	374	374	374	374
Biomass, 2012	1,469	1,435	1,500	1,394	1,452	1,424	1,391	1,372	1,387	1,356
Biomass, 2011	-697	-697	-697	-698	-698	-698	-698	-698	-698	-699
Dead organic matter, 2012	336	336	337	338	339	340	340	341	342	343
Dead organic matter, 2011	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE
N_2O from humus loss, 2012	199	199	199	199	199	199	199	199	199	199
N_2O from humus loss, 2011	707	707	707	707	707	707	707	707	707	707
[Gg a^{-1} CO_2 equiv.]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**5,460**	**3,978**	**4,026**	**4,091**	**3,909**	**3,941**	**3,771**	**3,697**	**3,606**	**3,544**
Total, 2011	**6,620**	**6,620**	**6,617**	**6,617**	**6,617**	**6,617**	**4,920**	**7,174**	**5,661**	**2,777**
Mineral soils, 2012	1,484	1,490	1,496	1,502	1,507	1,513	1,503	1,492	1,482	1,435
Mineral soils, 2011	6,238	6,238	6,238	6,238	6,238	6,238	4,351	6,826	5,099	2,553
Organic soils, 2012	2,057	2,041	2,026	2,010	1,994	1,978	1,941	1,904	1,867	1,795
Organic soils, 2011	374	374	374	374	374	374	263	439	186	91
Biomass, 2012	1,375	215	273	347	175	215	118	93	51	115
Biomass, 2011	-699	-699	-702	-702	-703	-703	-282	-1,007	-336	-222
Dead organic matter, 2012	344	31	31	32	32	32	8	8	8	8
Dead organic matter, 2011	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE
N_2O from humus loss, 2012	199	200	201	201	202	203	201	199	198	191
N_2O from humus loss, 2011	707	707	707	707	707	707	588	916	712	354

7.3.8 Category-specific planned improvements (5.B)

Activity data:

- Improvement of the area data for organic soils under cultivation: ongoing research project.
- Validation of area data for 1990 (cf. Chapter 7.2.8.1, 1. para.)

Emission factors:

Mineral soils: Agricultural soil inventory: generation of national measurements of C stocks in cropland and grassland; gradual revision of the database for mineral soils (cf. Chapter 7.2.8.2).

Organic soils: Greenhouse gas measurements for improvement and validation of the relevant emission factors: ongoing research project.

7.4 Grassland (5.C)

7.4.1 Source category description (5. C)

CRF 5.A	Gas	Key category	1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Grassland	**CO_2**	**L -/T2**	**11,561.9**	**(0.95%)**	**9,049.9**	**(0.95%)**	**(-21.73%)**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS	RS/NS	CS

The source category *Cropland* (5.B) is a key category of CO_2 emissions in terms of emissions level.

In 2010, net anthropogenic CO_2 emissions from grassland amounted to 9,050 Gg CO_2. Drainage of organic grassland soils resulted in emissions of 11,201 Gg CO_2. Via land-use changes, 1,075 Gg CO_2 were stored in mineral soils, and 1,120 Gg CO_2 were stored in biomass. Losses via decomposition of dead wood and litter from deforestation amounted to 44 Gg CO_2.

The time series for emissions from grassland show a clear trend (cf. Figure 61 and Figure 62 and Table 248 in Chapter 7.4.5). Emissions from grassland are decreasing. In 2010, the decrease amounted to -22 % with respect to the base year. The trends for all pool curves show a decreasing tendency. In mineral soils, both the increase in the sink function (5.2 %) and the decrease in emissions from organic soils (-3.9 %) are moderate. The sum curve is influenced especially strongly by biomass values. The sink function has increased by 439 % with respect to the base year. This is due primarily to discontinuation of cultivation on cropland areas; such areas turn into bush. The decrease in deforestation has led to a marked decrease of emissions from dead organic matter (-92.7 %), thereby also contributing to the decrease in net emissions from the grassland sector.

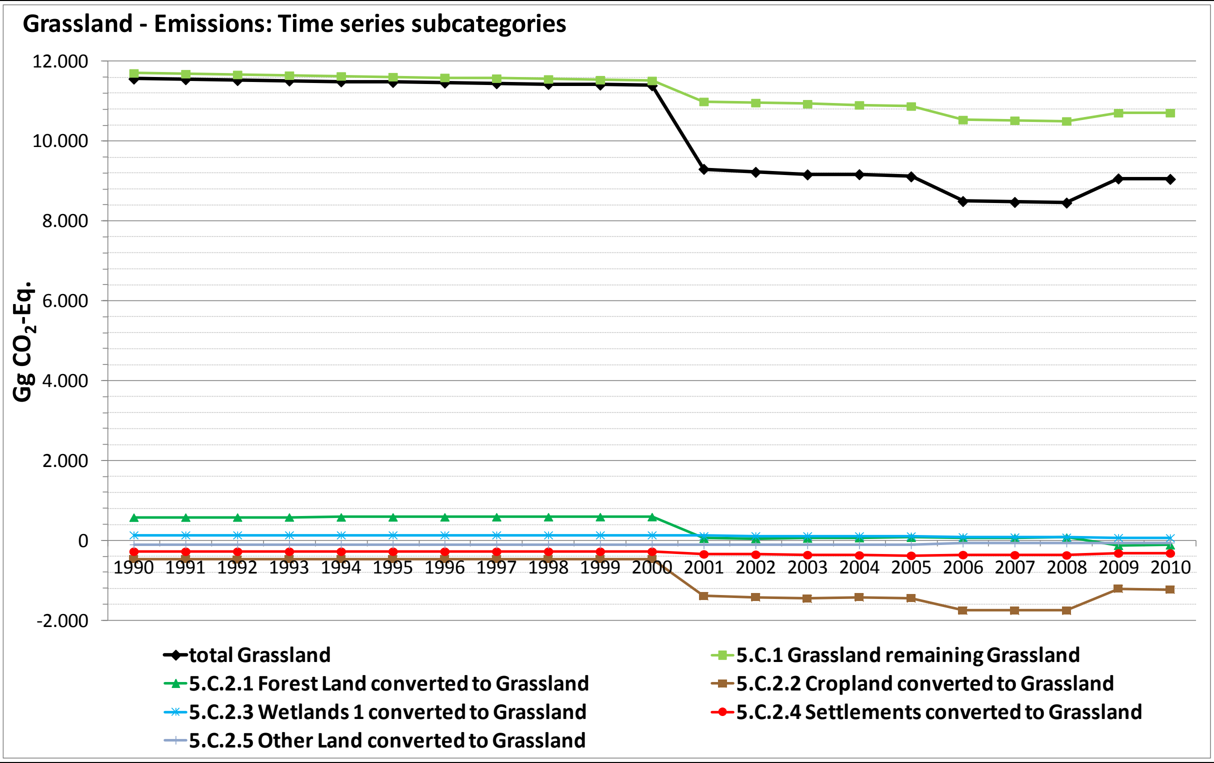


Figure 61: CO_2 emissions [Gg CO_2-Eq.] from Germany's grasslands, as a result of land use and land-use changes, 1990 – 2010, by sub-categories

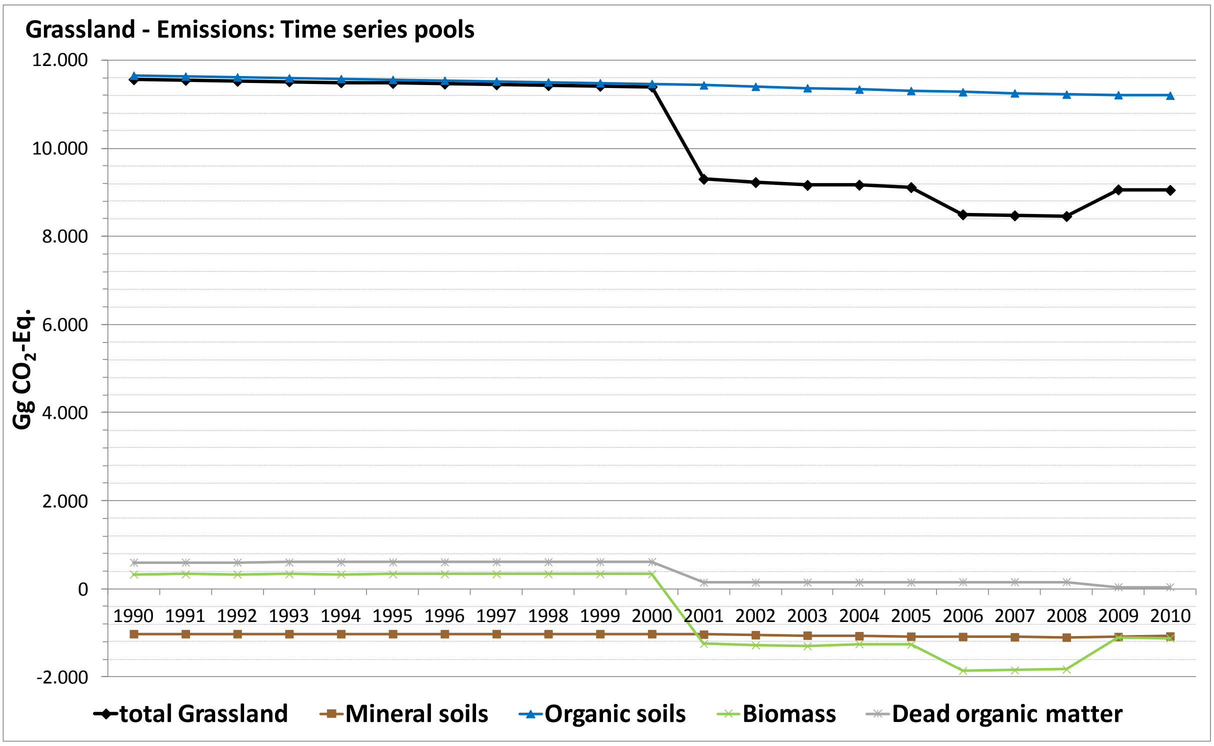


Figure 62: CO_2 emissions [Gg CO_2-Eq.] from Germany's grasslands, as a result of land use and land-use changes, 1990 – 2010, by pools

7.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation (5.C)

Cf. Chapter 7.1.3.

7.4.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.C)

The definition of "grassland" includes all grass-covered areas. In addition, this category includes wooded areas that are not included in the definition of "forest land". In a departure from previous submissions, object type 4106 "swamp, reeds" from the Basis-DLM (Chapter 7.1.3.2.1) was assigned to the grassland category (cf. Chapter 7.1.4). The reason for the placement change for that object type, which formerly was included in the wetlands category, was to establish consistency in the time series for land-use changes between grassland and wetlands as determined with the new sample-based method.

The grassland category has been broken down into two sub-categories (cf. Chapter 7.1.4):

- Meadows, pastures, alpine pastures, rough pastures, heath areas, natural-condition grassland, recreational areas and swamp/reeds are grouped under "grassland (in the narrow sense)".
- Hedges, field copses and shrubbery make up the sub-category "woody grassland".

Changes between these two sub-categories are treated like land-use changes.

Cf. also Chapter 7.1.4.

7.4.4 Methodological issues (5. C)

7.4.4.1 Data sources

- Statistisches Bundesamt, Fachserie 3, Reihe 3, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung und pflanzliche Erzeugung (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, agricultural soil use and crop cultivation; various years)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.2.1, Land- und Forstwirtschaft, Fischerei, Wachstum und Ernte – Feldfrüchte (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries, growth and harvests – crops; various years)
- Statistisches Bundesamt, Fachserie 3, Reihe 3.1.2, Land- und Forstwirtschaft, Fischerei,– Bodennutzung der Betriebe (Federal Statistical Office, Fachserie 3, Reihe 3, agriculture and forestry, fisheries – soil use by sectoral operations; various years)
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 - Agriculture, Forestry and Other Land Use (IPCC 2006)
- "Ordinance on application of fertilisers, soil additives, culture substrates and plant additives according to the principles of good practice in fertilization (Ordinance on Fertilisation – Düngeverordnung (DüV))“ (Ordinance on Fertilisation in the version as promulgated 27 February 2007 (Federal Law Gazette I, p. 221), last amended by Article 18 of the Act of 31 July 2009 (Federal Law Gazette I p. 2585).
- Interim report in the research project "Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Wäldern“ ("Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth") (PÖPKEN 2011)

7.4.4.2 Biomass

In the sub-categories "grassland (in the narrower sense)" and "woodlands", no change of carbon stocks in biomass is listed for areas that remain as they were (i.e. that undergo no conversion).

For calculation of carbon-stock changes in biomass, in connection with land-use changes to and from grassland, constant (over time) carbon stocks were determined for the sub-categories "grassland (in the narrower sense)" and "woody grassland". In addition, conversions from grassland (in the narrower sense) to woody grassland and vice-versa are treated like land-use changes, and listed as such in the CRF tables.

The manner in which CO_2 emissions from biomass, as a result of land-use changes, are calculated is presented in Chapter 7.1.7, while the method used to determine activity data is described in Chapter 7.1.3. The emission factors for the period 1990 to 2010, and their uncertainties, are shown in Table 248 and Table 249 in Chapter 7.4.5.

7.4.4.2.1 Grassland (in the narrower sense)

The carbon stocks in the above-ground and below-ground biomass of grassland were calculated on the basis of the Federal Statistical Office's harvest statistics. The harvests and areas of all meadows, mowed pastures, alpine pastures and rough pastures enter into the calculations for grassland (in the narrower sense). Since no significant trend emerged in the harvest covered by the harvest statistics, constant (over time) carbon stocks were calculated.

For annual crops, the dry biomass of individual plant parts is derived from harvest data, pursuant to RÖSEMANN et al. (2011), using relevant ratios and water-content data (obtained from various sources).

For calculation of biomass carbon stocks, an average carbon content of 45 % by weight – instead of the IPCC default value (50 % by weight) – was assumed, since OSOWSKI et al. (2004) give carbon contents of 44 – 48 % by weight for plants in central Europe and since PÖPKEN (2011), in her studies of cultivated trees (carried out for the German inventory), also found average values of 45 to 46 % by weight.

The area-related carbon stocks obtained for grassland (in the narrower sense) are shown in Table 244.

Table 244: Area-related carbon stocks [Mg C ha^{1}] of grassland (in the narrower sense) (± half of the 95 % confidence interval)

Grassland (in the narrower sense)	Carbon stocks [Mg C ha^{-1}] Bio_{total}	$Bio_{above-ground}$	$Bio_{below-ground}$
Grassland (in the narrower sense)	6.69 ± 1.65	4.36 ± 0.22	2.33 ± 1.65

7.4.4.2.2 Woody Grassland

In order to determine carbon stocks in hedges, PÖPKEN (2011) has studied 40 hedges to date, working in the framework of the research project "Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen" ("Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth") . The hedges studied to date vary widely in their characteristics:

1. Age

- About 4 – 20 years old

2. Dimensions

- Height, about 2 - 8 m
- Depth, about 1 – 6 m
- Length, about 100 – 500 m

3. Species composition

- Typical hedge plants, such as dog rose (Rosa canina), blackthorn/sloe (Prunus spinosa), common hazel (Corylus avellana), elder (Sambuccus spec.), hawthorn (Crataegus spec.), honeysuckle (Lonicera spec.), willow (Salix spec.)
- Trees, such as field maple (Acer campestre), common hornbeam (Carpinus betulus), willow (Salix spec.), beech (Fagus silvatica), linden (Tilia spec.) and elm (Ulmus spec.),

As a result, the study has included a representative spectrum of relevant field trees and shrubs. Laboratory analysis of samples taken of the various species in question included measurement of weight, water content and carbon content. That, in turn, made it possible, in connection with size data for the relevant fields, to determine absolute and area-related carbon stocks (cf. Table 245).

For reasons of nature conservation, the study carried out by PÖPKEN (2011) was able to survey only above-ground biomass. The below-ground biomass of the relevant trees and shrubs was estimated via the root / shoot ratio given by MOKANY et al. (2006) (cf. Table 245).

Table 245: Area-related carbon stocks [Mg ha^{-1}] in the biomass of trees and shrubs (range)

Trees and shrubs	**Carbon stocks [Mg C ha^{-1}]**		
	$Bio_{above-ground}$	**$Bio_{below-ground}$**	**Bio_{total}**
Trees and shrubs	35.27 (4.5 -125.8)	11.43 (2.0 – 28.4)	46.70 (6.5 – 154.3)

7.4.4.3 Mineral soils

No significant change in carbon stocks in mineral soils is listed for areas under permanent cultivation. The manner in which CO_2 emissions resulting from conversions leading to grassland (in the narrow sense) and to woody grassland are calculated is described in Chapter 7.1.5, while the pertinent emission factors are shown in Table 248 and Table 249 in Chapter 7.4.5, and derivation of the emission factors is described in Chapter 19.5.2. Table 246 shows the annual emission factors, averaged over all land-use categories, for conversions leading to grassland.

Table 246: Annual emission factors, averaged over all land-use categories, for conversions leading to grassland, broken down by grassland (in the narrower sense) and woody grassland [t C ha^{-1} a^{-1}]

Implied emission factors, mineral soils: Grassland$_{\text{in the narrow sense}}$ and Woody Grassland [Mg C ha^{-1} a^{-1}]											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Grassland	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
Woody GL	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Grassland	0.67	0.67	0.67	0.67	0.67	0.68	0.68	0.69	0.69	0.70	
Woody GL	0.52	0.51	0.51	0.50	0.49	0.49	0.49	0.48	0.48	0.48	

7.4.4.4 Organic soils

The annual emissions from grassland remaining grassland are calculated with the following partial emission factors:

Cultivated grassland: EF = 5 Mg C ha^{-1} a^{-1}
Swamp, reeds: EF = 0 Mg C ha^{-1} a^{-1}
Woodlands: EF = 0.68 Mg C ha^{-1} a^{-1} (same value as for forest land)

The area for swamp and reeds is constant in the time series, while the area for grassland (in the narrower sense) varies. As a result, the implied emission factor for the sub-category grassland (in the narrower sense) varies slightly from year to year, as is shown in Table 247.

Table 247: Implied emission factors for the sub-category grassland (in the narrower sense) [Mg C ha^{-1} a^{-1}]

Implied emission factors, organic soils$_{\text{grassland (in the narrower sense)}}$ [Mg C ha^{-1} a^{-1}]											
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
IEF	-4.866	-4.866	-4.865	-4.865	-4.865	-4.865	-4.865	-4.864	-4.864	-4.864	-4.864
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
IEF	-4.863	-4.863	-4.863	-4.862	-4.862	-4.862	-4.861	-4.861	-4.861	-4.861	

The annual emissions following land-use changes leading to grassland are calculated with the same procedure used for emissions from grassland remaining grassland. The procedure for calculating CO_2 emissions from organic soils that result from land use and land-use changes, and the procedure for deriving the pertinent emission factors, are described in Chapter 7.1.6.

N_2O emissions from organic soils on grassland (in the narrow sense) are reported as part of the "Agriculture" sector, under 4.D.1.5 "Cultivation of Histosols". To prevent double-counting, N_2O emissions from organic soils that result from conversions to grassland (in the narrow sense) are listed in the LULUCF tables with the notation key "IE".

7.4.4.5 Liming

Data for liming of grassland are not listed separately in the national database, and thus liming is assigned completely to cropland (cf. Chapter 7.3.4.5).

7.4.5 Uncertainties and time-series consistency (5. C)

Table 248 and Table 249 show the uncertainties relative to the emission factors for the grassland sub-categories grassland (in the narrower sense) and woody grassland. As a rule, the relevant distribution functions show a log-normal distribution, and they are characterised by their upper and lower boundaries. The uncertainties relative to mineral soils are of the same order of magnitude for both sub-categories. With regard to biomass, the uncertainties for the emission factors are higher for the "woody grassland" sub-category. Those uncertainties reflect the great diversity of relevant woody grassland in Germany.

The activity-data uncertainties shown in Table 339 in Chapter 19.5.4 have a normal distribution. The value "half of the 95 % confidence interval" varies throughout the range 1.7 – 147 %. In this case as well, the uncertainty depends on the sample size, and thus on the area share being considered. Weighted by area, the total uncertainty for activity data in the grassland category is 1.6 %. In terms of total emissions, Table 339 in Chapter 19.5.4 shows that emissions from organic soils under grassland, like those from biomass in this category, contribute significantly to the emissions and total uncertainty of the LULUCF inventory.

Table 248: Emission factors [Mg C ha^{-1} a^{-1}], with uncertainties [% of location scale], as used for calculation of GG emissions from grassland (in the narrower sense)

Grassland$_{\text{in the narrower sense}}$ Land use$_{\text{before}}$ Mineral soils CO_2-C[73]	**Area Land use$_{\text{after}}$**	**Emission factor [Mg C ha^{-1} a^{-1}]**	**Boundaries upper [%]**	**lower [%]**
Forest land	Grassland$_{\text{in the narrower sense}}$	0.77	49	31
Cropland	Grassland$_{\text{in the narrower sense}}$	0.87	49	30
Woody Grassland	Grassland$_{\text{in the narrower sense}}$	0.22	57	32
Wetlands (terr.)	Grassland$_{\text{in the narrower sense}}$	0.17	47	32
Waters	Grassland$_{\text{in the narrower sense}}$	0.00	78	46
Settlements	Grassland$_{\text{in the narrower sense}}$	0.94	57	33
Other land	Grassland$_{\text{in the narrower sense}}$	1.09	60	33
Organic soils (annual)		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
	Grassland$_{\text{in the narrower sense}}$	Chapter 7.4.4.4	50	50
Biomass[74]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Grassland$_{\text{in the narrower sense}}$	-25.94	29	29
Cropland	Grassland$_{\text{in the narrower sense}}$	-0.39	13	13
Woody Grassland	Grassland$_{\text{in the narrower sense}}$	-40.02	173	60
Wetlands (terr.)	Grassland$_{\text{in the narrower sense}}$	-13.34	115	41
Waters	Grassland$_{\text{in the narrower sense}}$	6.69	25	25
Settlements	Grassland$_{\text{in the narrower sense}}$	-6.66	115	41
Other land	Grassland$_{\text{in the narrower sense}}$	6.69	25	25
Dead organic matter[75]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Grassland$_{\text{in the narrower sense}}$	-21.97	35	56

Forest land, cropland: annual variable; all other factors are constant

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2010.

[73] Calculation for 20-year period
[74] Calculation only for the first year following the pertinent land-use change
[75] Calculation only for the first year following the pertinent land-use change

Table 249: Emission factors [Mg C ha^{-1} a^{-1}], with uncertainties [% of location scale], as used for calculation of GG emissions from woodlands

Woody Grassland Land use$_{before}$ Mineral soils CO_2-C[76]	Area Land use$_{after}$	Emission factor [Mg C ha^{-1} a^{-1}]	Boundaries upper [%]	lower [%]
Forest land	Woodlands	0.56	51	30
Cropland	Woodlands	0.66	51	28
Grassland (in the narrower sense)	Woodlands	-0.21	57	32
Wetlands (terr.)	Woodlands	-0.04	49	31
Waters	Woodlands	0.00	83	43
Settlements	Woodlands	0.73	60	31
Other land	Woodlands	0.88	62	31
Organic soil		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
	Woodlands	-0.68	181	40
Biomass[77]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Woodlands	14.07	117	43
Cropland	Woodlands	39.63	171	60
Grassland (in the narrower sense)	Woodlands	40.02	173	60
Wetlands (terr.)	Woodlands	26.68	123	43
Waters	Woodlands	46.70	197	69
Settlements	Woodlands	33.35	158	55
Other land	Woodlands	46.70	197	69
Dead organic matter[78]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Woodlands	-21.97	35	56

Forest land, cropland: annual variable; all other factors are constant

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2010.

7.4.6 Category-specific QA /QC and verification (5. C)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Internally, the possibility of determining uncertainties via data manipulation with cross-sum comparisons is being reviewed. Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators.

The intra-European comparison of implied emission factors shown in Table 250 shows that Germany, after Switzerland and the Netherlands, uses the third-highest emission factor for CO_2 from drainage of organic soils used as grassland. At the same time, that value is a mixed area-weighted value consisting of -4.86 Mg C ha^{-1} a^{-1} from grassland and -0.68 Mg C ha^{-1} a^{-1} from areas with field copses and shrubs. The mixed factor is in keeping with measurements made in Germany for grassland used moderately intensively (DRÖSLER et al. 2011). In the case of land-use changes leading to grassland, involving organic soils, the same emission factor applies, immediately, that applies for grassland remaining grassland.

[76] Calculation for 20-year period
[77] Calculation only for the first year following the pertinent land-use change
[78] Calculation only for the first year following the pertinent land-use change

In Germany, carbon-stock changes in mineral soils and biomass involve changes between cultivated grassland and woodland areas, within the category "Grassland remaining Grassland". The mean emission factors are very low, since only a small area share is involved. Such changes are handled very differently from country to country, and thus the relevant mean emission factors of different countries cannot be directly compared. Like Germany, most EU countries assign carbon sinks in mineral soils and biomass to the "grassland" category.

In Germany, land-use changes leading to grassland lead to large C sinks in mineral soils (only Belgium has a higher corresponding value) and biomass, in comparison to the corresponding values of European neighbour countries, and to small C losses in dead organic matter. The reason for this is that conversions to woodland account for a significant share of land-use changes in Germany. In neighbouring countries, mean emission factors are scattered throughout a range leading from C sources to C sinks. In each case, the values cannot be explained without data relative to the applicable shares of the pertinent original use categories.

Table 250: Comparison of implied emission factors (IEF), for various grassland pools, between Germany and European neighbouring countries

Implied emission factors (IEF), grassland, NIR 2009	Grassland remaining grassland			Land-use changes leading to grassland			
	Organic soils	Mineral soils	Biomass	Organic soils	Mineral soils	Biomass	Dead org. matter
	Mg C ha^{-1}						
Austria	IE	0.014	NO	NO	0.216	-0.703	-0.533
Belgium	NO	-0.179	NO	NO	1.442	-0.205	NO
Czech Republic	NO	0.000	NO	NA,NO	0.482	-0.008	-0.001
Denmark	-0.981	NA	-0.005	-1.250	-0.124	-0.130	-0.013
France	0.000	0.000	0.000	0.000	0.634	-0.112	-0.017
Netherlands	-5.793	NE	NE	NE	NE	-7.253	-2.519
Poland	-0.250	NO	NO	NO,NE	NO,NE	NO,NE	NO,NE
Sweden	-1.602	0.171	0.219	-1.600	0.399	0.397	-0.249
Switzerland	-8.415	0.005	0.003	-8.317	0.634	-0.935	-0.415
UK	NO	NO	NO	IE,NO	0.491	0.000	IE,NO
European Union (15)	-3.869	0.029	0.014	-2.147	0.955	-0.115	-0.016
European Union (27)	-3.286	0.021	0.014	-1.880	0.903	-0.122	-0.016
Germany, 2009	**-4.756**	**0.001**	**0.006**	**-3.666**	**0.756**	**0.644**	**-0.029**
Germany, 2010	**-4.753**	**0.001**	**0.006**	**-3.653**	**0.757**	**0.659**	**-0.029**

7.4.7 Category-specific recalculations (5. C)

For this year's report, the data for the entire report period, 1990 – 2010, have been largely recalculated (and are so presented) to take account of the transition in the reporting system. For the first time, a time series for emissions in connection with dead organic matter, and as a result of deforestation, is being provided. With the methods changes, all the requirements that emerged from the 2010 in-country review have been implemented (Chapter 7.1.2). The recalculation was required as a result of the change made in the procedure for determining the land-use-change matrix (cf. Chapter 7.1.3), and it was needed because a transition time of 20 years was used, for the first time, for the entire LULUCF sector. In addition, the calculation method for determination of emissions from mineral soils, as a result of land-use changes, was changed, and the emission factors for organic soils were updated. As a result of the numerous changes that have been made, the emissions as reported in 2011 cannot be compared directly with those as reported in 2012 (Table 251 and Table 252).

Table 251: Comparison of emissions [Gg CO_2], as reported in 2012 and 2011, from grassland remaining grassland (5.C.1)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**11,705**	**11,686**	**11,667**	**11,649**	**11,630**	**11,611**	**11,592**	**11,573**	**11,555**	**11,536**
Total, 2011	**10,133**	**10,109**	**10,085**	**10,062**	**10,038**	**10,014**	**9,991**	**9,967**	**9,943**	**9,920**
Mineral soils, 2012	-49	-49	-49	-49	-49	-49	-49	-49	-49	-49
Mineral soils, 2011	0	0	0	0	0	0	0	0	0	0
Organic soils, 2012	11,270	11,252	11,233	11,214	11,195	11,177	11,158	11,139	11,120	11,101
Organic soils, 2011	13,503	13,479	13,456	13,432	13,409	13,385	13,361	13,338	13,314	13,290
Biomass, 2012	483	483	483	483	483	483	483	483	483	483
Biomass, 2011	-3,371	-3,371	-3,371	-3,371	-3,371	-3,371	-3,371	-3,371	-3,371	-3,371
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**11,517**	**10,991**	**10,962**	**10,933**	**10,905**	**10,876**	**10,537**	**10,519**	**10,502**	**10,708**
Total, 2011	**9,896**	**9,873**	**9,849**	**9,825**	**9,802**	**9,778**	**10,219**	**10,518**	**10,356**	**12,356**
Mineral soils, 2012	-49	-47	-44	-41	-39	-36	-32	-28	-24	-21
Mineral soils, 2011	0	0	0	0	0	0	0	0	0	0
Organic soils, 2012	11,083	11,051	11,020	10,989	10,957	10,926	10,905	10,884	10,862	10,861
Organic soils, 2011	13,267	13,243	13,220	13,196	13,172	13,149	13,085	13,157	13,080	13,147
Biomass, 2012	483	-14	-14	-14	-14	-14	-336	-336	-336	-131
Biomass, 2011	-3,371	-3,371	-3,371	-3,371	-3,371	-3,371	-2,866	-2,639	-2,725	-790

Positive: emissions; negative: sink

Table 252: Comparison of emissions [Gg CO_2], as reported in 2012 and 2011, from land-use changes leading to grassland (5.C.2)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**-144**	**-139**	**-143**	**-134**	**-137**	**-134**	**-130**	**-127**	**-126**	**-123**
Total, 2011	**-5,433**	**-5,434**	**-5,435**	**-5,436**	**-5,436**	**-5,437**	**-5,438**	**-5,438**	**-5,439**	**-5,440**
Mineral soils, 2012	-973	-973	-973	-973	-973	-973	-973	-973	-973	-973
Mineral soils, 2011	-4,877	-4,877	-4,877	-4,877	-4,877	-4,877	-4,877	-4,877	-4,877	-4,877
Organic soils, 2012	383	383	383	383	383	383	383	383	383	383
Organic soils, 2011	181	181	181	181	181	181	181	181	181	181
Biomass, 2012	-154	-151	-156	-149	-153	-151	-149	-147	-148	-146
Biomass, 2011	-737	-738	-739	-740	-740	-741	-742	-742	-743	-744
Dead organic matter, 2012	600	602	603	605	606	607	609	610	612	613
Dead organic matter, 2011	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**-123**	**-1,691**	**-1,737**	**-1,772**	**-1,738**	**-1,765**	**-2,042**	**-2,048**	**-2,046**	**-1,647**
Total, 2011	**-5,441**	**-5,441**	**-5,457**	**-5,457**	**-5,458**	**-5,459**	**-4,679**	**-5,033**	**-4,384**	**-1,635**
Mineral soils, 2012	-973	-987	-1,001	-1,015	-1,029	-1,044	-1,055	-1,066	-1,077	-1,067
Mineral soils, 2011	-4,877	-4,877	-4,877	-4,877	-4,877	-4,877	-4,338	-4,450	-4,028	-1,603
Organic soils, 2012	383	383	383	382	382	381	375	369	363	352
Organic soils, 2011	181	181	181	181	181	181	221	175	137	58
Biomass, 2012	-148	-1,235	-1,267	-1,287	-1,240	-1,251	-1,521	-1,510	-1,492	-976
Biomass, 2011	-745	-745	-761	-761	-762	-763	-562	-758	-493	-90
Dead organic matter, 2012	615	148	148	148	149	149	159	159	160	44
Dead organic matter, 2011	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE

Positive: emissions; negative: sink

7.4.8 Category-specific planned improvements (5. C)

Cf. Chapter 7.3.8.

7.5 Wetlands (5.D)

7.5.1 Source category description (5.D)

CRF 5.D	Gas	Key category	1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Wetlands (5.D)	**CO_2**	**- -/T2**	**2,248.4**	**(0.18%)**	**2,156.5**	**(0.23%)**	**(-4.09%)**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS/Tier 1	RS/NS	CS/D
CH_4	Tier 1		
N_2O	Tier 1		

Pursuant to Tier-2 analysis, the source category Wetlands is a key category for CO_2 emissions.

In Germany, the "wetlands" category includes the country's few undrained semi-natural bogs that are largely free of anthropogenic impacts. It also includes other wetlands and water bodies without anthropogenic greenhouse-gase emissions. Water-storage bodies (dammed lakes, reservoirs, etc.) and settling basins, including waters used for energy production, irrigation, shipping and recreation, and basins/beds that have been flooded or drained or whose water levels fluctuate very widely, are insignificant in Germany in terms of total area and do not have to be reported at the Tier-1 level.

Emissions from industrial peat extraction are reported under "wetlands remaining wetlands".

In addition, reporting covers changes in carbon stocks of above-ground and below-ground biomass, and of soils created via land-use changes leading to wetlands.

In 2010, a total of 2,156 Gg CO_2 were released from wetlands. That sum consists of 2,006 Gg CO_2 emissions from industrial peat extraction and, in the context of land-use change, of 155 Gg CO_2 emissions from biomass and 4 Gg CO_2 storage in mineral soils.

The time series in Figure 63 and Figure 64 show no trend. The total emissions have decreased by about 4 % with respect to the base year. The annual changes in emissions from wetlands are due primarily to changes in industrial peat extraction. The trend curves for the other pools show virtually no fluctuations.

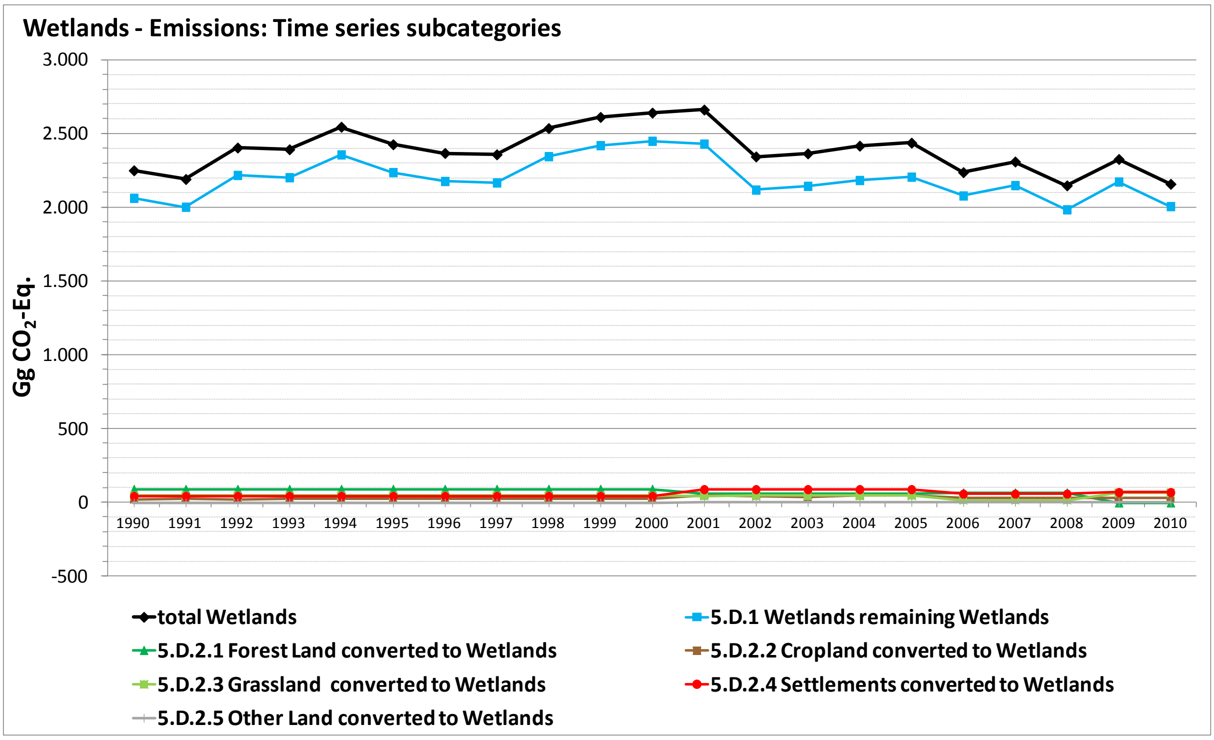


Figure 63: CO_2 emissions [Gg CO_2-Eq.] from Germany's wetlands, as a result of land use and land-use changes, 1990 – 2010, by sub-categories

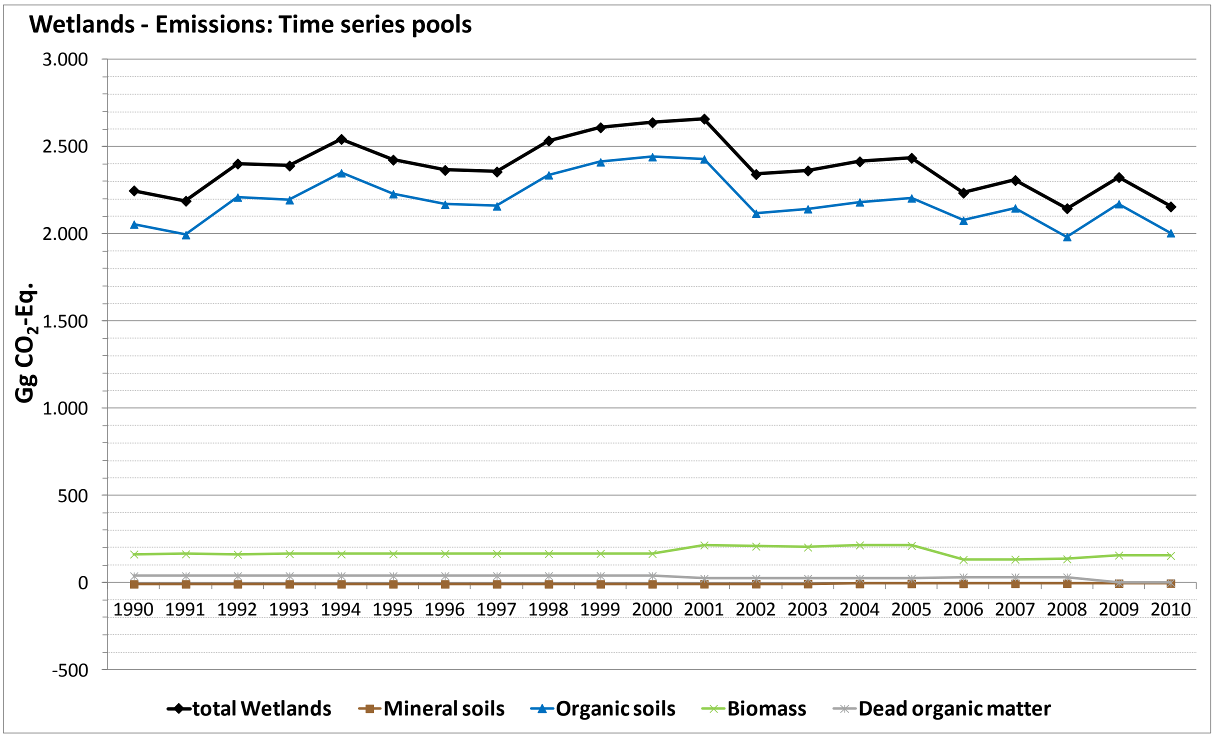


Figure 64: CO_2 emissions [Gg CO_2-Eq.] from Germany's wetlands, as a result of land use and land-use changes, 1990 – 2010, by pools

7.5.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation (5.A)

Cf. Chapter 7.1.3.

7.5.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.D)

This land-use category includes terrestrial wetlands and open water bodies that differ widely in terms of their emissions behaviour. For this reason, the land-use category "Wetlands" has been divided into two sub-categories, "wetlands (terrestrial)" and "waters". In the context of other land-use categories, these categories are listed as separate categories, and they are reported separately in the CRF tables.

For details, cf. Chapter 7.1.4.

7.5.4 Methodological issues (5. D)

7.5.4.1 Data sources

The production-quantity data for industrial peat extraction were taken from official German statistics (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 3.1).

For further sources, cf. Chapters 7.1.3.2, 7.1.4 and 19.5.2.

7.5.4.2 Biomass

Water-body areas are free of vegetation, and thus the carbon stocks in pertinent biomass are "zero".

For the sub-category " wetlands (terr.)", changes in biomass carbon stocks, as a result of land-use changes, are calculated with the procedures and methods described in Chapter 7.1.7.

As a rule, terrestrial wetlands are covered with woods (throughout a spectrum ranging from individual bushes to forests), mosses and grasses, with mosses and grasses predominating. Consequently, in the inventory the following assumption is made relative to the area-related distribution of carbon stocks in biomass: 1/3 woods share and 2/3 mosses/grasses share.

Since no biomass surveys of such lands have been carried out in Germany, the relevant values for woody grassland (Chapter 7.4.4.2.2) and grassland (in the narrow sense) (Chapter 7.4.4.2.1) are used as approximations.

The carbon stocks in terrestrial wetlands can then be calculated pursuant to Equation 40. The relevant results are shown in Table 253.

Equation 40:

$$\text{C stocks}_{\text{terr. wetlands}} = \text{C stocks}_{\text{woods}} * 0.333 + \text{C stocks}_{\text{grassland (in the narrower sense)}} * 0.667$$

Table 253: Area-related carbon stocks [Mg ha^{-1}] for biomass in Germany's terrestrial wetlands (range)

Wetlands (terr.)	**Carbon stocks [Mg C ha^{-1}]**		
	$\text{Bio}_{\text{above-ground}}$	**$\text{Bio}_{\text{below-ground}}$**	**$\text{Bio}_{\text{total}}$**
wetlands (terr.)	14.67 (4.4 - 44.9)	5.36 (2.0 – 11.1)	20.02 (9.2 - 50.7)

The emission factors and pertinent uncertainties are presented in Table 255 (Chapter 7.5.5).

7.5.4.3 Mineral soils

It was assumed that no changes in the carbon stocks of mineral soils occurred in connection with land-use changes leading to water bodies.

For the sub-category "wetlands (terr.)", changes in mineral-soil carbon stocks, as a result of land-use changes, are calculated with the procedures and methods described in Chapter 7.1.5.

The emission factors and pertinent uncertainties are presented in Table 255 (Chapter 7.5.5).

7.5.4.4 Organic soils

No drainage of organic soils occurs in the wetlands category. Land-use changes leading to wetlands are equivalent to conversions leading to semi-natural hydrologic conditions.

CO_2 emissions from peat extraction were calculated in conformance with the provisions of the 2006 IPCC Guidelines, with the applicable Tier 1 method and with the default factors of the IPCC (2006). The activity data on which the estimate is based consist of production quantities. They were taken from official German statistics (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 3.1). The emission factors for the period 1990 to 2010 are summarised in Table 254. No reliable data are available in Germany relative to areas subject to industrial peat extraction.

CH_4 emissions from peat extraction (pursuant to IPCC GPG-LULUCF 2003, p. 1.11) are not reported.

N_2O emissions from peat extraction do not have to be reported, since they are negligible. The reason for this is that almost all of the peat extracted in Germany is extracted from raised bogs, which have C/N ratios > 25 (pursuant to IPCC GPG-LULUCF 2003, p. 1.11).

Table 255 (Chapter 7.5.5) includes a mean implied emission factor that represents the CO_2 emissions from industrial peat production per area of terrestrial wetlands remaining terrestrial wetlands.

Table 254: Implied emission factors for peat extraction [Mg C ha^{-1} a^{-1}] in Germany

	Implied emission factors for peat extraction [Mg C ha^{-1} a^{-1}]										
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
IEF	-11.2	-11.2	-12.8	-13.1	-14.5	-14.3	-14.4	-14.9	-16.8	-18.0	-19.1
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	
IEF	-19.1	-16.8	-17.2	-17.6	-17.9	-16.8	-17.3	-15.9	-17.3	-15.9	

7.5.5 Uncertainties and time-series consistency (5. D)

The time series for activity data provided by the Federal Statistical Office for peat extraction are consistent and available for the entire period covered by the report. Pursuant to the Federal Statistical Office, the uncertainties for these activity data are "0", since the data have been obtained via an exhaustive survey entailing an obligation to provide information. Nonetheless, a conservative approach was applied, and an uncertainty of 20 % was assumed, since the data categories relative to peat-extraction products have varied over the years in the Federal Statistical Office's publications, and the possibility that the relevant survey pools have also varied somewhat over the years cannot be reliably ruled out. The uncertainties listed in Table 255, ranging up to 40 % for peat extraction, are the result of an uncertainties-propagation calculation. They are due especially to the large uncertainties in the IPCC default factors. The large uncertainties for the EF, with regard to biomass, reflect the fact that woods account for a considerable share of the category.

The activity data and area data have a normal distribution. Their uncertainties, depending on the area and sampling sizes involved, range from 6 % to 147 % (cf. Table 339 in Chapter 19.5.4). The total uncertainty for the area data in the wetlands category is 5.4 %. The wetlands pool's contributions to the total emissions and total uncertainty in the LULUCF sector are very small. Only the values relating to peat extraction are large enough to be perceived (cf. Table 339 in Chapter 19.5.4).

Table 255: Emission factors and uncertainties [in % of location scale] used for calculation of GG emissions from Germany's wetlands in 2010, broken down by pools and sub-categories

Wetlands (terr.)	**Area**	**Emission factor**	**Boundaries**		**Waters**	**Emission factors**	**Boundaries**	
Land use$_{before}$	**Land use$_{after}$**		**upper**	**lower**	**Land use$_{after}$**		**lower**	**upper**
Mineral soils CO_2-C[79]		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
Forest land	Wetlands (terr.)	0.60	36	30	Waters	No emissions		
Cropland	Wetlands (terr.)	0.70	37	28	Waters	No emissions		
Grassland (in the narrow sense)	Wetlands (terr.)	-0.17	47	32	Waters	No emissions		
Woody Grassland	Wetlands (terr.)	0.04	49	31	Waters	No emissions		
Settlements	Wetlands (terr.)	0.77	48	32	Waters	No emissions		
Waters	Wetlands (terr.)	0	0	0	Waters	No emissions		
Other land	Wetlands (terr.)	0.92	50	32	Waters	No emissions		
Organic soil		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
	Wetlands (terr.); peat extraction	-15.87	40	20				
Biomass[80]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Wetlands (terr.)	-12.61	62	30	Waters	-32.63	34	34
Cropland	Wetlands (terr.)	12.95	113	40	Waters	-7.07	8	89
Grassland (in the narrow sense)	Wetlands (terr.)	13.34	115	41	Waters	-6.69	25	25
Woody Grassland	Wetlands (terr.)	-26.68	123	43	Waters	-46.70	197	69
Terr. wetlands	Wetlands (terr.)	0	0	0	Waters	-20.02	153	54
Waters	Wetlands (terr.)	20.02	153	54	Waters	0	0	0
Settlements	Wetlands (terr.)	6.68	115	40	Waters	-13.35	173	60
Other land	Wetlands (terr.)	20.02	153	54	Waters	0	0	0
Dead organic matter[81]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Wetlands (terr.)	-21.97	35	56	Waters	-21.97	35	56

Positive: sink; negative: Source

The calculations are spatially and chronologically consistent and complete for the entire report period, 1990 – 2010.

[79] Calculation for 20-year period

[80] Calculation only for the first year following the pertinent land-use change

[81] Calculation only for the first year following the pertinent land-use change

7.5.6 Category-specific QA / QC and verification (5. D)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Internally, data processing is checked via comparisons of cross sums. Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators.

In a comparison of Germany's implied emission factors, in the wetlands category, with those of European neighbouring countries, Germany's IEF lie within the middle of the overall range (Table 256). National definitions play an especially strong role in the wetlands category. Since the applicable national circumstances differ widely from country to country, the various implied emission factors span a wide range overall. Like Germany, most neighbouring countries list soils as moderate carbon sinks, and biomass as a carbon source, in connection with conversions leading to wetlands. Unlike Germany, some neighbouring countries also include dead organic matter as a carbon sink in connection with conversions to wetlands. In the relevant German calculation, that pool is not listed separately, and it thus includes only C losses in connection with conversions from forest land to wetlands.

Table 256: Comparison of Germany's implied emission factors (IEF), for various wetland-sector pools, with those of European neighbouring countries

Implied emission factors (IEF), wetlands, NIR 2009	Wetlands remaining wetlands	Land-use changes leading to wetlands		
	Organic soils	Mineral soils	Biomass	Dead org. matter
	Mg C ha^{-1}			
Austria	NE	-3.738	-0.407	-0.099
Belgium	NO	0.869	-0.790	NO
Czech Republic	NO	NA,NO	-0.458	-0.005
Denmark	-4.787	0.500	0.185	-0.002
France	NO	NO	-0.338	-0.025
Netherlands	NE	NE	-5.133	-1.805
Poland	NA	NA,NO	-0.002	NA,NO
Sweden	-0.003	NA	NA	NA
Switzerland	0.002	0.439	-4.116	-0.827
UK	-10.427	IE,NO	IE,NO	IE,NO
European Union (15)	-0.049	-0.818	-0.248	-0.022
European Union (27)	-0.041	-0.836	-0.297	-0.031
Germany, 2009	**-1.058**	**0.013**	**-0.475**	**0.000**
Germany, 2010	**-0.971**	**0.011**	**-0.464**	**0.000**

Positive: sink; negative: Source

7.5.7 Category-specific recalculations (5. D)

For this year's report, the data for the entire report period, 1990 – 2010, have been largely recalculated (and are so presented) to take account of the transition in the reporting system. For the first time, a time series for emissions in connection with dead organic matter, and as a result of deforestation, is being provided. With the methodological changes, all the requirements that emerged from the 2010 in-country review have been implemented (Chapter 7.1.2). The recalculation was required as a result of the change made in the procedure for determining the land-use-change matrix (cf. Chapter 7.1.3), and it was needed because a transition time of 20 years was used, for the first time, for the entire LULUCF sector. What is more, the calculation method for determination of emissions from mineral soils, resulting from land-use changes, was changed, and nearly all emission factors for the categories 5.B – 5.F were changed. As a result of the numerous changes that have been made, the emissions as reported in 2011 cannot be compared directly with those as reported in 2012 (Table 257 and Table 258).

The comparison is shown for the entire wetlands category, since water bodies were not separately described in the 2011 Submission.

Table 257: Comparison of emissions [Gg CO_2], as reported in 2012 and 2011, from wetlands remaining wetlands (5.D.1)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**2,062**	**2,002**	**2,217**	**2,202**	**2,357**	**2,237**	**2,176**	**2,166**	**2,345**	**2,419**
Total, 2011	**2,236**	**2,236**	**2,236**	**2,235**	**2,234**	**2,234**	**2,233**	**2,233**	**2,232**	**2,232**
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2011	0	0	0	0	0	0	0	0	0	0
Organic soils, 2012	2,055	1,995	2,210	2,195	2,350	2,230	2,169	2,159	2,338	2,412
Organic soils, 2011	2,223	2,223	2,223	2,222	2,221	2,221	2,220	2,220	2,219	2,219
Biomass, 2012	7	7	7	7	7	7	7	7	7	7
Biomass, 2011	13	13	13	13	13	13	13	13	13	13
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**2,449**	**2,429**	**2,118**	**2,143**	**2,183**	**2,205**	**2,078**	**2,148**	**1,984**	**2,172**
Total, 2011	**2,231**	**2,212**	**2,236**	**2,260**	**2,284**	**2,307**	**1,436**	**1,495**	**1,530**	**2,356**
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2011	0	0	0	0	0	0	0	0	0	0
Organic soils, 2012	2,442	2,429	2,118	2,143	2,183	2,205	2,078	2,148	1,984	2,172
Organic soils, 2011	2,218	2,199	2,223	2,247	2,271	2,294	1,387	1,502	1,519	2,357
Biomass, 2012	7	0	0	0	0	0	0	0	0	0
Biomass, 2011	13	13	13	13	13	13	49	-7	11	-1

Table 258: Comparison of emissions [Gg CO_2], as reported in 2012 and 2011, from land-use changes leading to wetlands (5.D.2)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**187**	**188**	**186**	**190**	**188**	**189**	**190**	**191**	**190**	**191**
Total, 2011	**-72**	**-73**	**-73**	**-73**	**-74**	**-74**	**-74**	**-74**	**-75**	**-75**
Mineral soils, 2012	-8	-8	-8	-8	-8	-8	-8	-8	-8	-8
Mineral soils, 2011	-135	-135	-135	-135	-135	-135	-135	-135	-135	-135
Organic soils, 2012	0	0	0	0	0	0	0	0	0	0
Organic soils, 2011	0	0	0	0	0	0	0	0	0	0
Biomass, 2012	156	158	155	159	157	158	159	160	159	160
Biomass, 2011	62	62	62	62	62	61	61	61	60	60
Dead organic matter, 2012	38	38	39	39	39	39	39	39	39	39
Dead organic matter, 2011	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**191**	**231**	**225**	**220**	**233**	**230**	**158**	**160**	**163**	**152**
Total, 2011	**-75**	**-76**	**-82**	**-82**	**-83**	**-83**	**229**	**-102**	**44**	**53**
Mineral soils, 2012	-8	-8	-7	-7	-6	-6	-6	-5	-5	-4
Mineral soils, 2011	-135	-135	-135	-135	-135	-135	-101	-137	-130	-47
Organic soils, 2012	0	0	0	0	0	0	0	0	0	0
Organic soils, 2011	0	0	0	0	0	0	0	0	0	0
Biomass, 2012	160	215	208	203	215	212	132	133	136	157
Biomass, 2011	60	59	53	53	52	52	330	36	174	99
Dead organic matter, 2012	39	24	24	24	24	24	32	32	32	0
Dead organic matter, 2011	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE

7.5.8 Category-specific planned improvements (5. D)

- Validation of area data for 1990 (cf. Chapter 7.2.8.1, 1. para.)

7.6 Settlements (5.E)

7.6.1 Source category description (5. E)

CRF 5.E	Gas	Key category	1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Settlements (CRF 5.E)	**CO_2**	**- -/T2**	**2,751.6**	**(0.23%)**	**2,551.4**	**(0.27%)**	**(-7.28%)**

Gas	Method used	Source for the activity data	Emission factors used
CO_2	CS/Tier 1	RS/NS	CS

Pursuant to Tier-2 analysis, the source category *Settlements* is a key category for CO_2 emissions.

Reporting for the land-use category "settlements" has to cover CO_2 emissions / storage in the pools "soil", "biomass" and "dead organic matter" on land designated for settlement and transport uses. Precise definitions and category allocations are presented in Chapter 7.1.4.

In 2010, CO_2 emissions from Germany's settlement and transport areas, as a result of land-use changes, amounted to 2,551 Gg CO_2. That figure represents the sum of losses of 2,502 Gg CO_2 from organic soils, 584 Gg CO_2 emissions from mineral soils, 32 Gg CO_2 from decomposition of dead organic matter and storage of 567 Gg CO_2 in biomass.

An overview of the development of total emissions over time shows that total emissions decreased temporarily between 2000 and 2003 (cf. Figure 65 and Figure 66) and then increased again until they had almost re-attained their original level. Net emissions from the settlements category decreased by 7 % in 2010, with respect to the base year. The emissions decrease between 2000 and 2003 was the result of intensified conversion of cropland into settlements – and, thus, of intensified carbon storage in new biomass on settlement areas. A further emissions decrease occurred as the result of a decrease in deforestation, which entailed a reduction of CO_2 emissions from lost dead organic matter.

Since mineral soils in settlements have small carbon stocks, land-use changes leading to settlements entail decreases in carbon stocks – especially in the case of conversions of grasslands, which have the highest carbon stocks.

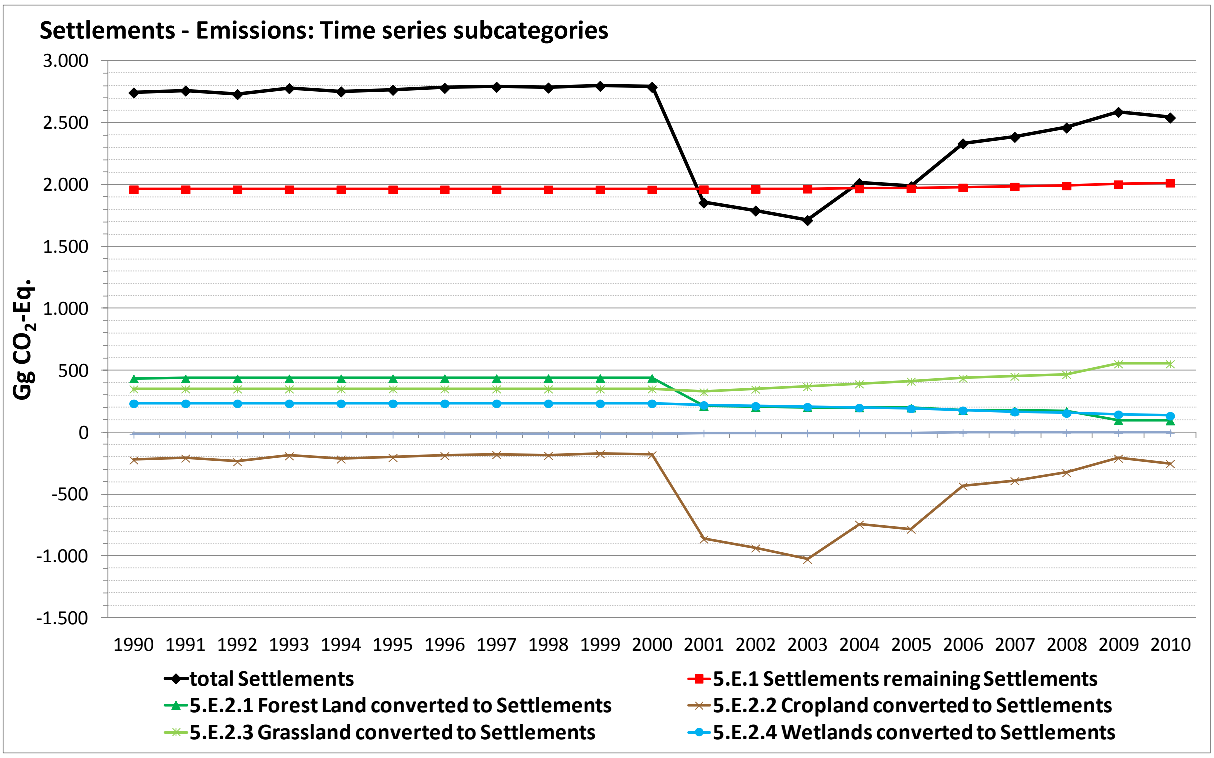


Figure 65: CO_2 emissions [Gg CO_2-Eq.] from Germany's settlements, as a result of land use and land-use changes, 1990 – 2010, by sub-categories

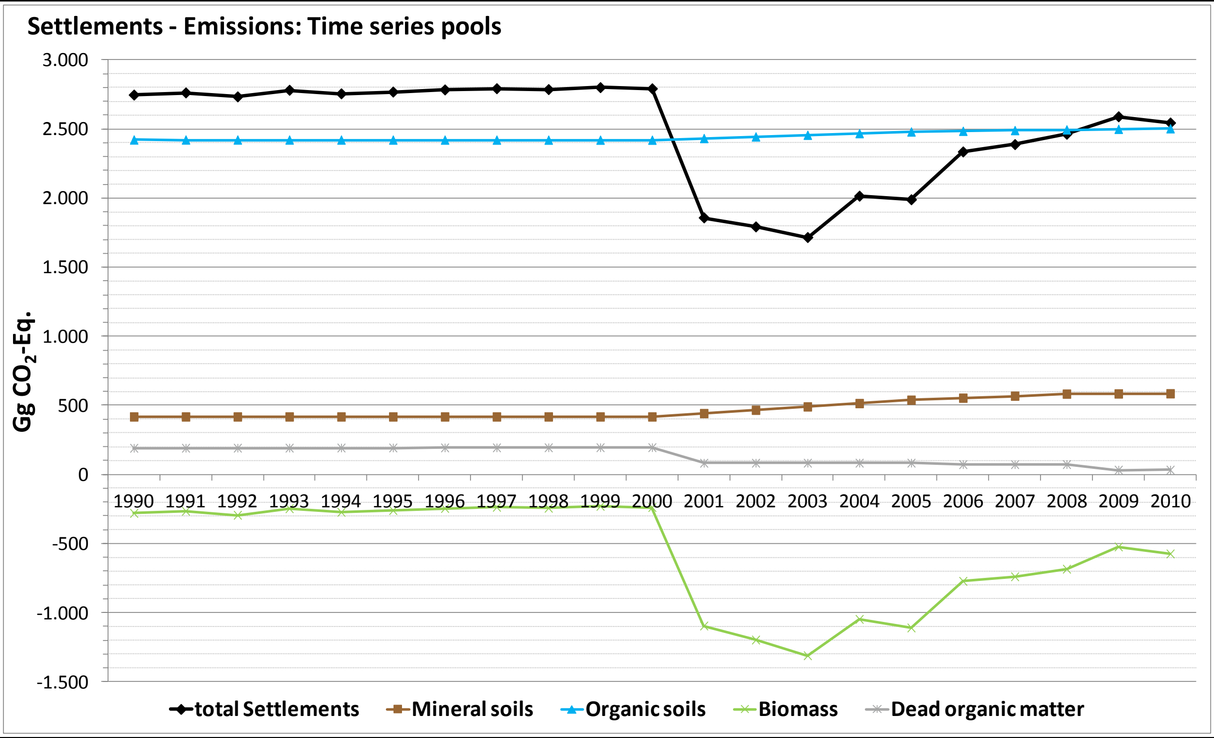


Figure 66: CO_2 emissions [Gg CO_2-Eq.] from Germany's settlements, as a result of land use and land-use changes, 1990 – 2010, by pools

7.6.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation (5.E)

Cf. Chapter 7.1.3.

7.6.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.E)

All settlement lands have been combined within a single category. Cf. Chapter 7.1.4.

7.6.4 Methodological issues (5. E)

In keeping with the Tier 1 method, it has been assumed that no carbon-stock changes occur in mineral soils and biomass in the case of settlements remaining settlements. It has also been assumed that organic soils in settlements have been drained.

All five carbon pools are reported in connection with land-use changes leading to settlements.

Cf. also Chapter 7.3.4.

7.6.4.1 Data sources

Cf. Chapter 7.1.3.2.

7.6.4.2 Biomass

Settlement and transport areas tend to have significant portions of unsealed land that is covered with vegetation. Representative-sample studies of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR), an institute sited within the Federal Office for Building and Regional Planning (BBR), have shown that built-over and sealed areas account for 40 – 50 % of designated settlement and transport areas (EINIG et al. 2009). In the German inventory, areas covered with vegetation are assumed to account for an average of 50 % of settlement areas.

No data have been collected specifically with regard to biomass and carbon stocks on such areas within Germany's settlement and transport areas. The following assumption is used as a way of compensating for that lack: half of all areas covered with vegetation consist of woods (trees and bushes) and half consist of green areas comparable to "grassland (in the narrower sense)". That assumption is approximately in keeping with the corresponding basic figures used in Switzerland. Via remote sensing, it was determined there that trees and bushes account for 47.4 % of plant cover, with trees accounting for 32.1 % and bushes accounting for 15.3 % (FOEN 2010). Since settlement and transport areas tend to have an enormous variety of trees and shrubs – including small-garden shrubs, many different types of hedges and large trees along roads and in forests – the tree/shrub biomass in this land-use category was determined on the basis of the country-specific value for woody grassland. The carbon stocks in settlement areas can then be calculated pursuant to Equation 41. The relevant results are shown in Table 259.

Equation 41:

$$C\ stocks_{settlements} = (C\ stocks_{woody\ grassland} * 0.5 + C\ stocks_{grassland\ (in\ the\ narrower\ sense)} * 0.5) * 0.5$$

Table 259: Area-related carbon stocks [Mg ha^{-1}] in biomass on settlement areas (range)

Settlements	**Carbon stocks [Mg C ha^{-1}]**		
	$Bio_{above-ground}$	**$Bio_{below-ground}$**	**Bio_{total}**
Settlements	9.91 (2.2 - 32.6)	3.44 (1.1 - 7.7)	13.35 (5.3 - 36.4)

7.6.4.3 Mineral soils

Cf. Chapters 7.1.5 and 19.5.2.

7.6.4.4 Organic soils

No data have been collected specifically with regard to drainage of organic soils in settlements. In compensation for that gap, it is assumed that such soils are drained in the same manner that cultivated grassland is drained, and thus the pertinent emission factor of 5 Mg C ha^{-1} a^{-1} is used (Chapter 7.4.4.4).

In cases involving land-use changes leading to settlements, the relevant value for settlements remaining settlements is used from the outset.

7.6.5 Uncertainties and time-series consistency (5. E)

The consistency of the time series is assured with regard to the activity data and emission factors.

The uncertainties for the emission factors are relatively high, and the values have a log-normal distribution (cf. Table 260). The uncertainties, as shown in Table 339 in Chapter 19.5.4, and depending on the area size concerned, range from 2.8% to 110.5 %. The total uncertainty for the activity data in the settlements category is 2.4 %. The emissions' contribution to the overall inventory is small. It is perceptible only with respect to organic soils and to biomass.

Table 260: Uncertainties of emission factors [in % of location scale] used for calculation of GG emissions from settlement and transport areas in 2010, broken down by pools and sub-categories

Settlements Land use$_{before}$ Mineral soils CO_2-C[82]	Area Land use$_{after}$	Emission factor [Mg C ha^{-1} a^{-1}]	Boundaries upper [%]	 lower [%]
Forest land	Settlements	-0.17	49	30
Cropland	Settlements	-0.07	49	28
Grassland (in the narrower sense)	Settlements	-0.94	57	33
Woody Grassland	Settlements	-0.73	60	31
Wetlands (terr.)	Settlements	-0.77	48	32
Waters	Settlements	0.00	85	45
Other land	Settlements	0.15	63	32
Organic soil		**[Mg C ha^{-1} a^{-1}]**	**[%]**	**[%]**
	Settlements	-5.00	50	50
Biomass[83]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	Settlements	-19.29	56	30
Cropland	Settlements	6.28	113	40
Grassland (in the narrower sense)	Settlements	6.66	115	41
Woody Grassland	Settlements	-33.35	158	55
Wetlands (terr.)	Settlements	-6.68	115	40
Waters	Settlements	13.35	173	60
Other land	Settlements	13.35	173	60
Dead organic matter[84]		**[Mg C ha^{-1} 1 a^{-1}]**	**[%]**	**[%]**
Forest land	**Settlements**	-21.97	35	56

7.6.6 Category-specific QA / QC and verification (5. E)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data sources used in preparation of this inventory fulfill the review criteria of the QSE manual for data sources (QSE-Handbuch für Datenquellen). Internally, data processing is checked via comparisons of cross sums. Quality assurance for input data (ATKIS®, BÜK, official statistics) is the responsibility of the relevant data administrators.

Table 261 compares Germany's implied emission factors, for the settlements category, with those of European neighbouring countries.

Only Germany and Switzerland report CO_2 emissions from drained organic soils in settlement areas. The implied emission factors are referenced to the total settlement land area. Consequently, they also reflect organic soils' share of that total area. In the German inventory, other C pools are calculated only in connection with land-use changes leading to settlements.

In a comparison with its neighbouring countries, Germany has the second-lowest (after France) C losses in mineral soils. Along with Austria, it has the highest level of C storage in biomass per hectare, in connection with conversions leading to settlement areas. In addition, Germany's IEF for dead organic matter lie within the lower section of the relevant range. The

[82] Calculation for 20-year period
[83] Calculation only for the first year following the pertinent land-use change
[84] Calculation only for the first year following the pertinent land-use change

implied emission factors for the three pools depend strongly on the original uses involved in each case, and thus the wide range seen throughout European countries cannot be interpreted without knowledge of such uses.

Table 261: Comparison of Germany's implied emission factors (IEF), for various settlement-sector pools, with those of European neighbouring countries

Implied emission factors (IEF), settlements, NIR 2009	Settlements remaining settlements	Land-use changes leading to settlements		
	Organic soils	soils	Biomass	Dead org. matter
		Mg C ha^{-1}		
Austria	NE	-0.472	0.225	-0.066
Belgium	NO	0.000	-0.159	NO
Czech Republic	NO	NA,NO	-0.395	-0.008
Denmark	NA	NA,NO	-0.214	-0.008
France	NO	-0.100	-0.470	-0.045
Netherlands	NE	NE	-5.084	-1.521
Poland	NA	-1.481	IE,NA	-0.051
Sweden	NE	-1.631	0.012	-0.882
Switzerland	-0.019	-1.102	-0.404	-0.054
UK	NO	-1.273	0.000	IE,NO
European Union (15)	-0.040	-0.852	-0.355	-0.099
European Union (27)	-0.028	-0.849	-0.393	-0.102
Germany, 2009	**-0.19**	**-0.398**	**0.191**	**-0.012**
Germany, 2010	**-0.19**	**-0.392**	**0.208**	**-0.012**

Positive: sink; negative: Source

7.6.7 Category-specific recalculations (5. E)

For this year's report, the data for the entire report period, 1990 – 2010, have been largely recalculated (and are so presented) to take account of the transition in the reporting system. For the first time, a time series for emissions in connection with dead organic matter, and as a result of deforestation, is being provided. With the methods changes, all the requirements that emerged from the 2010 in-country review have been implemented (Chapter 7.1.2).

The recalculation was required as a result of the change made in the procedure for determining the land-use-change matrix (cf. Chapter 7.1.3), and it was needed because a transition time of 20 years was used, for the first time, for the entire LULUCF sector. What is more, the calculation method for determination of emissions from mineral soils, resulting from land-use changes, was changed, and nearly all emission factors for the categories 5.B – 5.F (except those for organic soils) were changed. As a result of the numerous changes that have been made, the emissions as reported in 2011 cannot be compared directly with those as reported in 2012 (cf. Table 262 and Table 263).

Table 262: Comparison of emissions [Gg CO_2], as reported in 2012 and 2011, from settlements remaining settlements (5.E.1)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**1,964**	**1,964**	**1,964**	**1,964**	**1,964**	**1,964**	**1,964**	**1,963**	**1,963**	**1,963**
Total, 2011	**1,939**	**1,940**	**1,942**	**1,943**	**1,945**	**1,946**	**1,947**	**1,949**	**1,950**	**1,952**
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2011	0	0	0	0	0	0	0	0	0	0
Organic soils, 2012	1,964	1,964	1,964	1,964	1,964	1,964	1,964	1,963	1,963	1,963
Organic soils, 2011	1,799	1,800	1,802	1,803	1,805	1,806	1,807	1,809	1,810	1,812
Biomass, 2012	0	0	0	0	0	0	0	0	0	0
Biomass, 2011	140	140	140	140	140	140	140	140	140	140
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**1,963**	**1,965**	**1,966**	**1,968**	**1,970**	**1,972**	**1,979**	**1,987**	**1,994**	**2,005**
Total, 2011	**1,953**	**1,955**	**1,956**	**1,958**	**1,959**	**1,961**	**1,910**	**2,015**	**1,912**	**1,884**
Mineral soils, 2012	0	0	0	0	0	0	0	0	0	0
Mineral soils, 2011	0	0	0	0	0	0	0	0	0	0
Organic soils, 2012	1,963	1,965	1,966	1,968	1,970	1,972	1,979	1,987	1,994	2,005
Organic soils, 2011	1,813	1,815	1,816	1,818	1,819	1,821	1,739	1,752	1,805	1,856
Biomass, 2012	0	0	0	0	0	0	0	0	0	0
Biomass, 2011	140	140	140	140	140	140	171	263	107	28

Positive: emissions; negative: sink

Table 263: Comparison of emissions [Gg CO_2], as reported in 2012 and 2011, from land-use changes leading to settlements (5.E.2)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**787**	**803**	**775**	**822**	**797**	**810**	**826**	**834**	**828**	**842**
Total, 2011	**546**	**545**	**543**	**541**	**540**	**538**	**536**	**535**	**533**	**531**
Mineral soils, 2012	417	417	417	417	417	417	417	417	417	417
Mineral soils, 2011	0	0	0	0	0	0	0	0	0	0
Organic soils, 2012	456	456	456	456	456	456	456	456	456	456
Organic soils, 2011	2	2	2	2	2	2	2	2	2	2
Biomass, 2012	-276	-260	-289	-242	-268	-255	-240	-232	-238	-225
Biomass, 2011	544	543	541	539	538	536	534	533	531	529
Dead org. matter, 2012	190	190	191	191	192	192	193	193	193	194
Dead org. matter, 2011	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**834**	**-93**	**-160**	**-240**	**57**	**30**	**364**	**410**	**478**	**591**
Total, 2011	**530**	**528**	**493**	**492**	**490**	**488**	**111**	**96**	**154**	**395**
Mineral soils, 2012	417	441	465	489	513	538	552	567	582	583
Mineral soils, 2011	0	0	0	0	0	0	-96	-129	-60	-24
Organic soils, 2012	456	467	477	487	497	507	505	502	500	493
Organic soils, 2011	2	2	2	2	2	2	86	89	59	23
Biomass, 2012	-233	-1,083	-1,184	-1,298	-1,035	-1,097	-764	-731	-676	-517
Biomass, 2011	528	526	491	490	488	486	121	136	155	396
Dead org. matter, 2012	194	82	82	82	82	82	71	72	72	32
Dead org. matter, 2011	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE	NE/IE

Positive: emissions; negative: sink

7.6.8 Category-specific planned improvements (5. E)

Two pilot projects are currently underway for development of methods for determining wood biomass in settlements. The pilot projects are studying two German cities in this regard. In addition, plans also call for Validation of area data for 1990 (cf. Chapter 7.2.8.1, 1. para.)

7.7 Other land (5.F)

7.7.1 Source category description (5. F)

Since, by definition, the areas in the category "other land" consist of areas that are not cultivated, the sizes of such areas are included solely for the purpose of completing the area matrix. Emissions within the meaning of IPCC LULUCF cannot occur on such areas. Therefore, no such emissions are reported.

7.7.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation (5.F)

Cf. Chapter 7.1.3.

7.7.3 Land-use definitions and the classification systems used and their correspondence to the LULUCF categories (5.F)

The following object types defined in ATKIS® are assigned to the "Other land" category within the German LULUCF report system: "area currently not classifiable" (object number 4199), and "vegetation-free areas" (object number 4120). Areas are identified and classified in keeping with the algorithms described in Chapter 7.1.4.

7.7.4 Methodological issues (5. F)

In emissions calculation, Other Land areas are taken into account solely as a "before" category in connection with land-use changes leading to other categories. No conversions back to "Other Land" take place, since, by definition, land that has been used once can no longer be returned to an "unused land" land-use category.

The carbon stocks in biomass, dead wood and dead organic matter of Other Land are "zero".

The carbon stocks in mineral soils of Other Land are listed in Chapters 7.1.5 and 19.5.2.

Organic soils in Other Land are not drained.

7.7.5 Uncertainties and time-series consistency (5. F)

The uncertainties for emission factors and activity data were determined in accordance with the publication Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000) (cf. Chapter 19.5.4).

The time series is complete and consistent.

7.7.6 Category-specific QA / QC and verification (5. F)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

7.7.7 Category-specific recalculations (5. F)

Not applicable, since no greenhouse-gas sources and sinks are reported in this category.

7.7.8 Category-specific planned improvements (5. F)

Not applicable, since no greenhouse-gas sources and sinks are reported in this category.

7.8 Other sectors (5.G.)

The following emissions are reported under 5.G:

- CO_2 emissions from liming of forest soils (cf. Chapter 7.2.4.6.1), since the CRF Reporter allows only reporting of agricultural lime fertilisation.

8 WASTE AND WASTE WATER (CRF SECTOR 6)

8.1 Overview (CRF Sector 6)

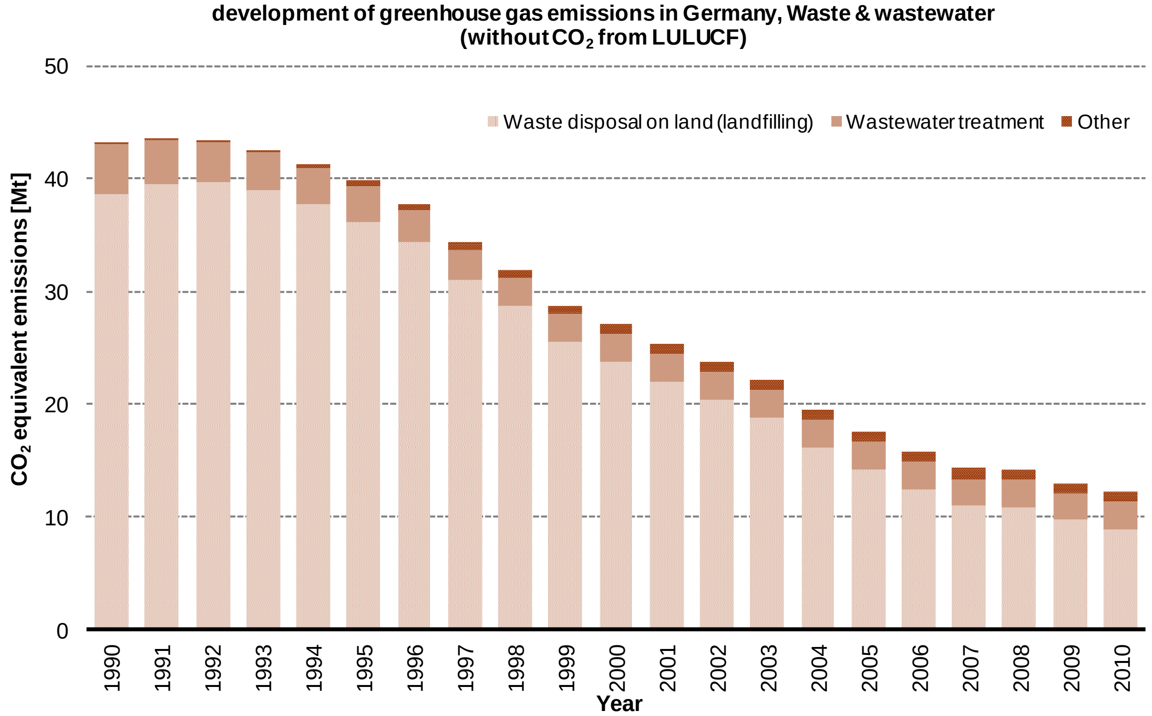


Figure 67: Overview of greenhouse-gas emissions in CRF Sector 6

8.2 Solid waste disposal on land (6.A)

CRF 6.A	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Solid waste disposal on land (managed) (CRF 6.A.1)	**CH_4**	**L**	**T/T2**	**38,598.0**	**(3.16%)**	**8,967.0**	**(0.94%)**	**-76.77%**

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 2	NS	CS/D

The source category *Solid waste disposal on land* is a key category of CH_4 emissions in terms of emissions level and trend.

Only managed disposal in landfills (6.A.1) is relevant for purposes of German emissions reporting under CRF 6.A. "Wild" or illegal dumping of solid waste (CRF 6.A.2) is prohibited by law in Germany.

In light of the growing importance of other methods for treating biodegradable waste fractions, emissions from composting and from mechanical-biological waste treatment have been reported since 2004. These emissions are reported under category 6.D Other.

In the CSE, source category 6.A Solid waste disposal on land includes landfilled household waste and sewage sludge.

8.2.1 Managed disposal in landfills – landfilling of municipal waste (6.A.1)

8.2.1.1 Source category description (6.A.1)

In the period since 1990 (and previously, to some extent), a number of legal provisions have been issued pertaining to Germany's waste-management sector, and a number of relevant organisational measures have been initiated. These moves have had a strong impact on trends in emissions from waste-landfilling. Relevant developments have included intensified collection of biodegradable waste from households and the commercial sector, intensified collection of other recyclable materials, such as glass, paper/cardboard, metals and plastics; separate collection of packaging; and recycling of packaging. In addition, incineration of municipal waste has been expanded, and mechanical-biological treatment of residual waste has been introduced. As a result of such measures, amounts of landfilled municipal waste decreased nearly to zero from 1990 to 2006 (cf. Figure 68). As the figure shows, over half of municipal waste produced in Germany today is collected separately and gleaned for recyclable materials (separate collection of recyclable materials and biodegradable waste). Official statistical data (*STATISTISCHES BUNDESAMT* Fachserie 19, Reihe 1 Abfallentsorgung 2009 ("Waste management, 2009") of 22 July 2011) are available for the period until 2009. In keeping with the drastic reduction in landfilling after 2005, linear extrapolation was carried out on the basis of the data for the years 2006 through 2009. A similar procedure was applied for source category 6.D.

In 2004, about 330 landfills for municipal waste were in operation in the Federal Republic of Germany. By that year, strict legal regulations were already in place that require such landfills to have equipment for collecting and treating landfill gas. Those regulations have extensively reduced methane emissions from such facilities. In June 2005, in keeping with new, stricter requirements under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Kitchen-Waste-Treatment Facilities (AbfAblV) and the Landfill Ordinance (Deponieverordnung), over half of all landfills were closed. As a result, only about 150 landfills for municipal waste are now still in operation. As a result of regulations in force since June 2005, landfilling of biodegradable waste is no longer permitted. As a result, since June 2005 it has no longer been possible to landfill waste with the potential for significant methane formation. For conformance with pertinent requirements, municipal waste and other biodegradable waste must be pre-treated via thermal or mechanical-biological processes. In waste landfilled after 2006, just a few waste components, with very small methane-formation potential (such as residues from treatment in MBT facilities; small wood fractions in construction rubble) have contributed to landfill-gas formation. As landfill-gas formation in older landfills drops off, methane emissions from landfills will again decrease extensively and will then, in the long term, stabilise at a very low level.

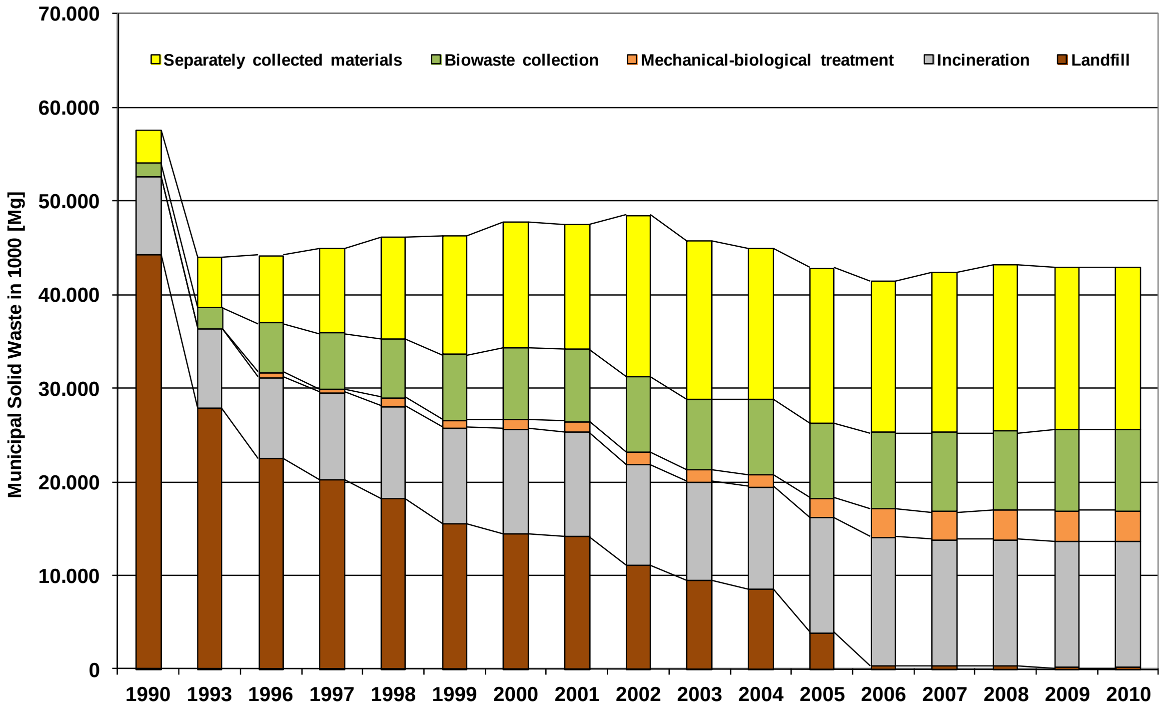


Figure 68: Changes in pathways for management of household waste, 1990 to 2010, with intermediate years

By reducing landfill methane emissions from 1.8 million Mg in 1990 to 0.4 million Mg in 2010, Germany's waste-management sector has made an important contribution to climate protection. The lower methane emissions from source category 6.A.1 amount to a decrease of 30 million tonnes of CO_2 equivalents per year and, thus, to a 3 % reduction of Germany's entire greenhouse-gas emissions. Experience gained by Germany's waste-management sector shows that reductions of landfilled quantities of biodegradable waste can provide significantly higher contributions to climate protection than can collection and treatment of landfill gas.

8.2.1.2 Methodological issues (6.A.1)

The *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 1996b) specify two methods for determining methane emissions from landfills, a default method (Tier 1), known as the "mass-balance approach", and the "first order decay method" (short name: "FOD method" or "Tier 2"). Whereas the default method functions under the assumption that methane from waste forms completely in the year in which the waste is placed in a landfill, the FOD method uses a kinetic approach that describes methane formation, more realistically, as taking place over several years.

There are at least two reasons why the Tier 1 method is inadequate for determining emissions in Germany:

IPCC *Good Practice Guidance* (IPCC, 2000) specifies that the first order decay method should be used when source category 6.A is a key category. At present, this source category is a key category in Germany in terms of emissions levels and trend.

The default method tends to underestimate emissions especially when quantities of waste being placed in landfills are decreasing, and this is occurring in Germany. For these reasons, in the following section, CH_4 emissions were calculated with the FOD method (Tier 2).

The following section describes the FOD method, and the relevant parameters used, for determining methane formation in landfills. The FOD method calculates in accordance with Equation 42:[85]

Equation 42: *(IPCC 2000 Good Practice Guidance, Chapter 5.1)*

$$CH_4 \ produced \ in \ year \ t \ (Gg / year) = \sum_x [(A * k * MSW_T(x) * MSW_F(x) * L_0(x) * e^{-k(t-x)}]$$

$$where: L_0(GgCH_4 / kgWaste) = MCF * DOC * DOC_F * F * 16/12$$

$$for \ x = first \ year \ to \ t$$

where:

t	*= Inventory year*
x	*= Year as of which the consideration begins and quantities data are collected*
MSW_T (x)	*= Total quantity of municipal waste*
MSW_F (x	*= Portion of waste that is landfilled*
A	*= $(1-e^{-k})/k$ = Normalisation factor for sum correction*
k	*= Constant methane-formation rate (1/year)*
L_0	*= Methane-formation potential*
MCF (x)	*= Methane correction factor for year x*
DOC (x)	*= Degradable organic carbon in year x (relevant share)*
DOC_F	*= Fraction of DOC converted into landfill gas*
F	*= Fraction of CH_4 in landfill gas*
16/12	*= Factor for conversion of C to CH_4*

A multi-phase model was used that calculates with, and then sums, a range of different half-lives for the various waste fractions involved, pursuant to Equation 42.

To obtain the final CH_4-emissions result, methane that is collected and then flared, or then used for energy recovery, is deducted, and a correction factor is applied that accounts for methane oxidation in landfill covering layers, as shown by Equation 43:

Equation 43 *(IPCC Guidelines, Equation 5.1)*:

$$CH_4 \text{ emitted in year t (Gg/year)} = (CH_4 \text{ produced in year t} - R(t)) \bullet (1- OX)$$

Where

R(t)	= CH_4 collection in year t
OX	= Oxidation factor (fraction)

For both Tier 1 and Tier 2, the relevant quantities of municipal waste (MSW_T), and the proportion of municipal waste that is landfilled (MSW_F), must be determined; for Tier 2, production of municipal waste over the previous decades must also be determined. Pursuant to IPCC Good Practice Guidance (2000), landfilled municipal waste should be broken down – via estimation – into waste types, since the further procedure takes account of the fact that different waste types have different DOC values.

85 A detailed description of the FOD method and its parameters is presented in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, in the Greenhouse Gas Inventory Reference Manual, known as the "IPCC Guidelines" (IPCC 1996b), and in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, known as the "Good Practice Guidance" (IPCC 2000).

8.2.1.2.1 Quantities of landfilled waste

The FOD model calculates emissions from landfilled municipal waste, landfilled industrial waste and landfilled sewage sludge.

Pertinent quantities of landifilled municipal waste (household and commercial waste) are taken from relevant statistics of the Federal Statistical Office, which are based on annual surveys of waste types, origins and final destinations, as well as on surveys taken of waste-storage facilities, every two years, that focus on specific equipment of the facilities. The surveys of landfilled quantities of municipal waste in the old German Länder commenced in 1975, on the basis of the Environmental Statistics Act of 1974. Waste quantities for the period from 1950 to 1975 were extrapolated on the basis of population data.

For the new German Länder, data on landfilled quantities of municipal waste, differentiated by Länder, is available for the years 1990 and 1993. For the 1980s in the former GDR, LALE (2000) has presented data that provide information about per-capita landfilled quantities of waste, waste composition, landfill types and types of waste storage involved. The per-capita quantities of landfilled waste in the former GDR, at 190 kg/person, were considerably lower than the corresponding quantities in the old German Länder (330 kg / person and year). This has to do with the fact that larger percentages of waste were recycled in the former GDR. In 1990, the year of German reunification, landfilled quantities of waste increased sharply in the new German Länder, to the extent that the relevant per-capita quantities even outstripped the corresponding quantities in the old German Länder. The reasons for this were that the former GDR's recycling systems collapsed in that year and that a flood of new products suddenly became available, leading to high levels of replacement purchases and to sharply increasing quantities of packaging waste. Since 1990, per-capita waste quantities in both parts of Germany have slowly been moving into alignment. In the former GDR, all non-recycled waste quantities were landfilled.

Since 1996, the Federal Statistical Office has published differentiated data on waste-landfilling by industry. The relevant inventory takes account of the landfilled waste quantities from industrial sectors as follows:

- Waste from agriculture, horticulture, forestry, fisheries and food processing
- Waste from wood processing
- Waste from production of pulp, paper and carton
- Waste from the textile industry
- Packaging waste
- Wood fractions in construction and demolition waste (data since 1975)

The quantities of industrial waste landfilled between 1975 and 1996 were derived on the basis of total quantities of landfilled waste. While the total quantities include industrial waste, the total-waste figures are not broken down to show industrial waste separately. Extrapolations between waste production and production data of relevant sectors, for the 1996-2002 period, produced no satisfactory statistical relationships. While production figures increased, waste-production figures decreased – considerably, in part – as a result of changes in production processes. Due to the lack of statistical relationships, the figures for landfilled waste quantities were kept constant for the period between 1950 and 1975. Changes in assumptions relative to industrial waste in the 1950-1970 period have only a very marginal effect on emissions in the base year.

Data on landfilling of sewage sludges from public and industrial wastewater treatment is available for the old German Länder for the period since 1975. Those data have been extrapolated via population data (public wastewater treatment), under the assumption that quantities of sewage sludge (industrial waste) remained constant. Here as well, changes in assumptions regarding industrial quantities for the 1950-1970 period have only slight impacts on base-year emissions, because the half-life for sewage-sludge decomposition in landfills is short – four years.

8.2.1.2.2 Waste composition

For purposes of inventory calculation, numerous studies on waste composition were evaluated to determine historical trends in waste fractions. In the years 1980 and 1985, waste composition was determined for the entire territory of the former Federal Republic of Germany (UBA 1983, 1986). For the subsequent period, a large number of individual studies exists – studies carried out by individual cities, administrative districts and Länder. Some of these had already been evaluated and combined within overarching studies. The pertinent figures were used to obtain time series for waste composition for the period between 1980 and 2005 (cf. Figure 69). Such evaluation of existing studies was carried out for household waste, household-like commercial waste and for bulky waste, categories that are listed separately in national statistics. As to waste composition in the new German Länder, the figures provided by LALE (2000) for the 1980s in the former GDR were adopted (composition of household waste: 28 % vegetable waste, 14 % paper/cardboard, 2.3 % wood, rubber, composites, 3 % textiles; household waste accounted for only 16 % of total landfilled waste quantities, however). Quantities of municipal waste landfilled in the former GDR contain smaller fractions of biodegradable materials and large inorganic fractions (primarily ash from household combustion systems). Food waste was collected and used as feed; feeds tended to be scarce during certain periods of time. Paper was collected; it was also a scarce resource. Wood and paper were often burned in ovens for purposes of heating and cooking. The "SERO" recycling system efficiently collected the country's relatively small fractions of plastic packaging. Deposit systems were operated for glass, and glass was also collected. All in all, the former GDR's economy was subject to scarcities of resources, and this led to efficient waste recycling. Ash from household combustion systems accounted for large fractions of landfilled quantities of household waste.

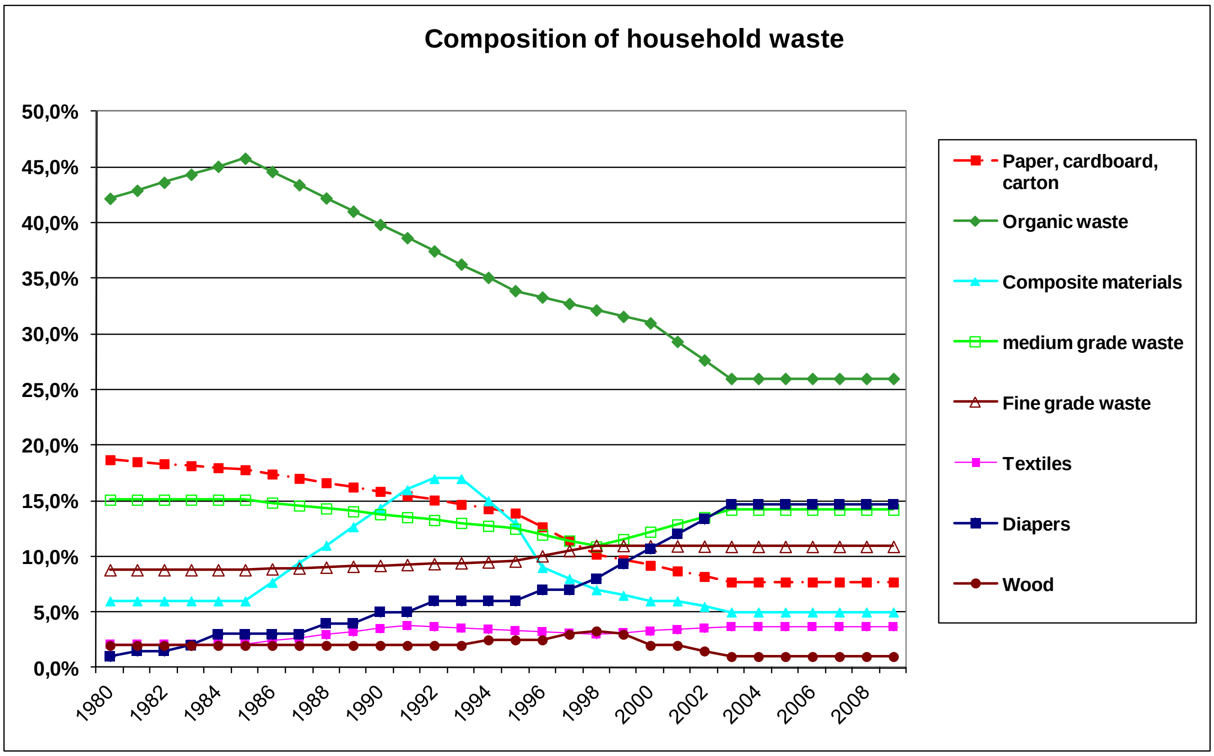


Figure 69: Trends in waste composition (old German Länder) between 1980 and 2009

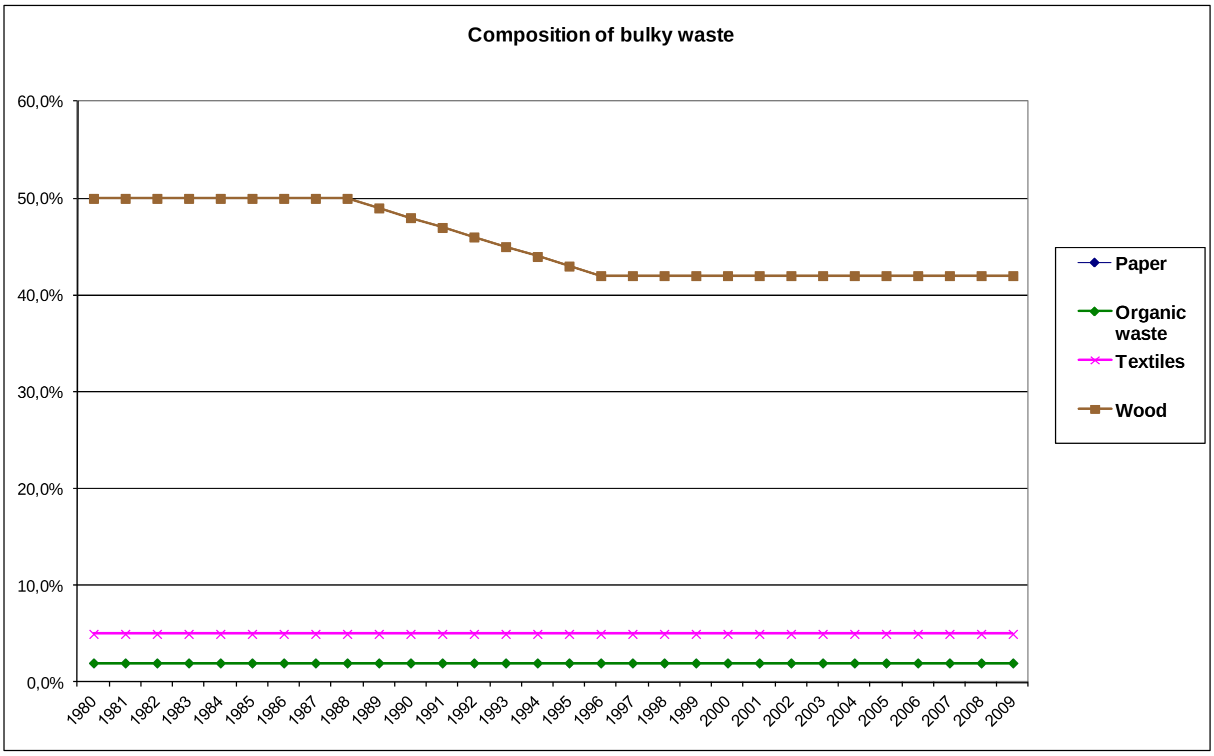


Figure 70: Trends in bulky-waste composition (old German Länder) between 1980 and 2009

Since 1 June 2005 only waste with a total carbon content < 3 %, and mechanically and biologically treated municipal waste, may be landfilled in Germany. Since that time, landfilled waste quantities have decreased very sharply and now make only very small contributions to gas formation. Table 264 outlines the development of quantities of landfilled biodegradable waste.

Table 264: Quantities of biodegradable waste landfilled between 2002 and 2010, broken down by waste fractions

Waste fraction	Units	2002	2003	2004	2005	2006	2007	2008	2009	2010
Organic	1000 t	2,050	2,227	1,667	785	1	0	0	0	0
Garden and park waste	1000 t	186	137	211	160	94	116	134	98	98
Paper	1000 t	1,448	1,515	995	499	26	12	9	3	3
Textiles	1000 t	336	376	293	135	5	3	2	1	3
Wood	1000 t	687	529	438	199	20	24	18	13	13
Diapers	1000 t	920	1,215	906	429	0	0	0	0	0
Diapers + textiles	1000 t	1,256	1,592	1,199	564	5	3	2	1	1
Composite materials	1000 t	379	414	309	146	7	5	4	2	2
Sewage sludge	1000 t TM	413	398	348	634	130	129	133	661	661
Output from MBT facilities	1000 t	0	0	743	1,092	665	545	616	647	647

During the 2010 inventory review, the review team requested that CH_4 emissions from landfilled MBT residues also be included in calculation of emissions from landfilling. While that fraction has now been included, there is no unambiguous method for that waste category, nor are there suitable national parameters for it. Furthermore, no results have yet been obtained with regard to the behaviour of landfilled waste from MBT facilities (i.e. behaviour in real landfills). Only laboratory results have been obtained to date, and thus the results in this area are subject to very high levels of uncertainty. The actual emissions from landfilled waste from MBT facilities are likely to be considerably lower than such laboratory emissions.

In keeping with the recommendations provided in the inventory review 2010 (paragraph 146, FCCC/ARR/2010/DEU), additional information is provided in this regard as of the 2011 report. Table 265 shows the per-capita waste quantities landfilled, per day, between 1990 and 2010. Those values do not represent the per-capita waste-production rate that is to be reported, as additional information, in the CRF tables. That figure comprises total waste consumption, taking all waste-management pathways into account. It will be calculated for the next report.

In Germany, landfilling of municipal waste has decreased very sharply since 2005, and that trend is also reflected in the per-capita rate.

Table 265: Per-capita quantities of landfilled household waste

	Units	1990	1995	2000	2001	2002	2003	2004
Per-capita quantities of landfilled household waste	kg/capita/day	1.389	0.655	0.284	0.327	0.211	0.226	0.196
	Units	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	
Per-capita quantities of landfilled household waste	kg/capita/day	0.135	0.031	0.027	0.030	0.048	0.048	

8.2.1.2.3 MCF (methane-correction factor)

Until 1972, when the first Waste Act was introduced, waste was usually stored in uncontrolled landfills; such landfills were closed after 1972. After 1972, waste was stored in managed landfills. In keeping with this history, a default MCF value of 0.6 was used for "unclassified landfills" ("nicht zugeordnete Deponien"), while an MCF of 1 was used after 1972.

Data are available from a 1989 survey of the territory of the former GDR that covered 120 managed landfills, some 1,000 controlled storage sites and some 10,000 uncontrolled dump sites (MNUW, 1990). Of the some 13,000 waste-storage sites, a total of 11,000 were for household waste and 2,000 were for industrial waste; most of the latter were plant-owned facilities (BMU, 1990: p. 28). Consequently, an MCF of 0.6 (default value for unclassified landfills) was assumed for the territory of the former GDR for the period 1970 to 1990. Upon German reunification, the Federal Republic of Germany's waste laws were extended to the territory of the new German Länder, and transitional regulations were introduced to ensure that facilities – including both decommissioned facilities and still-operational facilities in which waste was (or is) produced or disposed of – were accounted for and that suitable clean-up measures were initiated (BMU, 1990: p. 46). Uncontrolled landfills were closed in 1990, facilities permitted to remain open were secured, cleaned up and modernised/expanded in keeping with the standards of Federal German waste law, and sites for new facilities were sought. As of 1990, the Federal Statistical Office has collected statistics on both parts of Germany. For purposes of calculation for the period after 1990, an MCF of 1 is used for all of Germany's territory.

8.2.1.2.4 DOC

Both national data and IPCC default factors are used for DOC, the proportion of degradable organic carbon in waste. Table 266 below provides an overview of the DOC values used.

Table 266: DOC values used

Fraction	DOC	Source
Organic	18%	Various national studies show DOC levels that are higher than the IPCC default value
Garden and park waste	20%	National value
Paper and cardboard	40%	IPCC default
Wood and straw	43%	The national value is somewhat higher than the IPCC default
Textiles	24%	National value
Diapers	24%	National value
Composite materials	10%	National value
Sewage sludge	50%	IPCC default value for sewage sludge, referenced to dry weight
Waste from MBT facilities	2.3%	National value

8.2.1.2.5 DOC_F

DOC_F, the DOC fraction that can be converted into landfill gas, is put at 50 % for municipal waste, on the basis of a national study (RETTENBERGER et al, 1997: p. 277). That value lies within the IPCC default range of 0.5-0.6.

8.2.1.2.6 F = Fraction of CH_4 in landfill gas

A value of 50%, the mean value in the IPCC default-value range, is assumed for F. That value is based on data of the Federal Statistical Office for the years 2004, 2006 and 2008 (STATISTISCHES BUNDESAMT, Fachserie 19 Reihe 1).

8.2.1.2.7 Half-life

The calculation model is a multi-phase model that takes account of the different half-lives of different waste fractions. Table 267 shows the half-lives and the methane-formation rate used for the pertinent waste fractions. For conformance with the recommendations provided in the inventory review 2010 (paragraph 146, FCCC/ARR/2010/DEU), additional information has been provided for reporting as of 2011. The constant methane-production rate that appears in the FOD method corresponds to the time required for biodegradable organic carbon in waste to decompose to the point at which it has lost half of its original mass. It thus can be derived from the half-lives of the various relevant fractions, in keeping with Equation 44.

Equation 44: (IPCC 2000 Good Practice Guidance, Chapter 5.1.1.2)

$$k = \ln 2 / t_{1/2}$$

Since the constant methane-production rates, and the half-lives, of the relevant individual waste types are considered separately, in the CRF table "Table6.A,C" the notation key "IE" was used, instead of a universal value.

Table 267: Half-lives and constant methane-formation rates of waste fractions

Type of waste	Half-life (years)	CH_4-formation rate (k value)
Food waste	4	0.173
Garden/park waste	7	0.099
Paper / cardboard	12	0.058
Wood	23	0.030
Textiles / diapers	12	0.058
Composite materials	12	0.058
Sewage sludge	4	0.173
Waste from MBT facilities	12	0.058

8.2.1.2.8 Landfill-gas use

The "TA Siedlungsabfall" of 1993[86] made gas collection one of the prerequisites for licensing of landfills for municipal waste. The amended version of the Environmental Statistics Act (UStatG) of 2005 mandates that in future the Federal Statistical Office, in its surveys, is to take account of, and publish, levels of landfill-gas collection. For the years 2004, 2006 and 2008, data on landfill-gas collection and use were published in Fachserie 19 of 22 July 2011. No recent data on landfill gas are available for 2009 and 2010. For that reason, the methane quantity collected and used in those years was considered to be unchanged from 2008. Those data were collected only from landfills in the landfilling and decommissioning phases, however. To date, such surveys have not taken account of landfills in their after-closure phases.

Use of landfill gas for energy recovery is recorded and reported by the energy sector. Such data include only the energy quantities supplied by landfill operators to third parties, data from which the relevant methane used is calculated after the fact. Landfills' own consumption of energy from landfill-gas collection, at the pertinent landfill sites, and the methane burned in flare systems, without energy use, are not taken into account.

For determination of total quantities of landfill gas collected, it was necessary to combine data from the energy sector and from Fachserie 19. The listed quantity of collected landfill gas includes the landfill gas used for external energy provision, for all landfills; landfills' own consumption of collected gas; and gas quantities flared by landfills in landfilling and decommissioning phases. Landfills' own consumption and flaring losses during their after-closure phases – when landfills have very high landfill-gas-collection rates, because they have surface-sealing covers in place – cannot be quantified at present and taken into account as emissions reductions.

86 Technical instructions on recycling, treatment and other management of municipal waste (Third general administrative provision on the Waste Act (Abfallgesetz)) of 14 May 1993

Table 268: Methane collection in landfills

	Units	2000	2001	2002	2003	2004	2005
Landfill-gas use for public electricity generation, in keeping with energy data	TJ	9,704	9,588	9,472	9,356	11,970	13,238
Collected landfill gas	Millions of m^3	571	564	557	550	704	779
CH_4 quantity used for electricity generation	Gg CH_4	205	202	200	198	253	280
Flared quantities of landfill gas, pursuant to waste statistics	Millions of m^3	70	70	70	70	70	53
Flared quantities of CH_4	Gg CH_4	25	25	25	25	25	19
Landfills' own use of landfill gas, for electricity / heat, pursuant to data from waste statistics	Millions of m^3	341	358	375	392	409	414
CH_4 quantities used for own requirements	Gg CH_4	122	129	135	141	147	149
Total quantity of collected CH_4	Gg CH_4	352	356	360	363	425	447
	Units	**2006**	**2007**	**2008**	**2009**	**2010**	
Landfill-gas use for public electricity generation, in keeping with energy data	TJ	14,007	14,458	12,213	11,451	10,879	
Collected landfill gas	Millions of m3	824	850	718	674	640	
CH_4 quantity used for electricity generation	Gg CH4	296	305	258	242	230	
Flared quantities of landfill gas, pursuant to waste statistics	Millions of m3	37	29	21	21	21	
Flared quantities of CH_4	Gg CH4	13	10	7	7	7	
Landfills' own use of landfill gas, for electricity / heat, pursuant to data from waste statistics	Millions of m3	420	361	302	302	302	
CH_4 quantities used for own requirements	Gg CH4	151	130	108	108	108	
Total quantity of collected CH_4	Gg CH4	460	445	374	358	346	

8.2.1.2.9 Oxidation factor

As to the factor determining the proportion of CH_4 that is oxidised in landfill covering layers, the IPCC default value of 0.1 was assumed for the entire time series. On the one hand, a larger proportion of uncontrolled landfills can be expected in the former GDR in the early 1990s; on the other hand, a research project found only a low CH_4-formation potential for landfills of the former GDR, and thus the factor 0.1 was also used for that period (BMBF, 1997).

8.2.1.3 Uncertainties and time-series consistency (6.A.1)

The method's uncertainties were estimated for the first time for the NIR 2006. The results of this experts' assessment are presented in the Annex, Chapter 19.6.1.1.

Over the long, 30-year period covered by the activity data, inconsistencies in the time series are unavoidable, since the pertinent waste categories and survey methods changed several times as a result of improvements in legislation and waste statistics. In Germany, special problems arise especially via German reunification and the resulting merging of two different economic and statistical systems. For this reason, considerable effort has to be invested in reviewing data consistency and allocations to the reported categories, in the interest of making time series as consistent as possible.

8.2.1.4 Source-specific quality assurance / control and verification (6.A.1)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The selected parameters were compared with relevant data for other countries.

The per-capita rate for landfilling of municipal waste (Table 265) was compared with the default value in the Revised 1996 IPCC Guidelines (Table 6-1 in Chapter 6.2.4). For 1995, the default value is in line with the national value. In subsequent years, the national values decreased considerably – and, after 2005, drastically. Those decreases were caused by implementation, in June 2005, of the extensive requirements applying under the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (Abfallablagerungsverordnung) and the Landfill Ordinance (Deponieverordnung).

In the area of landfill-gas use, various national data sources were compared and a consistent, conservative approach was selected.

In entry of data, the correctness of entries was checked via sum values – various waste categories were recorded solely for the purpose of checking correctness of data entry.

The national calculation model used to date was reviewed via the IPCC's FOD model – i.e. by entering the same pertinent parameters and data into that FOD model. The same result was obtained.

8.2.1.5 Source-specific recalculations (6.A.1)

Recalculations were required for 2008 and 2009, since more-reliable energy data are now available for those years that can be used for calculation of landfill-gas collection. Furthermore, as the NIR 2011 was being prepared, data on landfilled waste quantities were available only up to 2008. Therefore, the emissions of the year 2009 were recalculated with the more recent data published in Fachserie 19 of 22 July 2011.

Table 269: Changes via recalculations in CRF 6.A.1

Reporting		2008	2009	2010
NIR 2011	Methane formation [Gg/year]	943	869	---
	Methane collection [Gg/year]	421	421	---
	Methane emissions [Gg/year]	**470**	**403**	**---**
NIR 2012	Methane formation [Gg/year]	943	874	821
	Methane collection [Gg/year]	374	358	347
	Methane emissions [Gg/year]	**518**	**464**	**427**

8.2.1.6 Planned improvements (6.A.1)

An experts' assessment (Wasteconsult international, 2009) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. The assessment confirms that emissions contributions of MBT systems' waste are very low in comparison to total landfill-gas emissions. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. The kinetics of landfill-gas formation in MBT waste are to be examined, in a further study, and then described in an improved model. The results of the study are to be used to describe, more precisely, and quantify the expected methane emissions from MBT waste, so that the emissions values derived via expert assessment in the aforementioned study (WASTECONSULT INTERNATIONAL, 2009) can be replaced with the improved data. The study was awarded in October 2011 in the framework of a public invitation to tender.

In future, the Federal Statistical Office plans to collect data on landfill-gas collection and use also from landfills in their after-closure phases. It is expected that in 2012 environmental statistics will include, for the first time, data on landfill-gas collection that have been collected in a consistent manner, from all relevant landfills.

8.3 Wastewater handling (6.B)

CRF 6.B	Natural gas		Key category (source)	1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Domestic and Commercial Wastewater	**CH_4**	**-**	**T/-**	**2,226.2**	**(0.18%)**	**70.9**	**(0.01%)**	**-96.81%**
Domestic and Commercial Wastewater	N_2O	-	-/T2	2,223.5	(0.18%)	2,302.5	(0.24%)	3.55%

The source category *Wastewater handling* is a key category of CO_4 emissions in terms of trend (cf. Table 7). Because relevant emissions have fallen sharply since 1990 (-96.81 %), and thus an extremely low emissions level has been attained (in 2010, emissions amounted to 2.0 % of the contribution of the smallest key category identified via the level procedure), the Single National Entity has decided, as part of its resources prioritisation, not to apply the more stringent methods to this source category that are required for key categories.

Under source category 6.B Wastewater handling (treatment), the CSE includes wastewater quantities, treatment of sewage sludge and sewage-sludge production in wastewater treatment.

8.3.1 Methane emissions from industrial wastewater and sludge treatment (6.B.1)

8.3.1.1 Source category description (6.B.1)

Gas	Method used	Source for the activity data	Emission factors used
CO_2, N_2O	NA	NA	NA

The source category "Methane emissions from industrial wastewater and sludge treatment" (6.B.1) is a key category only via the aggregated source category Wastewater handling (6.B). No calculations for this source category are carried out at present.

In its Fachserie 19 Reihe 2.2 (STATISTISCHES BUNDESAMT: 2010e, 2010f), the Federal Statistical Office provides data on wastewaster quantities and on the structure of the wastewater sector. About 75 % of the wastewater is coolant water that is not subjected to further treatment. About 96 % of the non-coolant water is biologically treated (aerobically and/or anaerobically). Municipal wastewater treatment facilities treat more than 65 % of the industrial wastewater that is treated; the remainder is treated in the industrial producers' own facilities.

The following table shows the industrial sectors of importance with regard to wastewater production. The sectors listed account for 95 % of the industrial wastewater produced.

Table 270: Direct discharged wastewater, with treatment, pursuant to [Statistisches Bundesamt 2010c, Table 8.8]

Production area	Millions of m³ of wastewater
Production of chemical products	310
Production of paper and cardboard	234
Energy production and distribution	149
Production of iron, steel and ferroalloys	74
Production of food, feed and drink	65
Production of coking-plant products, petroleum products and fissile and fertile materials	31
Extraction of non-metallic minerals; other mining products	29
Other	32
Total	**924**

The composition of industrial wastewater, in contrast to that of household wastewater, varies greatly; it varies by industrial sector. For different sectors, different parameters COB and BOB_5 apply; the relationships nitrogen : phosphorous (N:P) and nitrogen : phosphorous : sulphur (N:P:S) are significant. The possible ranges for COB are given in IPCC 2006c. The ranges given in that source only partly reflect the situation in Germany, however.

In Germany, the biological stage of industrial wastewater treatment is partly aerobic and partly anaerobic. The Federal Statistical Office (STATISTISCHES BUNDESAMT: Fachserie 19, Reihe 2.2) describes the applicable treatment percentages for biological wastewater treatment facilities in industry, but it does not take account of different treatment techniques, such as "aerobic" and "anaerobic". Anaerobic wastewater treatment is especially useful for industries whose wastewater has high levels of organic loads. That treatment method has the advantages that it does not require large amounts of oxygen, produces considerably smaller amounts of sludge requiring disposal and generates methane that can be used for energy recovery. Pursuant to KORRESPONDENZ ABWASSER, ABFALL 2009 (p. 1147 ff), some 205 anaerobically operating facilities are in operation in Germany's industrial sector – most of them are in service in the food-production and paper/cardboard- production sectors (as of 2008), however. Additional anaerobically operating facilities are appearing only slowly.

As in treatment of municipal wastewater, treatment of industrial wastewater releases no methane emissions into the environment.

Owing to the applicable biological principles involved, aerobic procedures produce no methane emissions. Methane occurs only in anaerobic cleansing of industrial wastewater. At the same time, the methane emissions are negligible, since all of the anaerobic wastewater treatment facilities in operation in Germany function as closed systems. The methane they produce is collected and used for energy generation. In addition, the facilities are equipped with gas flares for added safety. Methane emissions into the environment are thus prevented. Emissions occur only in cases of malfunction. No information on leakage rates is available.

Use for energy recovery is reported under CRF 1.A.1. In both treatment methods, no significant amounts of methane emissions are released into the environment.

Industrial sludge treatment and stabilisation, like industrial wastewater treatment, is carried out either aerobically or anaerobically with methane-gas use.

8.3.2 Municipal wastewater treatment (6.B.2)

8.3.2.1 Methane emissions from municipal wastewater treatment (6.B.2 wastewater treatment)

8.3.2.1.1 Source category description (6.B.2 wastewater treatment)

Gas	Method used	Source for the activity data	Emission factors used
CO_2	NA	NA	NA
CH_4	D/CS	NS	D/CS
N_2O	D	NS	D/CS

The source category Municipal wastewater treatment is a key category.

Municipal wastewater treatment in Germany – like that in Sweden and Denmark – uses aerobic procedures (municipal wastewater-treatment facilities, small wastewater-treatment facilities), i.e. it produces no methane emissions (default value for MCF = 0), since such emissions occur only under anaerobic conditions.

Treatment of human sewage from persons not connected to sewage networks or small wastewater-treatment facilities represents an exception: in cesspools and septic tanks, uncontrolled processes (partly aerobic, partly anaerobic) can occur that lead to methane formation. Since 1990, however, organic loads discharged into cesspools and septic tanks have been drastically reduced; the percentages of inhabitants connected to small wastewater-treatment facilities have continually increased. As a result, this sector's CH_4 emissions show a sharply decreasing trend.

8.3.2.1.2 Methodological issues (6.B.2 wastewater treatment)

Organic loads from cesspools and septic tanks are calculated pursuant to the IPCC method, in which the relevant population is multiplied by the average organic load per person. The average organic load is assumed to be 60 g BOD_5 per inhabitant. On the one hand, that value is the IPCC default value (IPCC Guidelines for National Greenhouse Gas Inventories 2006, Chapter 6: Wastewater Treatment and Discharge, Table 6.4). On the other hand, that value is used in Germany and throughout Europe as a statistical mean (EC OJ, L 135/40 , 30 p. 91, Article 2 No 6).

Methane emissions from cesspools and septic tanks are determined in keeping with the IPCC method. The IPCC default value for potential methane formation (0.6 kg CH_4 / kg BOD_5/), and an MCF of 0.5 for cesspools and septic tanks, are assumed. The MCF for cesspools and septic tanks has been estimated on the basis of experience gained in other countries (septic tanks in the U.S., anaerobically treated municipal wastewater in the Czech Republic (cf. Chapter 19.6.2). The emissions are determined as follows:

$$CH_4(cesspools\ and\ septic\ t.) = kg\ BOD_5\ /\ year\ x\ 0.6\ kg\ CH_4\ /\ kg\ BOD_5\ x\ 0.5$$

Calculation pursuant to Tier 3, as required for key categories, is not feasible, since the substance flows for cesspools and septic tanks are not separately recorded.

8.3.2.1.3 Uncertainties and time-series consistency (6.B.2 wastewater treatment)

Since the uncertainties of the method have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used.

The activity rates for organic loads in cesspools and septic tanks are based on data from the Federal Statistical Office's Fachserie 19 Reihe 2.1 that were published in 1991, 1995, 1998, 2001, 2004 and 2007 (*STATISTISCHES BUNDESAMT*, Fachserie 19 Reihe 2.1). Every three years, the Federal Statistical Office conducts a survey – without determining the relevant uncertainties – of the numbers of inhabitants who are not connected to the public sewer system and whose wastewater is disposed of via cesspools and septic tanks. No other pertinent data sources are available. The results of such surveys may be considered very precise, since the surveys are exhaustive surveys. For production of a consistent time series, the activity rates were linearly interpolated between 1991 and 1995, between 1995 and 1998, between 1998 and 2001, between 2001 and 2004 and between 2004 and 2007. The activity rates for 1990, on the other hand, were extrapolated from the 1991-1995 time series. The activity rates for 2008, 2009 and 2010 were extrapolated from the 2004 to 2007 time series.

Until 1995, data for the old and new Federal Länder were determined separately; since then, a single value for all of Germany has been determined in each case. This does not affect time-series consistency, however.

8.3.2.1.4 Source-specific quality assurance/ control and verification (6.B.2 wastewater treatment)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The MCF for cesspools and septic tanks in Germany was derived on the basis of an evaluation of national inventory reports of other countries (cf. Chapter 19.6.2). No other data sources are available.

The fact that aerobic wastewater treatment in relevant facilities produces no significant methane emissions can be confirmed in other countries (Sweden, Denmark).

8.3.2.1.5 Source-specific recalculations (6.B.2 wastewater treatment)

No recalculations are required.

8.3.2.1.6 Planned improvements (6.B.2 wastewater treatment)

No improvements are planned at present.

8.3.2.2 Methane emissions from municipal sludge treatment (6.B.2 sludge treatment)

8.3.2.2.1 Source category description (6.B.2 sludge treatment)

As a general rule, the treatment of municipal sewage sludge comprises two treatment stages:

- Dehydration, using: Mechanical processes (chamber-filter press, cyclone)
  Evaporation in a sludge lagoon or drying beds
- Stabilisation: Aerobic stabilisation (open pool with oxygen input)
  Stabilisation in digestion tower (anaerobic); Formerly: Open sludge digestion

With reference to population figures, mechanical *dehydration* before and after treatment in the digestion tower currently represents the main treatment method (with the exception of small, rural sewage treatment plants). Moreover, sewage sludge is generally limed prior to subsequent use, which stabilises it still further.

Sludge stabilisation is carried out in order to prevent uncontrolled putrefaction. In facilities for fewer than 10,000 inhabitants, such stabilisation is usually carried out aerobically, with energy consumption, while in facilities for more than 30,000 inhabitants it normally is carried out anaerobically, with production of methane gas. The amount of methane gas produced depends especially on the composition of the sewage sludge, the temperature and the reaction conditions. Gas so produced is usually used for energy recovery in combined heat/power generating systems (CHP). It is reported under 1.A.1. Where facilities are unable to use the methane gas cost-effectively in this manner, or when technical disruptions or overloads of attached CHPs occur, the methane gas may be flared off. In both treatment methods, no significant amounts of methane emissions are released into the environment.

In the early 1990s in eastern Germany, open sludge digestion was used for sludge stabilisation, a process that produced methane emissions. Open sludge digestion is now no longer used, however. It was phased out gradually, and was then completely discontinued in 1994.

In Germany, sewage sludge from biological wastewater treatment is managed in the following three ways (where applicable, after dehydration and stabilisation):

- Treatment in mechanical-biological waste-treatment facilities: resulting methane emissions are reported in the waste sector.
- Thermal disposal: no methane emissions occur. Thermal disposal requires energy inputs and thus is allocated to CRF 1.
- Recycling for substance recovery: the most important procedures for recycling sewage sludge for substance recovery include recycling in agriculture, pursuant to the Ordinance on Sewage Sludge, and use in recultivation measures and in composting. Emissions from recycling for substance recovery are also not reported under wastewater and sludge treatment.

8.3.2.2.2 Methodological issues (6.B.2 sludge treatment)

Table 271 lists the emission factors for open sludge digestion and the methane emissions determined for that process.

Table 271: Methane emissions from open sludge digestion, in the new German Länder

	Units	1990	1991	1992	1993	1994
Emission factor	[kg CH_4/t TS]	210	210	210	210	210
Sewage-sludge production	[t TS]	247,190	140,952	72,762	37,524	0
Methane emissions	[t]	51,910	29,600	15,280	7,880	0

Emission factors derived from (UBA 1993)

An emission factor of 210 kg CH_4/t TS is used for open sludge digestion in eastern Germany, in keeping with the results of the study FHG ISI (UBA, 1993: p.15)[87]. The activity rates for the

87 The emission factor was determined via the difference between methane emissions from psychrophilic sludge stabilisation in the new German Länder and the total amount of sewage sludge produced.

years 1990 to 1992 were communicated personally to the Federal Environment Agency by the Chief Inspector of the former GDR's water-processing plants.

In light of the fact that open sludge digestion is prohibited in the Federal Republic of Germany, it was assumed that use of that treatment method was gradually reduced in the new German Länder until 1994 and was no longer used at all as of 1994.

8.3.2.2.3 Uncertainties and time-series consistency (6.B.2 sludge treatment)

Since the uncertainties of the method have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used. The activity rates between 1990 and 1992 are based on a personal communication; those for 1993 are based on estimates of the Federal Environment Agency. As a result, a high degree of time-series consistency is not assured.

8.3.2.2.4 Source-specific quality assurance / control and verification (6.B.2)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

8.3.2.2.5 Source-specific recalculations (6.B.2 sludge treatment)

No recalculations are required.

8.3.2.2.6 Planned improvements (6.B.2)

At present, improvements seem neither necessary nor possible, since no further activity data can be obtained.

8.3.2.3 Nitrous oxide emissions from municipal wastewater (6.B.2 nitrous oxide emissions from municipal wastewater)

8.3.2.3.1 Source category description (6.B.2 nitrous oxide emissions from municipal wastewater)

Nitrous oxide (laughing-gas) emissions can occur as a by-product of municipal wastewater treatment, especially in connection with denitrification, in which gaseous end products – mainly, molecular nitrogen, however – are formed from nitrate (AUST, n.y.).

The emissions trend is stable stagnation.

8.3.2.3.2 Methodological issues (6.B.2 nitrous oxide emissions from municipal wastewater)

Pursuant to the IPCC method, nitrous oxide emissions from household wastewater can be roughly determined via the average per-capita protein intake. The IPCC default values are used in each case for the nitrous-oxide emission factor per kg of nitrogen in wastewater, and for the nitrogen fraction in protein; the average per-capita protein intake and relevant population figures for Germany have to be determined on a country-specific basis.

The FAO's figures are used for determination of the average protein intake per person and day:

- For Germany and for the years 1989-91, the FAO gives an average protein intake per person and day of 98g.[88]
- In keeping with the FAO Statistical Yearbook 2007 – 2008(2010)[89] average protein intakes, per person and day, of 95 g (1994 – 1996), 97 g (1999 – 2001) and 99 g (2003 – 2007) are given for Germany.
- The values for the years 1992-1993 and 2002 are interpolated.
- The values for 1997-1998 represent the arithmetic mean from 1996-1999.
- The values for the years 2008-2010 are extrapolated (on the basis of 2003-2007).

The nitrous oxide emissions are determined on the basis of average protein intake and population figures (*STATISTISCHES BUNDESAMT*, Statistisches Jahrbuch 2010), and with the IPCC method.

$$N_2O_{(s)} = \text{Pr}otein\ x\ Frac_{NPR}\, x\ NR_{PEOPLE}\, x\ EF_6$$

where

$$N_2O_{(s)} = N_2O\ emissions\ from\ human\ wastewater\ (kg\ N_2O - N/a)$$

$$\text{Pr}otein = annual\ protein\ intake\ (kg/person/a)$$

$$NR_{PEOPLE} = Population\ of\ the\ country$$

$$EF_6 = emission\ factor\ (default\ 0.01\ (0.002 - 0.12)\ kg\ N_2O - N/kg\ produced\ wastewater - N)$$

$$Frac_{NPR} = Nitrogen\ fraction\ in\ protein\ (default = 0.16\ kg\ N/kg\ protein\ )$$

8.3.2.3.3 Uncertainties and time-series consistency (6.B.2 nitrous oxide emissions from municipal wastewater)

Since the uncertainties for emissions determination have not yet been estimated, the default values (conservative factors) given in UNFCCC Decision 20/CMP.1 (p. 39ff) are used. The activity rates for 1989-1991 were taken from the Statistical Yearbook 2004. The data for 1994–1996 and 1999–2001, and for 2003-2007, were taken from the FAO Statistical Yearbook 2007-2008; 2010 Table D.1. As described in Chapter 8.3.2.3.2, lacking values were obtained via interpolation, extrapolation or calculation of the pertinent arithmetic mean.

Since the population-specific activity rates increased by only about 4 % within 10 years (1995 – 2005), the error for the extrapolation as of 2006 is, at most, of the same order.

Calculations were based on the average daily protein requirements listed by the FAO database, to ensure that the time series is consistent and to prevent any need for extrapolation of individual values.

88 FAO Statistical Yearbook 2004 Vol.1/1
http://www.fao.org/statistics/yearbook/vol_1_1/index.asp; September 2007

89 FAO Statistical Yearbook 2007-2008; 2010 table D.1;
http://www.fao.org/economic/ess/publications-studies/statistical-yearbook/fao-statistical-yearbook-2007-2008/d-consumption/en/; 2010

8.3.2.3.4 Source-category-specific quality assurance / control and verification (6.B.2 Nitrous oxide from municipal wastewater)

Quality control (pursuant to Tiers 1 + 2) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Analysis of the national inventory reports of other countries shows that most Annex I countries, like Germany, use the IPCC method for determining N_2O emissions.

Alternative data sources for the average protein intake per person and day include:

- The 1991 food table for practical applications (SENSER et al, 1991) lists an average protein intake of 94 g/inhabitant and day.
- The nutrition report of the German Nutrition Association (Deutsche Gesellschaft für Ernährung - DGE, 2000)[90] used estimated food-consumption data for 1993 to estimate average daily protein intake (among other figures). From that data, an average value of about 76.5 g protein / person and day[91] was derived.

The FAO database in the Statistical Yearbooks 2004 (Vol.1/1), 2007–2008 and 2010 (table D.1) is used as a basis for determination of N_2O emissions from wastewater, since those sources constitute a consistent time series. It is internationally comparable, and it is regularly updated. In addition, the FAO has declared that the new Yearbook for 2007-2008 supplants the previous four FAO yearbook publications. The Federal Environment Agency has no information to the effect that the country-specific values in the food table and in the 2000 nutrition report are more precise or enjoy greater national acceptance. In addition, many countries use the FAO database; as a result, the emissions-determination process used by Germany is internationally comparable. An international comparison shows that the daily protein intake assumed for Germany lies within the middle of the overall range.

8.3.2.3.5 Source-specific recalculations (6.B.2 Nitrous oxide from municipal wastewater)

No recalculations are required.

8.3.2.3.6 Planned improvements (6.B.2 Nitrous oxide from municipal wastewater)

No improvements are planned at present.

8.4 Waste incineration (6.C)

All waste incineration in Germany is carried out with energy recovery; for this reason, and in order to avoid double counting, the resulting emissions are reported in the energy section (CRF 1). No emissions (NO) from this energy use, therefore, are reported under 6.C.

8.5 Other areas (6.D)

In source category 6.D, emissions from composting systems (6.D.1) and from mechanical-biological waste treatment (6.D.2) are reported.

90 The nutrition report is published every four years.

91 This value was obtained with the help of the rough estimate that each population group in Germany consists of 50 % men (81.5 g/day) and 50% women (71.6 g/day).

CRF 6.D	Gas	Key category		1990 Total emissions (Gg) & percentage (%)		2010 Total emissions (Gg) & percentage (%)		Trend
Other	CH_4	-	-	49.8	(0.00%)	544.6	(0.06%)	994.12%
Other	N_2O	-	-	14.0	(0.00%)	353.8	(0.04%)	2430.6%

8.5.1 Other areas – composting facilities (6.D)

8.5.1.1 Source category description (6.D.1)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 1/CS	NS	CS
N_2O	Tier 1/CS	NS	CS

In Germany, annually increasing fractions of biodegradable waste are being managed in composting facilities. For this reason, the 2006 inventory included a first report on CH_4 and N_2O emissions from composting of municipal waste in composting facilities, along with a complete time series for these emissions. This category does not include composting of garden and household plant waste by households, in their own gardens. Such emissions are considered negligible, and no data regarding the relevant composted quantities are available.

8.5.1.2 Methodological issues (6.D.1)

Neither the "1996 IPCC Guidelines for National Greenhouse Gas Inventories" nor the IPCC report on "Good Practice Guidance" (2000) present any methods for calculating emissions from kitchen-waste composting. For this reason, a national method has been developed in which composted waste quantities are multiplied by emission factors from a national study (see below).

Activity data

Since 1980, the Federal Statistical Office has regularly collected and published data on waste quantities managed in composting facilities. Since 2000, data on pertinent inputs of kitchen waste and plant waste (garden and park waste), and on waste inputs in composting and fermentation facilities, have been separately collected and published.

The activity data for the current report year have to be estimated, since official waste statistics are published with a one-year time lag. For purposes of estimation, the waste-quantity figure from the previous year is used, unchanged.

Table 272: Quantities of waste placed in composting facilities

[in 1000 t]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Waste quantity	724	1,515	1,956	2,397	3,783	5,168	6,554	7,214	7,320	7,964
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Waste quantity	9,030	9,244	9,459	9,304	9,191	9,207	8,960	9,329	9,089	8,860
	2010									
Waste quantity	8,860									

Emission factors

A research project carried out under commission to the Federal Environment Agency (IFEU 2003a) derived a method for calculating emission factors for the substances CH_4, N_2O and NH_3 from composting. The relevant database was provided by a study of Deutsche Bundesstiftung Umwelt (DBU 2002). In the pertinent method for determination of emission factors, average concentrations of carbon and nitrogen in kitchen waste and plant waste were assumed. In addition, estimates were made of the average decomposition rates during composting, as well as of distribution of carbon and nitrogen throughout the relevant emitted decomposition products.

For kitchen waste from households, the following emission factors resulted:

$EF\text{-}N_2O$ = 83 g N_2O/Mg kitchen waste
$EF\text{-}CH_4$ = 2.5 kg CH_4/Mg kitchen waste

For plant waste, the same study obtained the following emission factors:

$EF\text{-}N_2O$ = 60.3 g N_2O/Mg plant waste
$EF\text{-}CH_4$ = 3.36 kg CH_4/Mg plant waste

These national emission factors were used for the inventory calculations.

8.5.1.3 Uncertainties and time-series consistency (6.D.1)

Activity data

The uncertainties for the composted waste quantities are considered very small (2 %), since the relevant data were obtained via a complete-coverage survey, the reporting quality is good and operators have an interest in high-quality reporting.

Emission factors

The uncertainties for the emission factors are high. They depend on the type of facility/plant in question, on waste composition and on the effectiveness of the biofilters used. The pertinent figures from the literature and from other countries vary so widely that uncertainties of +60 % to -30 % for CH_4, and of at least +100 % to -50 % for N_2O, are assumed.

8.5.1.4 Source-specific quality assurance / control and verification (6.D.1)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

8.5.1.5 Source-specific recalculations (6.D.1)

Recalculations have to be carried out annually for the year prior to the previous year. For this NIR, recalculations have to be carried out for 2009, since the activity data of the Federal Statistical Office appear with a one-year time lag and thus the current report-year data have to be estimated. In each case, such estimates are replaced in the following year with the relevant figures from survey statistics. For the year 2009, the current recalculations yield a 6.7 % reduction of emissions from composting of kitchen waste and a 2.9 % increase in emissions from composting of plant waste. In the 2012 report, the total emissions for 2009 for this category have been corrected downward by 2.3 % with respect to the NIR 2011 (from 755 Gg CO_2 equivalent to 738 Gg CO_2 equivalent).

8.5.1.6 Planned improvements (6.D.1)

Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improving the database for the emission factors for CH_4 and N_2O. The project includes both research, to obtain pertinent literature data, and measurements of composting and fermentation facilities. The project aim is to produce emission factors based on measured emissions from real systems. The project is expected to yield new emission factors, for both gases, that will then need to be integrated within the inventory.

8.5.2 Other areas – mechanical-biological waste treatment (MBT) (6.D.2)

8.5.2.1 Source category description (6.D.2)

Gas	Method used	Source for the activity data	Emission factors used
CH_4	Tier 1/CS	NS	CS
N_2O	Tier 1/CS	NS	CS

As of 1 June 2005, direct landfilling of organic and biodegradable waste is no longer permitted in Germany. Miscellaneous municipal waste, and other waste of similar composition, may thus be landfilled only following pre-treatment. In addition to thermal waste-treatment processes (waste incineration), mechanical-biological processes are increasingly being used for this purpose.

Since the 1990s, mechanical-biological processes have been used extensively in Germany for managing miscellaneous waste. Initially, relevant plants had relatively simple designs and were not fitted for waste-gas collection and treatment. As processes have improved, however, closed systems, with "biofilters" for waste-gas scrubbing, have gradually become the norm. While the waste-gas-scrubbing processes used by such plants have significantly reduced the plants' smell emissions, they have not reduced greenhouse-gas emissions.

In 2005, when all landfilling of untreated waste was terminated, capacities for mechanical-biological waste treatment were considerably expanded. Pursuant to the 30th Ordinance on the Execution of the Federal Immission Control Act (30th BImSchV), as of 1 March 2001, new plants for mechanical-biological waste treatment must fulfil strict technical requirements and conform to demanding standards for maximum permitted emissions. The transitional provisions for old plants call for such plants to be retroffited by no later than 1 March 2006.

Nearly all recently constructed new facilities were commissioned in 2005. Via expansions and operational upgrades, nearly all old facilities were brought into conformance with the 30th BImSchV by 2005. The transitional situation prevailing in 2005 can hardly be described with existing calculation models, since the relevant waste quantities cannot be correlated with the various relevant facility technologies. For the sake of simplicity, emissions through the year 2005 are calculated with the higher emission factors applying to the older-facility systems. For 2006, emissions are being calculated using the lower emission factors for the new facilities.

8.5.2.2 Methodological issues (6.D.2)

Since 1995, the Federal Statistical Office has regularly collected and published data on waste quantities managed in MBT systems. For the years 2007 through 2009, data from the research project "Facilities for mechanical-biological treatment of residual waste" ("Anlagen zur mechanisch-biologischen Restabfallbehandlung"; UBA, 2007) were used, since the pertinent data of the Federal Statistical Office contain inconsistencies that have not yet been eliminated. The data of the *Federal Statistical Office* do not cover all facility types that, in terms of their emissions behaviour, are similar to MBT facilities. For example, the data do not include waste quantities treated in mechanical-biological stabilisation (MBS) facilities. Pursuant to data of the Federal Statistical Office, in 2009 4.0 million Mg/a of waste were treated mechanically and biologically. The corresponding figure obtained by the research project is 4.9 million Mg/a. (According to information provided by the assocation of operators of waste-treatment facilities (Verband Abfallbehandlung) the corresponding figure assumed for 2010 is 5.0 million Mg/a. To prevent any underestimation of greenhouse-gas emissions from MBT facilities, emissions are calculated on the basis of the higher waste-quantity figures obtained by the research project and those provided in a communication of the Registered Association for Material Specific Waste Treatment (ASA).

Activity data

Since 1995, the Federal Statistical Office has regularly collected and published data on waste quantities managed in MBT systems. Those data have been used for the period through 2006. For the years 2007 through 2009, data from the research project "Facilities for mechanical-biological treatment of residual waste" ("Anlagen zur mechanisch-biologischen Restabfallbehandlung"; UBA, 2007) were used, and for 2010 data of MBT operators were used (cf. Methodological issues).

Emission factors

In the 1990s, emissions from mechanical-biological waste treatment were studied in a major collaborative research project supported by the Federal Ministry of Education and Research (BMBF). In a project carried out in 2003, the Institute for Energy and Environmental Research (IFEU) used the collaborative research project's findings to develop emission factors. In doing so, it differentiated between mechanical-biological waste-treatment processes that were open (with no waste-gas collection and treatment) and processes that were closed (with waste-gas collection and treatment in biofilters). For methane, the emission factors for both types of processes were considered to be the same, since that substance is hardly broken down at all in biofilters. The N_2O emission factor for closed systems was considered to be higher than that for open systems, since N_2O also forms in biofilters, via oxidation of ammoniacal nitrogen.

Since June 2005, as a result of new legal provisions (30th BImSchV), all mechanical-biological waste-treatment facilities are closed facilities, which have the more effective waste-gas-scrubbing processes. As of 2006, therefore, the emissions standards of the 30th BImSchV will be used as the emission factors for this area.

For open mechanical-biological waste-treatment facilities, the following emission factors resulted:

$EF\text{-}N_2O$ = 190 g N_2O/Mg waste
$EF\text{-}CH_4$ = 150 g CH_4/Mg waste

For closed mechanical-biological waste-treatment facilities with biofilters, the same study obtained the following emission factors:

$EF\text{-}N_2O$ = 375 g N_2O/Mg waste
$EF\text{-}CH_4$ = 150 g CH_4/Mg waste

For the period as of 2006, the emissions-load limitations imposed by the 30th BImSchV will be used as the applicable emission factors:

$EF\text{-}N_2O$ = 100 g N_2O/Mg waste

EF-CH_4 = 55 g CH_4/Mg waste

All German MBT facilities reliably conform with those emissions standards, and in some cases their emissions are even considerably lower. Since in 2005 most MBT systems were equipped with waste-gas-treatment systems for minimising N_2O emissions, the emission factor for 2005 was estimated to be 169 g.

These national emission factors were used for the inventory calculations.

8.5.2.3 Uncertainties and time-series consistency (6.D.2)

The uncertainties for the mechanically-biologically treated waste quantities are considered to be very small (2 %) theoretically, since the relevant data were obtained via a complete-coverage survey, the reporting quality is good and operators have an interest in quality reporting. Nonetheless, it will be necessary, in order to rule out any possibility of underestimation of waste quantities, to consult with the Federal Statistical Office to determine which versions of "cold" waste-treatment processes are assigned to the MBT category. The uncertainties for the emission factors are high for the period before 2005. They depend on the type of facility/plant in question, on the type of process used at the relevant time and on the effectiveness of the biofilters used. The pertinent figures from the literature vary widely. For the period after 2005, it may be assumed that emissions easily comply with the standards of the 30th BImSchV or are even much lower than those standards. The only uncertainties are found in the question of the extent to which emissions during actual plant operations lie below the standards.

8.5.2.4 Source-specific quality assurance / control and verification (6.D.2)

Quality control (pursuant to Tier 1) and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

8.5.2.5 Source-specific recalculations (6.D.2)

No recalculations were required.

8.5.2.6 Planned improvements (6.D.2)

The Federal Environment Agency plans to urge the Federal Statistical Office to take account, in its data collection, of versions of MBT systems that have not been included to date. To that end, a joint discussion involving the MBT operators and the Federal Statistical Office is planned.

9 OTHER (CRF SECTOR 7)

At present, no greenhouse gas emissions are calculated for Germany which cannot be allocated to one of the existing source categories.

10 RECALCULATIONS AND IMPROVEMENTS

In the following section, recalculations based on quantitatively effective inventory improvements are documented that occurred between the inventory calculations for submissions 2011 and 2012. Further information regarding recalculations is provided in CRF tables 8(a) and 8(b) and in the present report's chapters on source-specific recalculations.

Pursuant to the aims of the *Good Practice Guidance*, emissions calculations should be based on the best available data, and efforts should be made to improve the inventories continuously. A continual improvement process results in annual recalculations. Recalculations become necessary when statistics are updated retroactively and the relevant changes are adopted in the inventories. Recalculations are also required when more precise data are included, when manual-transfer errors are corrected and when key-category analysis reveals a need to change methods for individual source categories. In addition, a range of factors in specialised/technical areas can necessitate recalculations.

The recalculations described in the following are thus based on the inventory data provided with the Submission 2011.

10.1 Explanation and justification of the recalculations

10.1.1 Greenhouse-gas inventory

10.1.1.1 General procedure

There are a number of other reasons, in addition to the need for corrections, why recalculations and improvements can be necessary:

- Additional data become available that make it possible to close gaps in the inventory.
- A data source has changed.
- A method used for a source category has been adapted to provisions of the Good Practice Guidance.
- A source category has become a key category, thus necessitating a change of methods.
- New country-specific calculation procedures need to be used.
- Recommendations and results provided by reviews have been implemented.

In good practice, when methods change, the entire relevant time series should be consistently recalculated with the same method, to ensure that the same method is used each year and old values can be suitably replaced. Where the same method cannot be used every year, one of the following four recalculation procedures (IPCC Good Practice Guidance, 2000: Chapter 7) should be used:

- Overlapping procedure: For this method, the data for calculation pursuant to the old and new methods should be jointly available for at least one year.
- Replacement procedure: For this method, the EF and/or AD used to date should be highly similar to the newly available data.
- Interpolation procedure: The data previously used for recalculation cover only a few years of the time series, and the lacking data are interpolated.
- Extrapolation procedure: The data for the new method are not available for the beginning and/or end of the time series.

The QSE manual contains a guide to the above-outlined recalculation procedures. It also presents relevant examples.

10.1.1.2 Recalculations in the 2012 report year, by source categories

This year's recalculations were necessitated by a range of methodological adjustments, some which led to significant changes in the affected source categories (especially CRF 4 and 5), as well as by further improvements in details.

The inventories contain improvements in the following areas:

Energy (selection):

- Updating of statistical data for 2009 (1.A)
- Transition, in the activity data last used for 2009, from the evaluation tables to the Energy Balance, and from the provisional 2009 Energy Balance to the revised 2009 Energy Balance (1.A, 1.C)
- Revision of activity data for waste incineration (1.A.1, 1.A.2)
- Updating of the TREMOD-AV calculation module (1.A.3.a, 1.C.1.a)
- Revision of the intra-German (domestic) and the international shares of total kerosene use as of 2007 (1.A.3.a, 1.C.1.a)
- Activity data for kerosene and avgas brought into line with the Energy Balance (as of 2008) (1.A.3.a, 1.C.1.a)
- Updating (as of 1995) of the TREMOD calculation module (1.A.3.b, c, d)
- Recalculation of quantities of co-combusted lubricants, following correction of the quantities of diesel fuel and biodiesel used in 2009 (1.A.3.c)
- Slight correction of the EF(CH_4) pursuant to TREMOD (1.A.3.c)
- Conversion to ETS data (1.A.3.e i)
- Adjustment of all EF to TREMOD-MM (1.A.4.c ii)
- Rounding-related corrections of the activity data for kerosene (as of 2001) and avgas (as of 1995) (1.A.5.b)
- Comprehensive adjustments as the result of a research project (1.B.1)
- Conversion to updated association data (1.B.2)

Industrial processes:

- Increase in CO_2 emissions (as of 1990) from soda-ash use in the glass industry, following correction of the pertinent activity data (2.A.4.b)
- Updating of statistical input data for 2006-2009 (2.C.2) and for 2009 (2.C.1 & 2.C.3)
- Correction of production and registration figures for 2009 for refrigerated vehicles (2.F.1.c)
- Correction of the numbers of newly registered utility vehicles with gross vehicle weight greater than 7.5 t (on the basis of new publications of the Federal Motor Transport Authority (KBA) and of the quantities of F gases used in air-conditioning systems of new railway vehicles (2009) (2.F.1.f)
- Slight recalculations for electrical equipments (1995-1999) (2.F.7).

Solvent and other product use: *- no recalculations -*

Agriculture

- Updating of animal counts (horses, swine, poultry) (4A, 4B)

- Changes in the animal models for dairy cows, heifers, fattening bulls, suckler cows, stud bulls, sows, weaners, fattening pigs, lambs and turkeys (4.A, 4.B)
- Updating of feeding data for dairy cows, heifers, fattening bulls, sows and boars (4A, 4B)
- Improvement of the model for calculating animal populations in the inventory categories "suckling piglets", "weaners" and "fattening pigs" from officially reported swine counts (4.A, 4.B)
- New national procedure for calculating VS excretions (4.B)
- Updating of the N content in straw bedding in solid-manure systems (4.B)
- Updating of the distributions of stall-housing, manure-storage and manure-application systems, and of data on duration in pasture, via the 2010 agricultural census (Landwirtschaftliche Zählung 2010), the survey on manure application in 2010 and assessments of experts (4.B)
- Reduction in the N quantities entering the soil, as a result of reductions in N-excretion data via animal-model changes and a correction in harvest-residue data (4.D)
- Updating of areas with organic soils (4.D)
- Correction of a data-transfer error in the area of biological N fixing (4.D)
- Updating of the calculation of NO emissions in the area of agricultural soils (discontinuation of use of NO from legumes and harvest residues and updating of the NO emission factor for pasturing) (4.D)
- Updating of the sewage-sludge quantities for for the years 2007 and 2009

Land use, land-use changes and forestry:

- New reporting system / new land-area matrix, with largely new data for the entire report period (5.A-F)
- New emission factors for mineral soils (5.A-F)
- Change in the transition time for land-use changes to 20 years (5.A-F)
- First-time survey of dead organic matter resulting from deforestation (5.B-F)

Waste and wastewater:

- Updating of the statistical input data for 2008 and 2009 (6.A, 6.D),

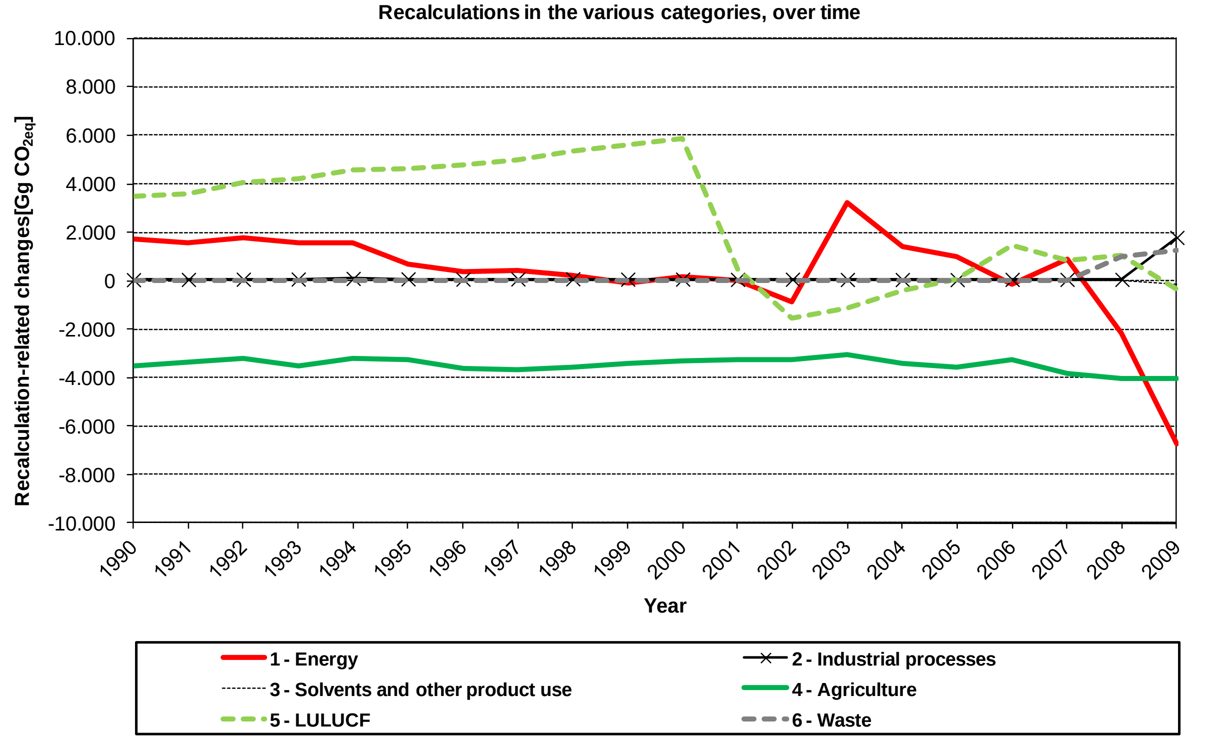


Figure 71: Change in total emissions, for all categories, and for the entire time series, in comparison to the relevant figures in Submission 2011

10.1.1.3 Recalculations in the 2012 inventory, by gases

Recalculations were carried out in the following source categories (in each case, cf. the specifications in 10.1.1.2):

Table 273: Source categories in which recalculations of the inventory, with regard to last year's report, were required

CRF	CO_2	CH_4	N_2O	F gases
1 – Energy	x	x	x	
2 – Industrial processes	x			x
3 – Solvent and other product use				
4 – Agriculture			x	
5 – LULUCF	x	x	x	
6 – Waste & wastewater				

Table 274: Percentage change, resulting from inventory recalculations, with respect to last year's report

	Base year (1990 / 1995)	2009
	Change in [%]	
Total (CO_2 equiv.)	-0.18%	-0.87%
CO_2	0.05%	-0.57%
CH_4	-0.17%	-0.50%
N_2O	-2.91%	-4.83%
HFC, PFC, SF_6	0.16%	-0.38%

Source: own calculations; emissions do not include LULUCF

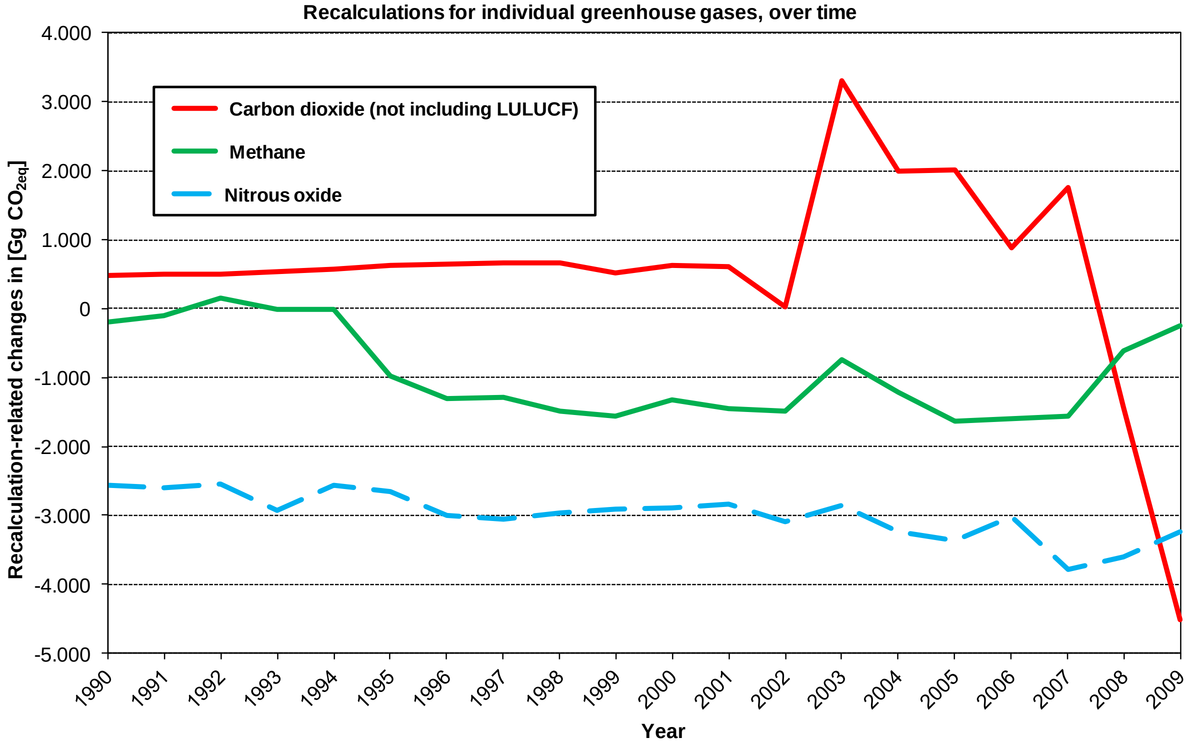


Figure 72: Recalculations of total emissions, for all source categories, and for the entire time series, in comparison to the relevant figures in Submission 2011

10.1.1.4 Recalculations carried out to implement results of the review process

With respect to Submission 2011, which serves as the database for the recalculations described in the present section, only minor Review-based, recalculations were carried out:

- Recalculation of the land-area matrix for the entire sector (5.A-5.F)

10.1.2 KP-LULUCF inventory

10.1.2.1 General procedure

The methods used for recalculations under the Kyoto Protocol are the same as those used under the Convention. Detailed information on the general procedure is provided in Chapter 10.1.1.1.

10.1.2.2 Recalculations in the 2012 report year, by source categories

- Changed EF for afforestation and deforestation on mineral soils were derived via use of a new method (KP 3.3). Further pertinent information is provided in Chapter 7.1.5.
- The methods change yielded other emission factors (EF) for biomass as well, for previous uses in connection with afforestation and subsequent uses in connection with deforestation (KP 3.3) (cf. Chapter 7.1.7).
- The emission factors for the litter category were adjusted to take account of the expanded available database, from the BZE II / BioSoil surveys, for afforestation and deforestation areas (KP 3.3) (cf. Chapter 7.2.4.3).
- Recalculation of emissions from drainage, to account for corrected EF for managed forests (KP 3.4)

10.1.2.3 Recalculations in the 2012 inventory, by gases

CO_2 recalculations were carried out for mineral soils, biomass and litter. One N_2O recalculation was carried out for drainage. For methane (CH_4), on the other hand, no recalculations were required.

10.1.2.4 Recalculations carried out to implement results of the review process

- Recalculation of the land-use matrix (KP 3.3, KP 3.4)

10.2 Impact on emissions levels

10.2.1 Greenhouse-gas inventory

The changes with respect to Submission 2011are very small for 1990 with a decrease of 0.18 %, and somewhat more pronounced for 2009 with a decrease of 0.87 %is. The larger impacts in the latter year are the result of use of updated figures from the 2009 Energy Balance and of revision of input data in the agricultural sector (cf. Table 277).

The inventory has been considerably improved with regard to completeness and accuracy.

Table 275: Recalculations-related percentage changes in total national emissions with respect to last year's report

Year	Submission 2011 [Gg CO_2 equivalent]	Submission 2012 [Gg CO_2 equivalent]	Change, absolute [Gg CO_2 equivalent]	Change, relative [%]
1990	1,248,676	1,246,407	-2,269	-0.18%
1991	1,202,864	1,200,651	-2,212	-0.18%
1992	1,152,732	1,150,852	-1,880	-0.16%
1993	1,144,108	1,141,686	-2,422	-0.21%
1994	1,124,054	1,122,050	-2,003	-0.18%
1995	1,120,673	1,117,698	-2,975	-0.27%
1996	1,140,280	1,136,625	-3,655	-0.32%
1997	1,104,163	1,100,494	-3,669	-0.33%
1998	1,078,413	1,074,642	-3,771	-0.35%
1999	1,044,277	1,040,323	-3,954	-0.38%
2000	1,042,839	1,039,264	-3,575	-0.34%
2001	1,057,706	1,054,025	-3,681	-0.35%
2002	1,037,440	1,032,891	-4,549	-0.44%
2003	1,031,372	1,031,084	-288	-0.03%
2004	1,021,970	1,019,509	-2,461	-0.24%
2005	1,000,541	997,544	-2,997	-0.30%
2006	1,002,901	999,164	-3,738	-0.37%
2007	980,847	977,257	-3,589	-0.37%
2008	981,885	976,233	-5,652	-0.58%
2009	920,106	912,064	-8,042	-0.87%

Source: own calculations; does not include carbon dioxide from LULUCF

In the area of emissions reported only as memo items (for information purposes), minimal recalculations were made for the area of international air transports, for all years as of 1995. They were carried out to account for the emissions-inventory recalculations carried out for all air transports, within the now-used TREMOD-AV model; those recalculations are described in detail in Chapter 3.2.10.1.

Corrections of the biodiesel quantities used in 2009 in road, railway and inland-shipping transports also led to slight changes for the year 2009.

Table 276: Recalculations-related percentage changes, with respect to last year's report, in inventory data reported for informational purposes

	Relative change	
	1990	**2009**
Emissions from international transports	0.00%	-0.43%
Air transports	0.00%	-0.52%
Maritime transports	0.00%	-0.16%
Multilateral missions	NE	NE
CO_2 emissions from biomass	0.00%	-0.64%

Source: own calculations

10.2.1.1 Impacts on 1990 emissions levels

The total emissions for 1990 have decreased only slightly, by a total of about 0.18 % (cf. Table 277).

The largest absolute changes were seen in the *Agriculture* and *Energy* sectors , at -3,529 and +1,719 Gg, respectively.

The emissions reported for the categories *Solvents and other product use (CRF 3)* and *Waste & wastewater (CRF 6)*, on the other hand, have remained unchanged.

At +47 Gg, or +0.05 %, the corrections made for 1990 in the *Industrial processes* category are very small.

A marked reduction was seen in the CH_4 and N_2O emissions reported for the *LULUCF* sector (-505 Gg, or 65 %).

Other significant changes – among the changes that do not enter into the inventory – were made in this sector's CO_2 removals and emissions. In that area, extensive methodological revision has resulted in a decrease in the emissions reported for 1990, amounting to about 4,000 Gg or more than 12 %.

More detailed pertinent information, in addition to that provided in the following table, is available in CRF tables 8(a).

Table 277: Recalculation of CRF-specific total emissions, for all greenhouse gases in 1990

	Submission 2011 [Gg CO_2 equivalent]	Submission 2012 [Gg CO_2 equivalent]	Change, absolute [Gg CO_2 equivalent]	Change, relative [%]
Total national emissions (not including CO_2 from LULUCF)	**1,248,676**	**1,246,407**	**-2,269**	**-0.18%**
1. Energy	**1,019,041**	**1,020,759**	**1,719**	**0.17%**
2. Industrial processes	**94,532**	**94,580**	**47**	**0.05%**
3. Solvent and other product use	**4,477**	**4,477**	**0**	**0.00%**
4. Agriculture	**86,740**	**83,211**	**-3,529**	**-4.07%**
5. Land-use changes and forestry	**-31,175**	**-27,699**	**3,476**	**11.15%**
CO_2 (net emissions / removals)	*-31,949*	*-27,968*	*3,981*	*12.46%*
N_2O + CH_4 (emissions)	*774*	*269*	*-505*	*-65.27%*
6. Waste	43,111	43,111	0	0.00%

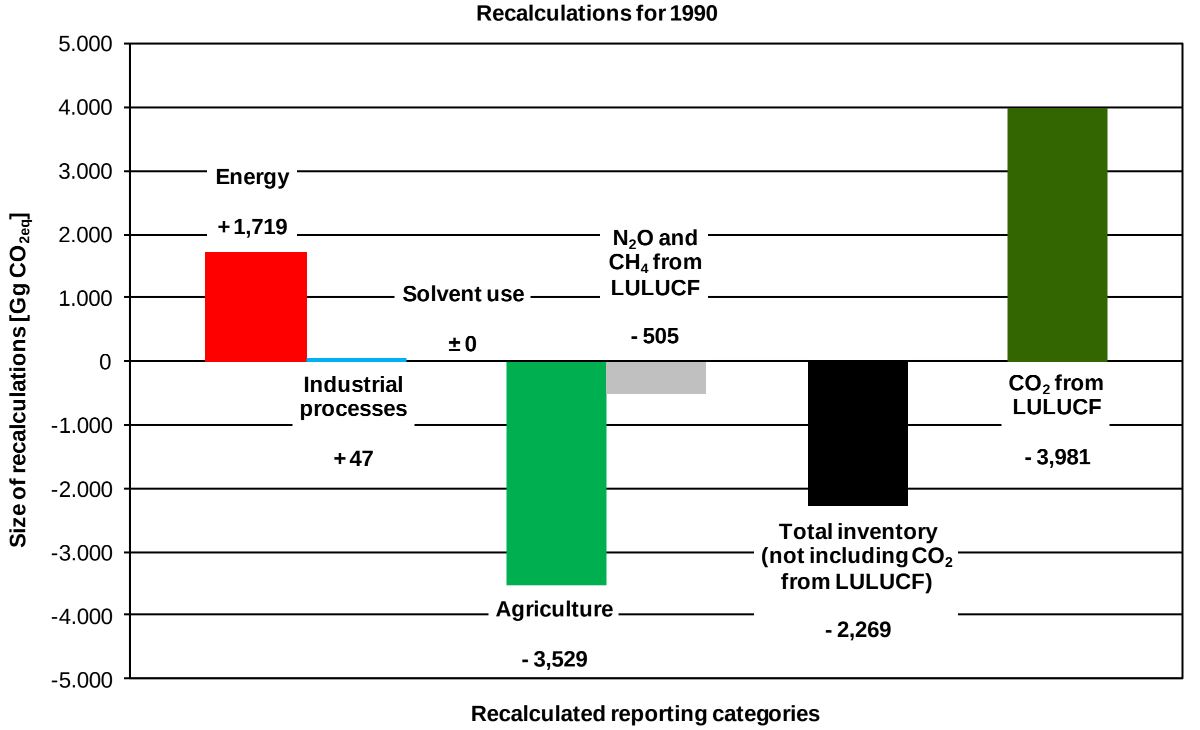


Figure 73: Recalculations of all greenhouse gases for 1990

10.2.1.2 Impacts on emissions levels of categories in 2009

Total emissions not including CO_2 from LULUCF reported for 2009 have decreased by 0.86 % in comparison to the Submission 2011 (cf. Table 278).

The largest changes, in terms of quantity, occurred in the sectors *Energy* (- 6,747 Gg) and *Agriculture* (-4,043 Gg). For CRF 1, those changes are due especially to revision of the 2009 Energy Balance. The comprehensive recalculations carried out in CRF 4 are listed in Chapter 10.1.1.2 and are discussed in detail in the relevant source-category chapters.

At +1,790 Gg or +2.44 %, the corrections in the *Industrial processes* sector were considerably more marked than they were for 1990.

In the category *Solvents and other product use*, reported emissions decreased by 160 Gg, or 8.95 %.

The also-considerable reduction in the CH_4 and N_2O emissions reported for the *LULUCF* sector (-36 %) has only a slight impact on the inventory as a whole.

Other significant changes – among the changes that do not enter into the inventory – were made in that sector's CO_2 removals and emissions. In that area, the above-mentioned methodological revision has resulted in a slight decrease in the emissions reported for 2009, amounting to 200 Gg or slightly more than 1 %.

At +1,264 Gg or +10.75 %, relatively large adjustments were made in the emissions reported for the sector *Waste & wastewater*.

Additional information about recalculations is provided in CRF tables 8(a), and 8(b) and in the table below.

Table 278: Recalculation of CRF-specific total emissions, for all greenhouse gases in 2009

	Submission 2011 [Gg CO_2 equivalent]	Submission 2012 [Gg CO_2 equivalent]	Change, absolute [Gg CO_2 equivalent]	Change, relative [%]
Total national emissions (not including CO_2 from LULUCF)	**920,106**	**912,064**	**-8,042**	**-0.87%**
1. Energy	**760,126**	**753,379**	**-6,747**	**-0.89%**
2. Industrial processes	**73,324**	**75,114**	**1,790**	**2.44%**
3. Solvent and other product use	**1,786**	**1,626**	**-160**	**-8.95%**
4. Agriculture	**72,702**	**68,659**	**-4,043**	**-5.56%**
5. Land-use changes and forestry	**17,563**	**17,221**	**-342**	**1.95%**
CO_2 (net emissions / removals)	*17,155*	*16,959*	*-196*	*1.14%*
N_2O + CH_4 (emissions)	*408*	*262*	*-146*	*-35.72%*
6. Waste	**11,760**	**13,024**	*1,264*	**10.75%**

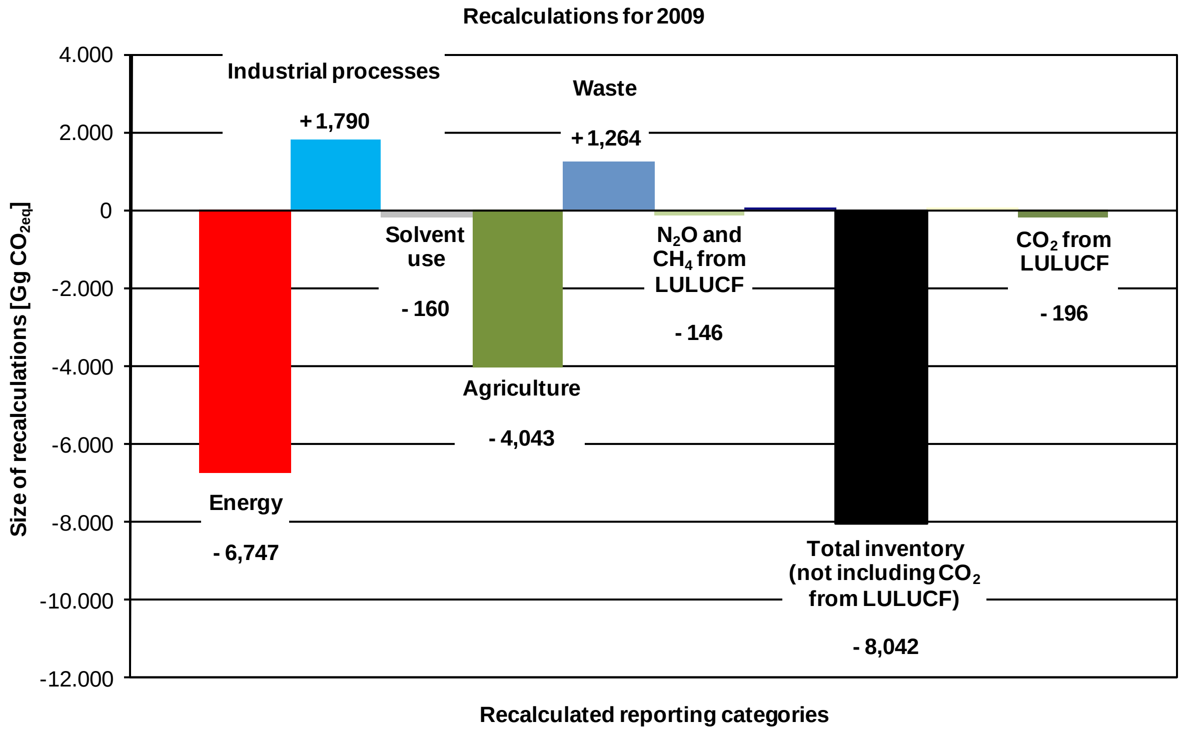


Figure 74: Recalculations of all greenhouse gases for 2009

10.2.2 KP-LULUCF inventory

10.2.2.1 Impacts on emissions levels of categories in 1990

Total sinks for 1990 decreased by a total of about 4 % as a result of methodological corrections (cf. Table 279). To a degree of 60 %, that change is due to the changes in forest management; to a degree of 40 %, it is due to afforestation or deforestation.

Table 279: Recalculation of total KP-LULUCF emissions, for all gases in 1990

	Submission 2011 [Gg CO_2 equivalent]	Submission 2012 [Gg CO_2 equivalent]	Change, absolute [Gg CO_2 equivalent]	Change, relative [%]
Afforestation (KP3.3)	934	1,139	205	21.95%
Deforestation (KP3.3)	1,172	2,102	930	79.35%
Forest management (KP3.4)	-70,927	-69,326	1,601	2.26%
Total	**-68,821**	**-66,085**	**2,736**	**3.97%**

10.2.2.2 Impacts on emissions levels of categories in 2009

The total removals for 2009 have increased by 0.80 % in comparison to the Submission 2011. That increase is due primarily to improved estimation of deforestation areas and of the pertinent emission factors.

Table 280: Recalculation of total KP-LULUCF emissions, for all gases in 2008

	Submission 2011 [Gg CO_2 equivalent]	Submission 2012 [Gg CO_2 equivalent]	Change, absolute [Gg CO_2 equivalent]	Change, relative [%]
Afforestation (KP3.3)	-4,779	-5,568	-789	-16.51%
Deforestation (KP3.3)	1,066	464	-602	-56.47%
Forest management (KP3.4)	-20,626	-19,429	1,197	5.80%
Total	**-24,339**	**-24,533**	**-194**	**0.80%**

10.3 Impacts on emissions trends and on time-series consistency

10.3.1 Greenhouse-gas inventory

The time-series consistency has improved as a result of the recalculations.

As a result, the trend for total national emissions (not including CO_2 from LULUCF) shows a reduction of 25.1 % with respect to the current base year.

Following decreases, of which the last were considerable, pure CO_2 emissions, at plus 4.4 %, are considerably higher than they were in the crisis year 2009. CH_4 emissions decreased slightly, with the change amounting to -1.8 %. Nitrous oxide emissions, on the other hand, decreased markedly by 13.6 %. The trends for HFC, PFC and SF_6 emissions have been diverging from each other: With respect to 2009, HFC emissions are down by 4.4 %, while PFC emissions are down by 15 %. SF_6 emissions, on the other hand, increased by 5.7 %.

10.3.2 KP LULUCF inventory

Due to the recalculations described, the consistency of the time series could be improved. In particular, use of a consistent method has made estimation of deforestation areas consistent, thereby significantly improving emissions estimates. Overall, that has led to only slight emissions adjustments for afforestation, deforestation and cultivated areas (cf. Chapter 10.2.2).

10.4 Inventory improvements

10.4.1 Greenhouse-gas inventory

The following table summarises the improvements made in greenhouse-emissions reporting on the basis of the ERT's references and remarks in past reviews under the UN Framework Convention on Climate Change and the Kyoto Protocol. The table lists only aspects that were not already successfully addressed during the Review.

Table 281: Compilation of successfully addressed review recommendations documented in the IP

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR-Chapter
QSE	Initial Review 2007 § 18; ARR 2006 §19	The ERT recommends that Germany continue its current QA/QC practices and enhance them where possible (e.g. by holding regularly scheduled workshops to discuss methods, data quality, etc., developing additional agreements with industry associations, and formalizing agreements with other government institutions to ensure continued timely and accurate information). Although the QA/QC plan is in line with the IPCC good practice guidance, the ERT notes that it is still evolving, in particular in respect of specific roles and responsibilities of data developers and data suppliers in institutions outside UBA. Implementation of the policy paper on the national system mentioned in paragraph 15 above will be essential in fully implementing the QA/QC plan. The ERT further recommends that Germany clearly document the quality control and quality assurance (QA) systems of external data providers to ensure that they conform to the IPCC good practice guidance under the implementation of the national QA/QC plan.	Minimum requirements pertaining to data documentation, a system for QA/QC and archiving for extenral data providers have been established and approved by the coordination commitee.	Chapter 1.3.3
QSE	Initial Review 2007 § 19	The ERT recommends that additional category-specific analyses such as those prepared for the in-country review be incorporated in the QA/QC activities (e.g. analyses of trends and underlying drivers, as well as additional reviews (e.g. peer reviews), as part of QA).	Category-specific analyses of trends, incl. Underlying factors, as well as additional peer reviews are incorporated into the QA/QC activities.	Various NIR Chapters
QSE	ARR 2010 § 39	The ERT recommends that Germany strengthen the implementation of the QA/QC procedures in those institutions outside UBA which participate in the inventory preparation.	These minimum QA/QC requirements, established and approved by the coordination commitee, are part of all new cooperation agreements with external institutions providing data or participating in the inventory preparation. With regard to agricultural and LULUCF sector the Heinrich von Thünen Institute has established an internal quality management, applying the quality manangement system of the UBA.	Chapter 6&7
Key Category Analysis	ARR 2010 § 29	In presenting the results of the key category analysis Germany has removed six categories from the list of identified key categories due to their small importance and declining trend. This is not consistent with the IPCC good practice guidance and IPCC good practice guidance for LULUCF. The ERT recommends that Germany present the results of the key category analysis in accordance with the IPCC good practice guidance for LULUCF.	Germany Reports all identified categories in its key category analysis.	Chapter 17
Recalculations	ARR 2009 §§33, 60	ERT recommends that Gemrany improve the reporting of recalculations and ensure that information in the NIR and in the CRF tables are consistent	Germany has improved the consistency of the reporting and description of recalculations in the NIR.	Chapter 10.1

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR-Chapter
1.A	ARR 2010 §§ 41c, 57	The ERT noted that the NIR described the trends for the energy sector in chapter 2, but did not provide explanations of emissions trends at the category level. However, this information was provided by the Party during the review week. The ERT recommends that Germany explore including this information in its next annual submission.	Germany provided detailed descriptions of emssions trends at hte category level for the most categories	Chapter 3.2
1.A.1.a / 1.A.2.a	SL 2010	ERT recommends that Germany use the acitivity data available from BGS statistics to estimate the consumption of blast furnance gas, estimate emissions from blast furnance gas using the fuel consumption and the CS EF for CO2 and N2O and report these in the relevant categories in line with the Revised 1996 IPCC GL and the IPCC GPG.	Germany follows the recommendation by ERT and provides new estimates for source category 1.A.2.f Other (industrial steam boiler). The party found an underestimation of blast furnace and blast oxygen furnace gas.	Chapter 3.2
1.B.1.c	ARR 2008 §30	ERT recommended that Germany include a table with the time series of pit gas recovered in the next NIR	Germany has included a figure on Pit gas emitted and used as fuel in the NIR	Chapter 3.3.1
1.B.2.c	SL 2010	Ert recommends that Gemrany assess the flaring/losses as reported in the Energy Balance to derive a separation between the amount of natural gas used for flaring and the amount of natural gas losses. Germany should estimate emissions from losses using country specific emission factors and the amount of natural gas lost and report these in line with the Revised 1996 IPCC GL; estimate emissions from flaring using CS EF and the quantity of natural gas flared	Germany provides new estimates for source category 1.B.2 for N2O emissions only. For CO2 and CH4 no new estimates will be provided as they have already been reported under 1.B.2.b and 1.B.2.c.	Chapter 3.3.2
2.F	ARR 2010 § 90	Germany reports potential emissions of HFC, PFC and SF6. However, the calculations of the potential emissions are not in line with the IPCC good practice guidance. In the CRF tables, the potential emissions reported only give values for „imports“ and for total potential emissions. During the in-country visit, the ERT identified that, for many categories, the values calculated as potential emissions referred only to the difference between stocks and the actual emissions. This approach is not in line with the definition of potential emissions in the Revised 1996 IPCC Guidelines. The ERT recommends that Germany correct the calculation of potential emissions in its next annual submission, applying the correct definition (potential emissions = production + imports (in bulk and inside equipment) - exports (in bulk and inside equipment)).	Germany has corrected the reporting of potential emssions using the equation of the Revised 1996 IPCC GL.	Chapter 4.7
4	ARR 2010 § 102	The ERT acknowledged that Germany has significantly improved its documentation of this sector in the NIR. The ERT noted that each year Germany compiles a separate, more detailed report on the inventory calculations for the agricultural sector ... The ERT recommends that Germany include this report with its annual submission.	Since the Submission 2011 Germany provided a detailed report on the inventory calculations for the agricultural sector as an attachement to the NIR.	
4	ARR 2010 § 103	The ERT noted the following quote from this chapter the following document, „Comparison of IPCC 2006 with IPCC 1996b“, justifies the use of the new methods described in IPCC 2006 instead of the methods described in IPCC 1996b for calculation of greenhouse gases in the German agricultural sector. The ERT noted with concern that there is no mention of or reference to the IPCC good practice guidance. The ERT concluded that information contained in this chapter is, to a certain degree, selective and	The respective NIR chapter has been revised and updated.	Chapter 19.4.1

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR-Chapter
		insufficient in its argumentation,		
4.A	ARR 2010 § 109	Germany uses a model developed by Ellis et al. (2008) to estimate CH4 enteric fermentation emissions from dairy cattle. This has resulted in a MCF of 5.34 per cent for the latest inventory year. However, the ERT noted that this model was developed based on North American conditions where there is intensive use of Monensin (a growth regulator that is known to depress the CH4 formation) and other feeding additives. Monensin was banned in the European Union on 1 January 2006 and Germany confirmed that Monensin is not used in Germany. Therefore, the ERT recommended that Germany revise its estimate to be applicable for German conditions. In response, Germany submitted revised estimates on 5 November 2010 using an MCF of 6.0 per cent, which is in accordance with the IPCC good practice guidance. ... In its response, Germany also indicated that this value leads to a national IEF value which is higher than the IEFs of other central European countries with similar milk yields. The ERT recommends that Germany explore this issue further. The ERT also encourages Germany to make the comparison with other countries as suggested in paragraph 104(a) above.	A MCF of 6.0 per cent for Dairy cattle is used, which is in line with the IPCC GPG.	Chapter 6.2
4.A	ARR 2010 § 110	The ERT found that Germany continues to use the 2006 IPCC Guidelines to estimate emissions for other cattle, which gives rise to a slightly higher emission when compared to emissions compiled using the IPCC good practice guidance. The German model differentiates between the MCF for small calves (2.0 per cent) based on national expertise) and older animals, where the default MCF of 6.5 per cent from the 2006 IPCC Guidelines is used. The ERT recommends that Germany verify the MCF for small calves in its next annual submission.	The MCF for small calves has been verified.	Chapter 6.2
4.B.	ARR 2010 § 112	The information provided by the Party in the NIR, the CRF and during the review week was not fully coherent nor transparent. The ERT recommends that, in its next annual submission, Germany provide detailed information on revisions to its stable type distribution and surface cover of manure stores, and recommends that the Party define and justify the NH3, N2O and CH4 EFs used for each stable type.	The stable type distribution has been revised and updated (LZ, 2010)	Chapter 6.3
4.B.	ARR 2010 § 114	Germany has used a country-specific ash content value of 13.9 per cent to estimate the amount of VS in dairy cattle manure; this value is based on a study in 1975. For other cattle, Germany uses the default value of 8.0 per cent from the IPCC good practice guidance. ... During the review week, the ERT sought justification from the Party on the assumed value and Germany subsequently acknowledged that the current value is too high. The ERT concludes that the assumed value for the ash content is too high and results in a reduction in the amount of VS in manure, and therefore is a potential underestimation of CH4 emissions. The ERT therefore recommended that Germany revise its emission estimate for all years using an ash content from the Revised 1996 IPCC Guidelines.	Germany submitted revised estimates on 5 November 2010 which satisfied the concerns of the ERT.	Chapter 6.3
4.A / 4.B	ARR 2008 §46	ERT recommends that Germany extrapolate the number of animals to the inventory year to improve the time-series consistency of the inventory.	Time-series consistency of the inventory is improved by an interpolation of numbers of animals were necessary and appropriated.	Chapter 6.1.4.2
4.B.	ARR 2010 § 115	The stable type distribution in Germany has not been updated since 1999. The ERT noted that the current information on stable types and storage times appear to be insufficient, especially knowing the detailed livestock categories used by Germany to estimate emissions. ... During the review week, Germany informed the ERT that its national statistical agency together with EUROSTAT, the European Commission's statistical agency, is planning a survey of stable types in Germany. The ERT recommends that Germany update its stable type distribution and storage times for the different manure and livestock types, and to report thereon in its next annual submission.	The stable type distribution has been revised and updated (LZ, 2010)	Chapter 6.3

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR-Chapter
4.B.	ARR 2010 § 116	The ERT concludes that this exclusion may result in a high uncertainty of CH4 emissions, especially in the case of deep litter bedding. The ERT encourages Germany to investigate the possible effect of excluding straw from the manure management system, and if an underestimation is occurring then revise its methodology and emission estimates and report thereon in its next annual submission.	Germany investigated the possible effect of excluding straw from the manure management system and concluded that no significant effects can be found.	Chapter 6.3
4.B.	ARR 2010 § 117	Table 230 of the NIR is used by Germany to compare the effect of using the 2006 IPCC Guidelines instead of the Revised 1996 IPCC Guidelines. Furthermore, the Party concludes from this comparison that the use of the 2006 IPCC Guidelines yields the highest N2O emission. However, the ERT found that, in this comparison, the Party is using the lower bound of the uncertainty range of the EF for solid manure instead of the average EF; therefore a contradictory conclusion is noted by the ERT. The ERT recommends that Germany improve the transparency of its basis for emissions estimation, including calculations and justification (argumentations) in line with the IPCC good practice guidance.	Germany uses again the EF of the IPCC 1996 GL and hence is in line with IPCC GPG since the submission 2011.	Chapter 19.4
4.D.	ARR 2010 § 111	The NIR outlines justification on the use of the default factor from national research made in northern Germany (Weymann et al. 2008). The ERT found that Weymann et al. (2008) only considers N2O emissions from groundwater and not the two latter components (rivers and estuaries). ... During the review week, Germany provided further documentation to justify the use of the factor from the 2006 IPCC Guidelines. However, this documentation provides information from rivers and riparian areas in Scotland, France, Belgium and the Netherlands. The ERT acknowledges the efforts made by Germany in this regard, but recommends that Germany develop a country-specific N2O EF for groundwater based on national circumstances. With respect to the rivers element of the default value, the ERT noted that, given the limited time available during the review week for it to review the scientific studies provided by the Party, it was not able to give a qualified judgement on the applicability of the documentation provided, which the Party had stated as being based on German conditions. Hence the ERT recommends that Germany either: develop and transparently justify the use of a country-specific EF; or use the recommended value from the IPCC good practice guidance.	Germany submitted revised estimates for indirect emissions from leaching where the default EF of 0.025 is used, which is in accordance with IPCC good practice guidance.	Chapter 19.4
5	Initial Review 2007, §§ 16, 88	ERT recommends that good coordination and coorperation by organizations be maintained where it exists and enhanced where needed.	The German Federal Ministry of Food, Agricualture and Consumer Protection has established a conceptz for the preparation of GHG emissions- and carbon inventory of the source and sink groups 4 and 5 by the Johann Heinrich von Thünen Institute (vTI). The National Coordination Agency and the vTI have established regular co-ordiniation meetings to enhance the incooporation of the Agricultural- and LULUCF experts into the National System.	Chapter 13
5	ARR 2010 § 10	ERT identified a need for improvement in the quality of reporting under Article 3, paragraphs 3 and 4, of the Kyoto Protocol. There were numerous deficiencies and errors, which meant that the ERT was not able to assess the accuracy of the reporting. Germany was requested by the ERT to provide an action plan outlining how it plans to resolve the issues identified by the ERT. Germany provided this plan on 5 November 2010. The ERT recommends that Germany implement the planned improvements set out in this action plan as far as possible and to report thereon in its 2011 annual submission, and to provide information from its action plan in the national inventory report (NIR)	Germany has implementated all improvements planned until 2012 out of the action plan	Chapter 7

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR-Chapter
5	ARR 2010 §§ 16f, 46e	Improve the reporting of land area to ensure a consistent land-use matrix in the LULUCF sector and reporting under KP-LULUCF	A consistent land-use matrix has been established with the entire rework of the reporting scheme for LULUCF.	Chapter 7.1
5	ARR 2010 §§ 16g, 24, 46f	Improve the quality of reporting of emissions/removals under KP-LULUCF	A consistent land-use matrix has been established with the entire rework of the reporting scheme for LULUCF and KP-LULUCF	Chapter 7.1
5	ARR 2010 § 24b	The revision of AD does not cover the whole time series and the identification of land areas does not result in consistent reporting	A consistent land-use matrix has been established with the entire rework of the reporting scheme for LULUCF and KP-LULUCF	Chapter 7.1
5	ARR 2010 § 24c, 39	The ERT noted several errors and mistakes in the reporting, especially in the LUUCF sector, and concluded that the implementation of the QA/QC procedures needs to be strengthened.	The Heinrich von Thünen Institute has established an internal quality management, applying the quality manangement system of the UBA. Hence Germany has improved the QA/QC procedures.	
5	ARR 2010 § 25	Additional information provided on QA/QC mainly addresses organisation issues related to quality management, rather than the actual procedures. The ERT strongly recommends that Germany make additional efforts to ensure complete and consistent reporting in its annual submissions. Continued inconsistencies and incompleteness in the reporting of land use and land-use change under the Kyoto Protocol could indicate a problem with the national system. The ERT also recommends that Germany enhance its QA/QC procedures for these emission /removal estimates in accordance with section 5.5 of the IPCC good practice guidance for LULUCF.	The Heinrich von Thünen Institute has established an internal quality management, applying the quality manangement system of the UBA. Hence Germany has improved the QA/QC procedures.	
5	ARR 2010 § 123	The ERT noted a lack of QA/QC of the inventory preparation. The ERT recommends that the cooperation between these institutions should be strengthened, including a need to clarify the responsibility of the single national entity,UBA, for the LULUCF sector. The ERT recommends that Germany improve the current arrangements among agencies and organizations involved in the collection of the land use data to ensure the consistency and the timeliness of the data.	The German Federal Ministry of Food, Agricualture and Consumer Protection has established a conceptz for the preparation of GHG emissions- and carbon inventory of the source and sink groups 4 and 5 by the Johann Heinrich von Thünen Institute (vTI). The National Coordination Agency and the vTI have established regular co-ordiniation meetings to enhance the incooporation of the Agricultural- and LULUCF experts into the National System.	
5	ARR 2010 § 124	Germany is using two different methodologies to establish a complete LUM. One based on ATKIS for the old German Länder and satellite monitoring for the new German Länder. ... the pattern in land-use change differs significantly between the old and the new Länder. ... Germany has not provided the ERT with examples of how the land has been indentified and the ERT is therefore not in a position to verify that the proposed land-use changes are genuine or a function of the interpretation of the land use classification. It is the opinion of the ERT that the indentified problems can be attributed to methodological inconsistencies related to the classification of the satellite monitoring data and the use of the detailed ATKIS vector data. Without consistent land representation,double counting or omission of an area might occur, leading to incorrect estimates of a source or a sink. ... The ERT considers that, in its next possible annual submission, Germany has the capacity to make a proper land-use classification and recommends that Germany submit detailed information on how the two different methodologies are used consistently and in accordance with the chosen forest	A consistent land-use matrix has been established with the entire rework of the reporting scheme for LULUCF and KP-LULUCF	Chapter 7.1

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR-Chapter
		definition, as well as for other land use categories and subcategories for the whole of Germany in scale and time.		
5	ARR 2010 § 125	The default transition time of 20 years may not be appropriate for German conditions, but as it is not possible for the soils to reach the new equilibrium within one year. The ERT recommends that Germany change its methodology to either the default linear methodology, in line with the IPCC good practice guidance for LULUCF, or develop a country-specific model taking into account national conditions which can be scientifically verified.	A default transition time of 20 years has been applied for the entire LULUCF sector	Chapter 7
5	ARR 2010 § 127	In the CRF tables, the level of loss from conversion of forest to the five other land categories are the same. ... During the in-country review, Germany was not able to provide a clarification of this uniform value. Given the size of Germany, and that the other land use classes are estimated at district level, the ERT recommends that Germany revisit the approach used in defining carbon stock of forest land subject to deforestation.	A consistent land-use matrix and time-series have been established with the entire rework of the reporting scheme for LULUCF and KP-LULUCF	Chapter 7
5	ARR 2010 § 128	In the CRF tables, the ERT found that the loss or gain of carbon in the living biomass that occurred in 2000 is considerably different from the corresponding 2001 values. During the review week, Germany explained that this significant change is partly due to the different level of land classification used before and after 2000. ... Different levels of land-use aggregation may affect the uncertainty level. In order to improve the transparency, the ERT recommends that, in its next possible annual submission, Germany report the approach for classification of the land-use categories in CORINE and in ATKIS, and how these are connected and how this is managed in the uncertainty assessment.	A consistent land-use matrix has been established with the entire rework of the reporting scheme for LULUCF and KP-LULUCF	Chapter 7
5	ARR 2010 § 129	To improve transparency,comparability and consistency, the ERT recommends that the Party provide a description or definition of the land-use categories, and begin the process of harmonizing the land-use classifications between the two systems and their consistency with the IPCC good practice guidance for LULUCF. The ERT encourages Germany to develop CRF tables with subdivisions for each land-use category.	A consistent land-use matrix has been established with the entire rework of the reporting scheme for LULUCF and KP-LULUCF. Subdivisions for grassland and wetland have been developed.	Chapter 7.4 / 7.5
5.A	ARR 2010 § 121	The trends and reasons for the mentioned significant change were not transparently described in the NIR, but presented to the ERT during the review. The ERT recommends that this information is included in the next annual submission.	Trends and reasons for the significant change of the removals of emissions under 5.A. have been decribed in a transparent manner.	Chapter 7.2.4
5.A.	ARR 2010 § 131	The rate of carbon removal from forest land remaining forest land showed a significant reduction between 2001 and 2002. ... These results are used directly in the inventory without any explanation for this large change in the sink in the German forests. One major factor causing such significant change may be a rapid increase in harvesting rate. For transparency, the ERT recommends that the Party provide supporting information in the next annual submission on harvesting rates and other important management issues.	Supporting information on harvesting rates and other important management issues has been provided.	Chapter 7.2.4
5.A	ARR 2010 § 132, 160	The ERT found that the area reported in the NIR for the new German Länder increased consistently from year to year and then a sudden drop in 2008 is observed. The Party explained that this is primarily due to the difficulties in harmonizing the data from different sources and it will be corrected in the next annual submission. The ERT recommends that Germany use a stringent methodology according to the IPCC good practice guidance for LULUCF when reporting the land-use changes.	A consistent land-use matrix and time-series have been established with the entire rework of the reporting scheme for LULUCF and KP-LULUCF	Chapter 7.1
5.A.	ARR 2010 § 134	ERT found that the gain of carbon stock in the living biomass in the conversion of crop land, grassland, wetlands, settlements and other land to forest land were all the same (1.44 Mg C/ha). Including carbon losses into the gain should lead to a different rate of gain because the amount of carbon losses in the conversion of these lands was not the same. Furthermore, it is	A consistent land-use matrix and time-series have been established with the entire rework of the reporting scheme for LULUCF and KP-LULUCF. The notation key "IE" is not used for gains in living biomass in	Chapter 7.2

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR-Chapter
		apparent that the same methodology is not used for all years. The ERT recommends that Germany check the methodology applied and avoid the use of "IE" in its next annual submission.	land converted to forest land categories.	
5..D	ARR 2010 § 136	The ERT noted that the carbon loss from living biomass in the conversion of cropland and settlements to wetlands in 2000 was considerably higher when compared with the corresponding emissions in 2001. ... During the review week, Germany explained that this may be due to a mistake made during the calculation process and that it intends to revise the calculation in the next annual submission.	A consistent land-use matrix and time-series have been established with the entire rework of the reporting scheme for LULUCF and KP-LULUCF	Chapter 7.1
5.D.	ARR 2010 § 137	Germany only reports one subdivision in the wetlands category. ... To improve the transparency the ERT encourages Germany to report subdivisions of the wetlands category as land with peat extraction, fully water covered wetlands and partly water covered wetlands.	Two subdivisions are reported for wetlands.	Chapter 7.5
5.F	ARR 2010 § 126	The ERT, therefore, recommends that Germany make a detailed investigation to find out whether these areas have been misclassified and/or whether the changes in carbon stock in living biomass have been estimated incorrectly.	Together with a new approach of reporting in the LULUCF sector the correct classification of areas is ensured.	Chapter 7
6	ARR 2010 § 41a	The ERT also noted areas in which transparency can be improved: The choice of methodology and emission factors (EFs) is not sufficiently described in all cases (e.g. in the energy and waste sectors)	Germany has improved the description of the methodological choice and the EF.	Chapter 3.2 / 8.4
6	ARR 2010 § 143	Category-specific QA/QC procedures have been implemented. Nevertheless, there are some typing mistakes and discrepancies between the data in the CRF tables and the NIR. The ERT recommends Germany to apply QA/QC procedures more strictly.	Germany has improved the QA / QC procedures.	Various
6.A.	ARR 2010 § 144	Germany uses different CH4 generation rate constants (k) and degradable organic carbon (DOC) values for different waste types. The ERT noted that there is no comprehensive explanation of these parameters in the NIR. The fraction of DOC dissimilated is country-specific. Other parameters are defaults from the IPCC good practice guidance. The ERT noted that some additional information, such as the waste generation rate, is not presented in the NIR and CRF tables. The ERT recommends that Germany improve the transparency of reporting by providing more detailed information about the CH4 generation rate constant, DOC, and waste generation rate in the NIR and CRF tables in the next annual submission.	Germany has improved the transparency of description for data sources.	Chapter 8.2
6.A.	ARR 2010 § 145	The ERT found that the documentation provided by the Party to substantiate its reported recovery was insufficient. The ERT noted that, in accordance with the IPCC good practice guidance, the default CH4 recovery is zero. This default should only be changed when references documenting the amount of CH4 recovery are available. The use of undocumented estimates of landfill gas recovery potential is not appropriate; as such, estimates tend to overestimate the amount of recovery. The ERT reiterated the recommendations from previous reviews and recommended that Germany use monitored data to report recovery and actual emissions aer recovery, and reconstruct the full time series using methodologies in line with the IPCC good practice guidance. Following the ERT recommendation, the Party resubmitted revised estimates for the full time series. As a result, in 2008 47.3 per cent of total CH4 generated by waste disposal on land (421.10 Gg) was reported as recovered and deducted from total CH4 emissions. The ERT recommends that the Party provide a detailed description of the new calculation approach in its next annual submission.	Germany provides a description of the calculation approach used since the In Country Review in its NIR.	Chapter 8.2
6.A.1	ARR 2009 §99	ERT recommends to improve transparency of reporting of the use of biogas from landfills and emissionsin the sectoral parts of the NIR on waste and energy in the next submission	Germany provides a description of the calculation approach used since the In Country Review in its NIR.	Chapter 8.2

CRF	ARR Reference	Recommendation / Aspect	Improvement	NIR-Chapter
6.B.1	ARR 2010 § 148	Germany does not estimate CH4 emissions from industrial wastewater and sludge treatment (the notation key "NO" is used in CRF table 6.B), but the ERT finds that the information provided by the Party is not transparently presented in the NIR and CRF tables. ... The ERT reiterates the recommendation from the previous review report that Germany improve its reporting for this category by providing more details on the treatment of industrial wastewater in Germany and justification (including references) for the assumption that no CH4 is emitted to the atmosphere from the treatment processes, in accordance with the IPCC good practice guidance, in its next annual submission.	Germany provided a description for the assumption that no CH4 is emitted to the atmosphere from the treatment processes in the industrial waste water sector.	Chapter 8.3

All measures are aimed at achieving complete consistency with the UNFCCC report guidelines and the IPCC Guidelines and at preventing any adjustments under the Kyoto Protocol.

Details on the planned improvements are provided in the relevant source-category chapters. The following table summarizes the pertinent statements made in those chapters.

Table 282: Summary of planned improvements as described in the source-category chapters

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
1.	Energy	In future, CO_2 verification will have to be improved especially via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). In the process, reference data from detailed emissions calculation (primarily, activity data) are to be compared more closely with aggregated data from emissions trading. Initial pertinent results are presented in the relevant source category chapters.	Verifiability of CO_2 emissions is to be improved via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). To that end, comparison of a) reference data from detailed emissions calculation (primarily, activity data) and b) aggregated data from emissions trading is to be intensified.	2012	in progress		NIR	Ch. 3.2.1.2.3	2012
1.A	Fuel Combustion Activities	In future, CO_2 verification is to be improved especially via intensified cross-checking of data against data obtained by the German Emissions Trading Authority (DEHSt) in the framework of monitoring of the Emissions Trading Scheme (ETS). In the process, reference data from emissions calculation (primarily, activity rates) are to be compared more closely with aggregated data from emissions trading.	Cross-checking of calculated emissions data against aggregated emissions-trading data provided by the German Emissions Trading Authority (DEHSt) needs to be intensified.	2011	in progress		NIR	Ch. 3.2.1.2.3	2011
1.A.1.a	Public electricity and Heat Production	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO_2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N_2O-emissions behaviour of combustion and gas-turbine systems and the CH_4-emissions behaviour of gas-turbine systems.	Results from the project have to be integrated within the inventory.	2011	in progress		NIR	Ch. 3.2.6.6	2011
1.A.1.a	Public electricity and Heat Production	In addition, plans call for further improvement of the methods for calculating activity data for waste incineration.	Methods for calculating activity data for waste incineration have to be improved further.	2011	done		NIR	Ch. 3.2.6.6	2011
1.A.1.a	Public electricity and Heat Production	Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO_2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH_4 and CO_2 need to be integrated within the inventory.	2012	in progress		NIR	Ch. 3.2.6.6	2012
1.A.1.b	Petroleum Refining	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO_2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N_2O-emissions behaviour of combustion and gas-turbine systems and the CH_4-emissions behaviour of gas-turbine systems. The research project also covers power stations and bottom-heating systems in petroleum refineries.	Results from the project have to be integrated within the inventory.	2011	in progress		NIR	Ch. 3.2.7.6	2011
1.A.1.b	Petroleum Refining	Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO_2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH_4 and CO_2 need to be integrated within the inventory.	2012	in progress		NIR	Ch. 3.2.7.6	2012

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
1.A.1.c	Manufacture of Solid Fuels and Other energy Industries	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO_2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N_2O-emissions behaviour of combustion and gas-turbine systems and the CH_4-emissions behaviour of gas-turbine systems. The research project also covers power stations and other combustion systems of the mining sector.	Results from the project have to be integrated within the inventory.	2011	in progress		NIR	Ch. 3.2.8.6	2011
1.A.1.c	Manufacture of Solid Fuels and Other energy Industries	Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO_2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH_4 and CO_2 need to be integrated within the inventory.	2012	in progress		NIR	Ch. 3.2.8.6	2012
1.A.2.f	Manufacturing Industries and Construction: Other	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO_2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N_2O-emissions behaviour of combustion and gas-turbine systems and the CH_4-emissions behaviour of gas-turbine systems. The research project also covers power stations and other combustion systems of the manufacturing sector – other energy production.	Results from the project have to be integrated within the inventory.	2011	in progress		NIR	Ch. 3.2.9.11.6	2011
1.A.2.f	Manufacturing Industries and Construction: Other	Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO_2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH_4 and CO_2 need to be integrated within the inventory.	2012	in progress		NIR	Ch. 3.2.9.11.6	2012
1.A.3.a	Civil Aviation	The Federal Environment Agency continues to seek an agreement with Eurocontrol regarding the provision of original Eurocontrol data.	An agreement needs to be reached with Eurocontrol relative to provision of original Eurocontrol data.	2011	closed	By now under the auspices of the EU. Therefore no task for the UBA any more.	NIR	Ch. 3.2.10.1.6	2011
1.A.3.a	Civil Aviation	As soon as Eurocontrol provides data from the AEM 3 model, such data can be used in reporting. With such data, the applicable share for national air transports, the breakdown of kerosene consumption by the two relevant flight phases and NO_x, HC and CO emissions data would all be based on calculations pursuant to Tier 3b.	As soon as an agreement between the EU and EUROCONTROL, concerning the availability of data (AEM 3 data), has been achieved, Eurocontrol data have to be integrated within the inventory	2011	closed	Will become part of the inventory plan, at the time when an agreement between EU and EUROCONTROL is achived.	NIR	Ch. 3.2.10.1.6	2011
1.A.3.c	Railways	A project is determining the quantities of coal and coke, and of all other fuels in addition to diesel fuel and biodiesel, used since 1990 .	After the project's completion, data for all fuels should be updated where necessary.	2012	open		NIR	Ch. 3.2.10.3.6	2012
1.A.3.d	Navigation	Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.3.d.	Results from revision of the greenhouse-gas inventory relative to sea transports have to be integrated within the inventory.	2011	overdue		NIR	Ch. 3.2.10.4.6	2011
1.A.3.d	Navigation	Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.3.d.	Results from revision of the greenhouse-gas inventory relative to sea transports have to be integrated within the inventory.	2012	overdue		NIR	Ch. 3.2.10.4.6	2012

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
1.A.3.d	Navigation	In a project, the basic data used in the TREMOD module for inland shipping are being extensively revised.	After the project's completion, the basic data used for inland shipping have to be updated.	2012	open		NIR	Ch. 3.2.10.4.6	2012
1.A.3.e	Other Transportation	As part of a research project, updating of the data described in Chapter 3.2.6.2 for emission factors (except for CO_2) has begun. Initial results from the project are to enter into the NIR report. Parts of that project will address the N_2O-emissions behaviour of combustion and gas-turbine systems and the CH_4-emissions behaviour of gas-turbine systems. The research project also covers gas turbines in natural gas compressor stations.	Results from the project have to be integrated within the inventory.	2011	overdue		NIR	Ch. 3.2.10.5.6	2011
1.A.3.e	Other Transportation	In future, emissions from construction-sector transports will be reported under 1A.2.f ii. No additional improvements are planned at present.	Emissions calculations relative to construction-related transports have to be reported under 1A.2.f ii.	2011	closed	The planned re-allocation of emissions from mobile sources in construction activities currently reported under 1.A.3.e ii to CRF sub-category 1.A.2.f ii in order to achieve comparability to the UNECE NFR structure and with the goal to meet likely new requirements according to the draft 2006 reporting guidelines was cancelled as the final 2006 reporting guidelines as well as the corresponding CRF tables do not incorporate these changes.	NIR	Ch. 3.2.10.5.6	2011
1.A.3.e	Other Transportation	Natural-gas-compressor stations: Following the completion of the research project begun at the end of 2008 (FICHTNER et al. 2011) the emission factorsfor NOx and SO_2 were updated. Updating of the emission factors for CH4 and N2O is currently in progress.	The project's results for CH_4 and CO_2 need to be integrated within the inventory.	2012	overdue		NIR	Ch. 3.2.10.5.6	2012
1.A.4	Other Sectors	The current survey of consumption and emissions of German high-seas fisheries, which is based on a number of highly simplified and conservative assumptions, is to be revised in the medium term.	The assumptions relative to consumption and emissions of German high-seas fisheries have to be revised (cf. the relevant individual objective).	2011	overdue		NIR	Ch. 3.2.11.6	2011
1.A.4	Other Sectors	Currently, the greenhouse-gas inventory for sea transports, including transports between German seaports, is being thoroughly revised. The findings and results from that effort will enter into future reporting on source category 1.A.4.c iii.	The findings and results from the relevant project on maritime transports, FKZ 3709 43 111 / 01, need to be integrated within the inventory.	2012	overdue		NIR	Ch. 3.2.11.6	2012
1.B.1.c	Solid Fuels: Abandoned Mining	Scientific estimates of the relevant quantities of fugitive methane emissions from decommissioned sections of mines are now available. To date, experts have placed these emissions at 300 million m³ and assumed that some 5 million m³ of these escape into the atmosphere. Since this figure is subject to large uncertainties, a research project on "Potential for release and use of pit gas" is working to improve it. Fugitive releases at ground surface amount to no more than 0.02 ‰ of total gas releases.	Results from the project have to be integrated within the inventory.	2011	done		NIR	Ch. 3.3.1.3.6	2011

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
1.B.1.c	Solid Fuels: Abandoned Mining	Scientific estimates of the relevant quantities of fugitive methane emissions from decommissioned sections of mines are now available. To date, experts have placed these emissions at about 260 million m³ and assumed that some 0.5 million to 1 million m³ of these escape into the atmosphere. Fugitive releases at ground surface amount to no more than 0.02 ‰ of total gas releases. The determined emissions have been verified, via research projects, to the year 2009. Plans call for the estimates for subsequent years to be verified as well.	For years as of 2010, estimates relative to the levels of fugitive methane emissions from decommissioned sections of mines need to be verified.	2012	open		NIR	Ch. 3.3.1.3.6	2012
1.B.2	Oil and Natural Gas	The results produced by a research project of Müller-BBM (2009a) include an analysis of the source categories 1.B.2.a.iii-vi, which need to be improved. Additional studies will be carried out in order to obtain still-lacking emission factors and activity rates for these categories.	Lacking emission factors and activity data have to be determined.	2011	overdue		NIR	Ch. 3.3.2.2	2011
1.B.2	Oil and Natural Gas	The results produced by a research project of Müller-BBM (2009a) include an analysis of the source categories 1.B.2.a.i-vi, which need to be improved. Additional studies will be carried out in order to obtain still-lacking emission factors and activity data for these categories.	Lacking emission factors and activity data have to be determined.	2012	overdue		NIR	Ch. 3.3.2.2	2012
1.B.2	Oil and Natural Gas	Research projects are underway to verify emission factors for storage of natural gas.	Emission factors for storage of natural gas need to be verified.	2012	open		NIR	Ch. 3.3.2.2	2012
1.B.2	Oil and Natural Gas	Plans also call for verification of emission factors for gas distribution.	Emission factors for distribution of natural gas need to be verified.	2012	open		NIR	Ch. 3.3.2.2	2012
1.B.2.a.v	Distribution of oil products	A research project will be carried out to update data for cleaning of railway tank cars (UBA 2004b) and to obtain data for other cleaning areas, such as cleaning of inland-waterway tanker ships and road tankers.	The data on cleaning of railway tanker cars (UBA 2004b), and data for other areas of cleaning such as inland-waterway tanker ships and road trankers, need to be updated / determined via the research project. The inventory then has to be revised accordingly.	2012	open		NIR	Ch. 3.3.2.3.5.6	2012
1.B.2.d	Oil and Natural Gas: Distribution/Production	Even though the quantities involved are expected to be very small, plans call for quantification of gas releases from exploratory drilling in cases in which no blow-out preventers are used (in the near-surface range to depths of 400 m).	Gas releases from exploratory wells in which no "blow-out preventers" have been used have to be quantified (cf. the relevant individual objective).	2011	overdue		NIR	Ch. 3.3.2.5.6	2011
1.B.2.d	Oil and Natural Gas: Distribution/Production	Even though the quantities involved are expected to be very small, plans call for quantification of gas releases from exploratory drilling in cases in which no blow-out preventers are used (in the near-surface range to depths of 400 m).	Gas releases from exploratory wells in which no "blow-out preventers" have been used have to be quantified.	2012	overdue		NIR	Ch. 3.3.2.5.6	2012

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
1.B.2.d	Oil and Natural Gas: Distribution/Production	In a departure from the standard concept for such processes, use of fluorinated substances to enhance the efficiency of geothermal electricity and heat generation in low-temperature thermal power stations is currently being tested. The implications of such technical developments, relative to safety and emissions, are being determined by the Federal Environment Agency (UBA). In a workshop ("Effektivität und Umweltverträglichkeit in geothermischen Niedertemperatur-Kreisprozessen"; "Effectiveness and environmental compatibility in low-temperature geothermal circuit processes") held at the Deutscher Bundeskongress Geothermie (a national congress on geothermal energy) that took place in November 2011, such implications were presented and discussed.	Collection of data relative to F gases in the geothermal sector has to be assured.	2012	open		NIR	Ch. 3.3.2.5.6	2012
1.C.1.B	Marine Bunkers	A study is currently gathering AIS- based ship-movement data. The resulting bunkering-quantities data will then be used, in combination with also-updated specific emission factors, for description of the emissions to be assigned to Germany.	Results from the AIS project have to be integrated within the inventory.	2011	overdue		NIR	Ch.3.2.2.3.6	2011
1.C.1.b	Marine Bunkers	In the framework of a study, ship-movement data are currently being determined via the Automatic Identification System (AIS; a radio-based and satellite-based system for transmission of ship data such as size, load, speed, route, etc.). The resulting bunkering-quantities data will then be used, in combination with also-updated specific emission factors, for description of the emissions to be assigned to Germany.	Results from the AIS project have to be integrated within the inventory.	2012	overdue		NIR	Ch. 3.2.2.3.6	2012
2.A.2	Lime Production	The emission factors determined, in the framework of a research project, on the basis of emissions declarations of German lime works (including works producing dolomite) are only of limited use for verification of the figures in the CSE. The completion of that project has been delayed.	Results from the project have to be integrated within the inventory.	2011	done		NIR	Ch. 4.2.2.6	2011
2.A.4	Soda Ash Production and Use	No specific improvements are planned at present. In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method needs to be verified.	In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method needs to be verified.	2011	overdue		NIR	Ch. 4.2.4.6	2011
2.A.4	Soda Ash Production and Use	In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method still needs to be verified.	In light of the large extent of uncertainties relative to quantities of soda ash use, the relevant calculation method needs to be verified.	2012	overdue		NIR	Ch. 4.2.4.6	2012
2.A.5	Asphalt Roofing	The VDD plans to carry out additional considerations relative to export-import offsetting.	A new relevant expert (Fachverantwortlicher) will have to re-study the data relative to correction of foreign-trade statistics – possibly, via the National Co-ordinating Committee. (cf. also "additional need for action")	2011	overdue		NIR	Ch. 4.2.5.6	2011

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
2.A.5	Asphalt Roofing	The VDD plans to carry out additional considerations relative to export-import offsetting.	A new relevant expert (Fachverantwortlicher) will have to re-study the data relative to correction of foreign-trade statistics – possibly, via the National Co-ordinating Committee.	2012	overdue		NIR	Ch. 4.2.5.6	2012
2.A.6	Road Paving with Asphalt	Relevant findings currently available from a research project are to be used for specific evaluation of emission factors.	The emission factors need to be evaluated on the basis of the existing project report.	2011	overdue		NIR	Ch. 4.2.6.6	2011
2.A.6	Road Paving with Asphalt	Relevant findings currently available from a research project are to be used for specific evaluation of emission factors.	The emission factors need to be evaluated on the basis of the existing project report.	2012	overdue		NIR	Ch. 4.2.6.6	2012
2.A.7 (a)	Mineral Products: Other - Glass Production	At present, review of various items of information relative to cullet input is planned. Such review could lead to improvements and slight changes in the relevant emissions level.	The figures relative to cullet inputs need to be reviewed. This should include research into data sources – possibly, carried out via the National Co-ordinating Committee. (cf. also "additional need for action")	2011	overdue		NIR	Ch. 4.2.7.6	2011
2.A.7.a Glas	Mineral Products: Other - Glass Production	At present, review of various items of information relative to cullet input is planned. Such review could lead to improvements and slight changes in the relevant emissions level.	The figures relative to cullet inputs need to be reviewed. This should include research into data sources – possibly, carried out via the National Co-ordinating Committee.	2012	overdue		NIR	Ch. 4.2.7.6	2012
2.C.1	Iron and Steel Production	The plausibility of the consistent statistical figures, net calorific values and emission factors required for the carbon balance for primary steel production is to be reviewed via discussions among experts.	Expert discussions need to be carried out to review the plausibility of the statistical data, net calorific values and emission factors required for the carbon balance for primary steel production.	2011	overdue		NIR	Ch. 4.4.1.6	2011
2.C.1	Iron and Steel Production	The plausibility of the consistent statistical figures, net calorific values and emission factors required for the carbon balance for primary steel production is to be reviewed via discussions among experts.	Expert discussions need to be carried out to review the plausibility of the statistical data, net calorific values and emission factors required for the carbon balance for primary steel production.	2012	overdue		NIR	Ch. 4.4.1.6	2012
2.C.3	Aluminium Production	Determination of uncertainties continues, with the involvement of the industry association. The correct PFC emissions for 2009 will be submitted later.	The "correct" PFC emissions for 2009 need to be incorporated, and the relevant uncertainties need to be determined.	2011	done		NIR	Ch. 4.4.3.6	2011
2.C.4	SF6 Used in Aluminium and Magnesium Foundries	For some time now, discussions have been underway with users with the aim of determining how realistic it is to assume that the emission factor for the aluminium industry is "1". We expect such discussion to produce concrete results by the next round of reporting. In all likelihood, such results will lead to correction of the emission factor.	The emission factor needs to be corrected on the basis of discussions with the "users".	2011	done		NIR	Ch. 4.4.4.6	2011
2.D.1	Pulp and Paper	The CO_2 emissions from caustification in sulphate pulp production are of biogenic origin; thus, they do not have to be reported. In future, CO_2 of biogenic origin may also be reported, in the interest of enhancing transparency.	Review of whether CO_2 of biogenic origin should be reported in future.	2011	overdue		NIR	Ch. 4.5.1.6	2011

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
2.D.1	Pulp and Paper	The CO2 emissions from caustification in sulphate pulp production are of biogenic origin; thus, they do not have to be reported. In future, CO2 of biogenic origin may also be reported, in the interest of enhancing transparency.	Review of whether CO_2 of biogenic origin should be reported in future.	2012	overdue		NIR	Ch. 4.5.1.6	2012
2.F.1	Refrigeration and Air Conditioning equipment	The refrigerant models being used are to be reviewed for currentness.	The refrigerant models used need to be reviewed for currentness.	2012	open		NIR	Ch. 4.7.1.5	2012
4.A	Enteric Fermentation	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2011	open		NIR	Ch. 6.2.6	2011
4.A	Enteric Fermentation	Efforts to improve modelling of feeding of swine continue. To date, the required highly detailed data have been obtained, nationwide, via surveys of experts, and they have been evaluated (Dämmgen et al., 2011b). The next planned next work step is to process the data for GAS-EM inventory model. Possibly, findings from official survey of protein inputs in swine fattening during the period November 2010 to October 2011, which took place in fall 2011, can enter into the model. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH4 emissions from enteric fermentation. Cf. in this regard LfdNr. 3587	Modelling of feeding of swine needs to be improved. The validity of the model calculation needs to be made transparent.	2012	open		NIR	Ch. 6.2.6	2012
4.A	Enteric Fermentation	At the recommendation of the ERT of the in-country review of September 2010, an effort is being made to derive a national methane-conversion factor for dairy cows.	A national methane-conversion factor for dairy cows needs to be derived.	2012	open		NIR	Ch. 6.2.6	2012
4.A	Enteric Fermentation	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2012	open		NIR	Ch. 6.2.6	2012
4.A (b)	Enteric Fermentation - Cattle, Swine, Sheep, Horses	Efforts are currently underway to improve modelling of feeding of swine. The improved model is to include data from a survey to be carried out by the Federal Statistical Office, in November 2011, of protein inputs in swine feeding. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH_4 emissions from enteric fermentation.	Modelling of feeding of swine needs to be improved. The validity of the model calculation needs to be made transparent.	2011	open		NIR	Ch. 6.2.6	2011
4.B	Manure Management	In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.	The results of LZ 2010 have to be integrated within the inventory.	2011	done		NIR	Ch. 6.3.2.6	2011

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
4.B	Manure Management	Efforts are currently underway to improve modelling of feeding of swine. The improved model is to include data from a survey to be carried out by the Federal Statistical Office, in November 2011, of protein inputs in swine feeding. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH_4 emissions from enteric fermentation.	Modelling of feeding of swine needs to be improved.	2011	open		NIR	Ch. 6.3.2.6	2011
4.B	Manure Management	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2011	open		NIR	Ch. 6.3.2.6	2011
4.B	Manure Management	With regard to planned improvements, the reader's attention is called to Chapter 6.3.2.6. The improvement in modelling of feeding of swine is expected to also influence the results for N_2O emissions from manure management.	If improvement of the model for feeding of swine affects N_2O emissions from (farm) manure management, then the pertinent impacts need to be integrated within the inventory.	2011	open		NIR	Ch. 6.3.4.6	2011
4.B	Manure Management	Efforts to improve modelling of feeding of swine continue. To date, the required highly detailed data have been obtained, nationwide, via surveys of experts, and they have been evaluated (Dämmgen et al., 2011b). The next planned next work step is to process the data for GAS-EM inventory model. Possibly, findings from official survey of protein inputs in swine fattening during the period November 2010 to October 2011, which took place in fall 2011, can enter into the model. Improved modelling of feeding of swine will affect data on total energy intake, which serve as a basis for calculating CH4 emissions from enteric fermentation. Cf. in this regard LfdNr. 3586	Modelling of feeding of swine needs to be improved.	2012	open		NIR	Ch. 6.3.2.6	2012
4.B	Manure Management	At the recommendation of the ERT of the in-country review of September 2010, an effort is being made to determine methane-conversion factors (MCF), for the storage procedures commonly used in Germany, that adequately represent national circumstances and are consistent with pertinent measurements. Since the methane-conversion factor MCF and the maximum methane-formation capacity Bo have to be set in relation to one another, efforts are also being made to derive national values for Bo. The results will be reviewed by the newly created KTBL working group on climate protection (sub-working group on manure management).	A national methane-conversion factor for storage procedures in Germany needs to be derived.	2012	open		NIR	Ch. 6.3.2.6	2012
4.B	Manure Management	The fact that part of the liquid manure is processed in biogas systems is currently not being taken into account in the inventory, due to a lack of representative activity data. KTBL is currently carrying out a project aimed at supporting collection of required activity data and emission factors for future reports. In addition, a number of research projects on the same topic are being carried out in Germany.	The results of the KTBL project relative to liquid manure in biogas systems need to be integrated within the inventory.	2012	open		NIR	Ch. 6.3.2.6	2012

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
4.B	Manure Management	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2012	open		NIR	Ch. 6.3.2.6	2012
4.B	Manure Management	The national N2O emission factors currently being used by Germany are to be reviewed by the newly created newly created KTBL working group on climate protection (sub- working group on manure management) (KTBL = Association for Technology and Structures in Agriculture).	The national N_2O emission factors need to be reviewed. The inventory should then be revised, if necessary, in light of the results.	2012	open		NIR	Ch. 6.3.4.6	2012
4.B	Manure Management	The improvement, referred to in Chapter 6.3.2.6 (LfdNr. 3586 + 3587), of modelling of feeding of swine, and collection of data on N-reduced feeding of swine, are expected to influence the results for N2O and NO emissions from manure management.	If improvement of the model for feeding of swine affects N_2O/NO emissions from (farm) manure management, then the pertinent impacts need to be integrated within the inventory.	2012	open		NIR	Ch. 6.3.4.6	2012
4.D	Agricultural Soils	In 2010, the Federal Statistical Office conducted an extensive survey of agricultural data ("Landwirtschaftliche Zählung 2010" ("agricultural census 2010"), LZ2010). Analysis of the LZ2010, with regard to data of relevance for the inventory, is being carried out as of the end of 2010, in co-operation with the Federal Statistical Office.	The results of LZ 2010 have to be integrated within the inventory.	2011	done		NIR	Ch. 6.5.6	2011
4.D	Agricultural Soils	In March 2011, the Federal Statistical Office plans to carry out a special survey of data relative to application of farm manure. The results of that survey will have an impact on the NH_3 and NO emissions of relevance for indirect N_2O emissions.	The Federal Statistical Office's special survey "Data on manure spreading" ("Daten zur Wirtschaftsdünger-Ausbringung") has to be integrated within the inventory.	2011	done		NIR	Ch. 6.5.6	2011
4.D	Agricultural Soils	Currently, efforts to improve modelling of feeding of swine are underway. In addition, the Federal Statistical Office plans to conduct a survey of protein inputs in swine fattening. The model changes are also expected to affect the results for NH_3 emissions from farm-manure management, which are of relevance with regard to indirect N_2O emissions from agricultural soils. In co-operation with the Federal Statistical Office, efforts are being made to produce a reliable estimate of Germany's net imports of farm manure.	Modelling of feeding of swine needs to be improved. The validity of the model calculation needs to be made transparent.	2011	open		NIR	Ch. 6.5.6	2011
4.D	Agricultural Soils	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2011	open		NIR	Ch. 6.5.6	2011

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
4.D	Agricultural Soils	Efforts to improve modelling of feeding of swine continue (DÄMMGEN et al., 2011b). Possibly, findings from official survey of protein inputs in swine fattening during the period November 2010 to October 2011, which took place in fall 2011, can enter into the model. Improved modelling of feeding of swine will affect data on N excretions and, thus, on the N quantities entering the soil via manure management.	Modelling of feeding of swine needs to be improved. The validity of the model calculation needs to be made transparent.	2012	open		NIR	Ch. 6.5.6	2012
4.D	Agricultural Soils	In data management and emissions calculations for this area, a transition is being made from spreadsheet files to a relational database and procedural programmes. That step, for which work began in summer 2010, is oriented primarily to QC/QA purposes. Its benefits, for example, will include facilitation of automatic plausibility checks.	The relational database needs to be completed.	2012	open		NIR	Ch. 6.5.6	2012
4; 5	Agriculture; LULUCF	Improvement of the QA/QC concept (cf. the answer to ERT: Action plan for resolving issues identified by the ERT regarding KP LULUCF).	Completion of the QA/QC concept.	2011	overdue		NIR	Ch. 7.3.8, 7.4.8, 19.5.2.6	2011
5.	LULUCF	A sample-based information system was introduced for determination of area data throughout the entire LULUCF sector. With the data available for the relevant years, each sample point can be assigned a land-use category, tied to a quality level. The land-use categories for each year have been derived from such assignations. In addition, records have been kept of the number of points that are considered validated as a result of agreement with respect to LULUCF categories, on the various quality levels. The percentage of points in 1990 that have not yet been validated is still high. Plans call for that percentage to be considerably improved via integration of new data sources (in particular, 1990 maps derived from ColorInfraRed data) (cf. also Chapter 7.1.3.3).	Improvement of the proportion of validated points for the year 1990. That proportion is to be improved via integration of new data sources (in particular, 1990 maps derived from ColorInfraRed data).	2012	open		NIR	Ch. 7.2.8.1	2012
5.A	Forest Land	*Land-use changes* In the new German Länder, the relevant areas and land-use changes were determined with the help of the data from the GSE FM-INT project. Forest-land parcels with an area of at least 0.5 hectares were categorised. That categorisation produced some discrepancies with forest areas as determined in accordance with the definition of "forest" used in the National Forest Inventory (BWI). A project is to be carried out with the aim determining whether, with the help of additional data sources, the relevant areas in the new German Länder can be determined more precisely for the period 1990 to 2005 (cf. also Chapter 19.5.1.1.3).	Initiation of a project to determine whether, with the help of additional data sources, the relevant areas in the new German Länder can be determined more precisely for the period 1990 to 2005.	2011	closed	Not necessary anymore. For the reason see NIR 2012 chap.7.1.3.2.1.	NIR	Ch. 7.2.8.1	2011

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
5.A	Forest Land	*Land-use changes* The National Forest Inventory 3 (Bundeswaldinventur 3; BWI 3), which is currently being prepared, will make it possible to determine relevant areas and land-use changes in a consistent manner for the entire territory of Germany. The results of BWI 3, which is being carried out from 2011 to 2012, will make it possible to estimate the areas and land-use changes for all LULUCF land categories for the period 2002 through 2012.	Estimation of the applicable land areas, and relevant changes, for all LULUCF land categories, for the period 2002 to 2012, on the basis of the National Forest Inventory 3 (BWI 3).	2011	open		NIR	Ch. 7.2.8.1	2011
5.A	Forest Land	*Litter and mineral soils* Still-lacking Länder data records are to be collected for purposes of future evaluations. To date, it has been possible to calculate carbon stocks for only about half of the BZE II soil-survey points. Inclusion of the currently lacking data will make it possible to carry out evaluations on a basis that is statistically more reliable. The approach chosen, involving main soil units, offers potential for more-detailed evaluation, since the analyses have not yet taken account of covariables (texture, precipitation, temperature, inclination, exposition).	The still-lacking Länder data sets needed for calculation of carbon stocks need to be obtained from the Länder. The approach chosen (cf. the relevant individual objective) needs to be further improved.	2011	open		NIR	Ch. 7.2.8.2	2011
5.A	Forest Land	The BÜK map data are currently being revised. They will soon be published with a higher level of precision (scale of 1:200.000).	Once the BÜK soil map has been revised, it must be determined whether that map's high level of precision has an impacts on emission calculations. The inventory then has to be revised accordingly.	2011	open		NIR	Ch. 7.2.8.2	2011
5.A	Forest Land	*Litter and mineral soils* Evaluation of the data relative to changes in organic carbon in the upper 30 cm of mineral soil shows that sandy soils in particular, soils whose distribution is concentrated in northern Germany, have accumulated carbon since the BZE I survey. A study is already underway, with regard to the BZE, to determine the reasons for the carbon increase. A comparison with a regional soil inventory carried out on long-term study areas (KONOPATZKY 2009) indicates that changes have taken place primarily in recent years. On the other hand, a study carried out in the framework of the BZE has concluded that significant changes of carbon stocks in mineral soil take at least 10 years to become apparent in surveys (MELLERT et al. 2007). It is thus necessary to determine the relevant rate of change via a follow-on inventory. The time for that inventory will be determined after evaluation of the BZE II survey has been completed.	Once the Forest Soil Inventory II (BZE II) has been evaluated, a follow-on inventory needs to be initiated to determine changes in organic carbon in the top 30cm of mineral soils (cf. the relevant individual objective).	2011	open		NIR	Ch. 7.2.8.2	2011

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
5.A	Forest Land	The National Forest Inventory 3 (Bundeswaldinventur 3; BWI 3) that is currently being carried out will add, to the sample-based information system, an important database for determination of activity data. The results of BWI 3, which is being carried out from 2011 to 2012, are expected to make it possible, in 2013, to estimate the areas and land-use changes for all categories of conversion from and to forest land, and for forest land remaining forest land, for the period 2002 through 2012. The high quality of the pertinent data is expected to make highly precise conclusions possible with regard to forest land areas and pertinent changes.	Estimation of the applicable land areas, and relevant changes, for categories of changes to and from forest, and for forest land remaining forest land, for the period 2002 to 2012, on the basis of the National Forest Inventory 3 (BWI 3).	2012	open		NIR	Ch. 7.2.8.1	2012
5.A	Forest Land	Still-lacking Länder data records are to be collected for purposes of future evaluations. To date, it has been possible to calculate carbon stocks for only about 75% of the BZE II survey points. Inclusion of the currently lacking data will make it possible to carry out evaluations on a basis that is statistically more reliable. The approach chosen, involving dominant soil units, offers potential for more-detailed evaluation, since the analyses have not yet taken account of covariables (texture, precipitation, temperature, inclination, exposition). Furthermore, the BÜK map data are currently being revised. They will soon be published with a higher level of precision (scale of 1:200.000).	The still-lacking Länder data sets needed for calculation of carbon stocks need to be obtained from the Länder. The approach chosen needs to be further improved.	2012	open		NIR	Ch. 7.2.8.2	2012
5.A	Forest Land	Evaluation of the data relative to changes in organic carbon in the upper 30 cm of mineral soil shows that sandy soils in particular, soils whose distribution is concentrated in northern Germany, have accumulated carbon since the BZE I survey. A study is already underway, with regard to the BZE, to determine the reasons for the carbon increase. A comparison with a regional soil inventory carried out on long-term study areas (KONOPATZKY 2009) indicates that the changes have taken place primarily in recent years. On the other hand, a study carried out in the framework of the BZE has concluded that significant changes of carbon stocks in mineral soil take at least 10 years to become apparent in surveys (MELLERT et al. 2007). It is thus necessary to determine the relevant rate of change via a follow-on inventory. The time at which that inventory is to be carried out will not be decided until after the BZE II inventory has been evaluated.	Once the Forest Soil Inventory II (BZE II) has been evaluated, a follow-on inventory needs to be initiated to determine changes in organic carbon in the top 30cm of mineral soils.	2012	open		NIR	Ch. 7.2.8.2	2012

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
5.A, 5.B, 5.C	Forest Land, Cropland, Grassland	The values listed in the above chapters are the best data now available in complete-coverage form. Major inventories for determination of the carbon and nitrogen stocks in mineral soils have been carried out, and are being carried out, in Germany, with a view to improving such data: • The Forest Soil Inventory II (Bodenzustandserhebung II Wald), for all forest soils (currently being evaluated) • The Agricultural Soil Inventory (Bodenzustandserhebung Landwirtschaft), for cropland and grassland soils These two major inventories cover some 84 % of Germany's total area, an area which corresponds to about 88 % of its mineral-soil area. • The results of the inventories are gradually being used for determination of precise emission factors. • As part of integration of the results of the major inventories, the reporting system for mineral soils (Berichtssystem Mineralboden) is to be converted from a soil depth of 30 cm to a depth of 1 m.	The results of the major inventories (BZE II Wald (Forest Soil Inventory II), BZE LaWi-Acker-Grünl. (inventory of agricultural, cultivated and grassland soils) need to be integrated within the inventory, and pertinent reporting for mineral soils needs to cover a soil depth of 1 m (i.e. a transition needs to be made from current 30 cm coverage).	2012	open		NIR	Ch. 19.5.2.2.6	2012
5.A; 5.B; 5.C; 5.D	Forest Land, Cropland, Grassland, Wetland	The area-identification process, for all categories, will be converted to an approach that uses a point raster and that is consistent for purposes of reporting forest categories and reporting in the KP-LULUCF framework. In addition, that method will simplify use of other data/sources, such as data from the European LUCAS grid, and satellite/aerial photos, etc., thereby making it possible for backward projections to 1990 to draw on additional data sources.	Preparation of a consistent land-use matrix (cf. also the relevant Action Plan), on the basis of a consistent sampling network.	2011	done		NIR	Ch. 7.3.8, 7.4.8, 19.5.2.6; ActPl	2011
5.B, 5.C	Cropland, Grassland	Improvement of the area data for organic soils under cultivation: ongoing research project.	The area data for organic soils on cropland need to be improved.	2012	open		NIR	Ch. 7.3.8	2012
5.B, 5.C	Cropland, Grassland	Mineral soils: Agricultural soil inventory: generation of national measurements of C stocks, for cropland and grassland.	On the basis of the Agricultural Soil Inventory, data on C stocks in mineral soils need to be derived for cropland and grassland, and the inventory has to be improved accordingly.	2012	open		NIR	Ch. 7.3.8	2012
5.B, 5.C	Cropland, Grassland	Mineral soils: Agricultural Soil Inventory: gradual revision of the database for mineral soils.	The database for mineral soils needs to be revised on the basis of the Agricultural Soil Inventory, and the inventory has to be improved accordingly.	2012	open		NIR	Ch. 7.3.8	2012
5.B, 5.C	Cropland, Grassland	Organic soils: Greenhouse gas measurements for improvement and validation of the relevant emission factors: ongoing research project.	The national emission factors for organic soils need to be improved and validated with the help of greenhouse-gas measurements.	2012	open		NIR	Ch. 7.3.8	2012
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	The point raster will ensure that reporting for the "cropland" category is spatially and chronologically consistent, and it will make it possible to reconstruct actual land use between 1990 and 2000 in a consistent manner.	Reconstruction of a contradiction-free land-use matrix for 1990 (cf. also Action Plan, Chapter 1).	2011	done		NIR	Ch. 7.3.8, 7.4.8, 19.5.2.6; ActPl	2011

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Changes in the system for reporting emissions from mineral soils: Derivation of typical, use-dependent carbon stocks in mineral soils, weighted by soil type and area, for all of Germany Development of a new system for describing carbon-stock changes as a function of land use	Improvement of the procedure for estimating C-stock changes in mineral soils, for all land-use categories, by making a methodological transition to a symmetric approach (cf. also Action Plan Chapter 1).	2011	done		NIR	Ch. 7.3.8, 7.4.8, 19.5.2.6; ActPl	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	New emission factors, differentiated by soil type and soil use, for organic soils	Determination of differentiated EF for organic soils.	2011	open		NIR	Ch. 7.3.8, 7.4.8, 19.5.2.6	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Change in the system for determining carbon-stock changes in biomass: Reduction in the total number of emission factors, via calculation of area-weighted mean values for all of Germany. An increase, over the number used to date, in the number of plant species that enter into area-weighted mean values	Reduction of the EF used to date, by calculating area-weighted means for all Germany and by including more plant species.	2011	done		NIR	Ch. 7.3.8, 7.4.8, 19.5.2.6	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Change in the system for determining carbon-stock changes in biomass: Separate calculation of carbon stocks for above-ground and below-ground biomass New country-specific default factors for carbon stocks in wood plantations outside of forests	Calculation of carbon stocks separately for above-ground and below-ground biomass, and determination of new, country-specific default factors for carbon stocks in wood stands outside of forests (cf. also the Action Plan).	2011	done		NIR	Ch. 7.3.8, 7.4.8, 19.5.2.6	2011
5.B; 5.C; 5.D	Cropland, Grassland, Wetland	Complete, GPG-conformal uncertainties calculation	Requirements-conformal calculation of uncertainties for all land-use categories.	2011	done		NIR	Ch. 7.3.8, 7.4.8, 19.5.2.6	2011
5.D	Wetland	In the wetlands category, an effort is being made to derive country-specific emission factors for emissions of the greenhouse gases CO_2, N_2O and CH_4 from peat extraction. To this end, measurements are being carried out, in the framework of the project "Organic Soils", that cover all phases of this form of land use (cf. Chapter 19.5.2.6). The results will be used for parametrisation and validation of mathematical models, and for determination of country-specific, regional default factors. As soon as they become available, the results of this project will enter into national reporting.	The results from the project have to be integrated within the inventory.	2011	open		NIR	Ch. 7.5.8	2011
5.E	Settlements	Planned source-specific improvements for this sector include determination of country-specific emission factors for vegetation cover in cities and settlements and along transport infrastructure. A preliminary study has been commissioned to this end. The project will determine carbon stocks, and their changes, in urban trees. (cf. Chapter 19.5.2.6).	Country-specific emission factors need to be determined for vegetated areas in cities, in settlements and along transport infrastructure. The inventory needs to be revised on the basis of the results of the pilot study and of the pertinent subsequent projects.	2011	closed	Planned improvement has been devided in 2012 Reporting into two improvements.	NIR	Ch. 7.6.8	2011

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
5.E	Settlements	Two pilot projects are currently underway for development of methods for determining wood biomass in settlements. The pilot projects are studying two German cities in this regard.	Country-specific emission factors need to be determined for vegetated areas in cities, in settlements and along transport infrastructure. In addition, such factors must explicitly include hedges. The inventory needs to be revised on the basis of the results of the pilot studies and of the pertinent subsequent projects.	2012	open		NIR	Ch. 7.6.8	2012
6.A.1	Controlled landfilling of waste	An experts' assessment (Wasteconsult international, 2009) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. The assessment confirms that emissions contributions of MBT systems' waste are very low in comparison to total landfill-gas emissions. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. The kinetics of landfill-gas formation in MBT waste are to be examined, in a further study, and then described in an improved model.	The results from the project have to be integrated within the inventory.	2011	open		NIR	Ch. 8.2.1.6	2011
6.A.1	Controlled landfilling of waste	In future, the Federal Statistical Office plans to collect data on landfill-gas collection and use also from landfills in their after-closure phases. It is expected that in 2012 environmental statistics will include, for the first time, data on landfill-gas collection that have been collected in a consistent manner, from all relevant landfills.	If environmental statistics in 2012 include consistently collected data on collection of landfill gas, for all landfills, then the inventory needs to be revised accordingly on the basis of the new data.	2011	open		NIR	Ch. 8.2.1.6	2011
6.A.1	Controlled landfilling of waste	An experts' assessment (Wasteconsult international, 2009) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. The assessment confirms that emissions contributions of MBT systems' waste are very low in comparison to total landfill-gas emissions. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. The kinetics of landfill-gas formation in MBT waste are to be examined, in a further study, and then described in an improved model. The results of the study are to be used to describe, more precisely, and quantify the expected methane emissions from MBT waste, so that the emissions values derived via expert assessment in the aforementioned study (WASTECONSULT INTERNATIONAL, 2009) can be replaced with the improved data. The study was awarded in October 2011 in the framework of a public invitation to tender.	The inventory needs to be improved on the basis of the study results. The study results need to be documented.	2012	open		NIR	Ch. 8.2.1.6	2012
6.A.1	Controlled landfilling of waste	In future, the Federal Statistical Office plans to collect data on landfill-gas collection and use also also from landfills in their after-closure phases. It is expected that in 2012 environmental statistics will include, for the first time, data on landfill-gas collection that have been collected in a consistent manner, from all relevant landfills.	The data on landfill-gas formation that the Umweltstatistik 2012 (2012 environmental statistics) completed need to be integrated within the inventory.	2012	open		NIR	Ch. 8.2.1.6	2012

Category	Category name	Planned improvement	Need for action	IP [year]	STATUS	Comment	Source	Source reference	Reporting year
6.D.1	Composting	Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improving the database for the emission factors for CH_4 and N_2O. The project includes both research, to obtain pertinent literature data, and measurements of composting and fermentation facilities. The project aim is to produce emission factors based on measured emissions from real systems. This project, when completed, is expected to yield new emission factors for both gases.	The results from the project have to be integrated within the inventory.	2011	open		NIR	Ch. 8.5.1.6	2011
6.D.1	Composting	Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improving the database for the emission factors for CH4 and N2O. The project includes both research, to obtain pertinent literature data, and measurements of composting and fermentation facilities. The project aim is to produce emission factors based on measured emissions from real systems. The project is expected to yield new emission factors, for both gases, that will then need to be integrated within the inventory.	The results from the project have to be integrated within the inventory.	2012	open		NIR	Ch. 8.5.1.6	2012
6.D.2	MBT	The Federal Environment Agency plans to urge the Federal Statistical Office to take account, in its data collection, of versions of MBT systems that have not been included to date.	The Federal Statistical Office needs to be requested to gather data on types of waste-incineration plants that have not been included in surveys to date. The inventory then has to be revised accordingly.	2011	open		NIR	Ch. 8.5.2.6	2011
6.D.2	MBT	The Federal Environment Agency plans to urge the Federal Statistical Office to take account, in its data collection, of versions of MBT systems that have not been included to date. To that end, a joint discussion involving the MBT operators and the Federal Statistical Office is planned.	The Federal Statistical Office needs to be requested to gather data on types of waste-incineration plants that have not been included in surveys to date. The inventory then has to be revised accordingly.	2012	open		NIR	Ch. 8.5.2.6	2012

10.4.2 KP & LULUCF

The improvements described in the Convention inventory for the LULUCF sector in areas 5.A and 5.B.2.1 through 5.F.2.1 are also to be applied to the KP-LULUCF inventory (cf. Chapter 10.4.1).

11 SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11.1 General information

11.1.1 Definition of forest, and any other criteria

The National Forest Inventory is the main data source used for determination of activity data and emission factors. Its forest definition serves as a basis for the report and is presented in Chapter 7.2.3.1.

In keeping with Germany's initial report under the Kyoto Protocol (UNFCCC 2007), Germany has selected the following specific parameters for the national forest definition:

Table 283: Definition of forest in Germany

Parameter	Range	Selected value
Minimum area of land	0.05 – 1.00 ha	0.1 ha
Tree crown cover or equivalent stocking level	10 – 30 %	10 %
Potential tree height at maturity	2 – 5 m	5 m

Within the range defined by the Marrakesh Accords, these values are the ones that come closest to the definition used in the National Forest Inventory. As comparative studies have shown, the differences between activity-data calculations carried out using the definitions of the National Forest Inventory (BWI) and these values are negligible.

The first National Forest Inventory does not include data for the new German Länder, and the project GSE Forest Monitoring (GSE 2003, GSE 2006, GSE 2007, GSE 2009) was carried out to compensate for that gap. Working on the basis of maps, it determined forest cover, and its changes, between 1990 and 2002 and between 1990 and 2005/2006. The forest definition used within GSE was based on the internationally accepted definition of the FAO, however, which specifies a minimum area of land of 0.5 ha (cf. also OEHMICHEN et al. (2011b)). The original data available to the Johann Heinrich von Thünen Institute (vTI) include land areas and land-use changes smaller than the 0.5 ha threshold, and down to a pixel size of 25m x 25m. Such smaller units may be considered similar to the "minimum mapping units" used in the National Forest Inventory (cf. also Chapter 7.1.3.2.1).

Pursuant to UNFCCC (1998), areas are to be assigned to the categories afforestation and deforestation if they have been afforested / deforested since 1990. Such areas remain in assigned categories until the end of the commitment period. As a result the areas of said categories increase constantly. For afforested areas, so GPG LULUCF (IPCC 2003), a further distinction must be made between a) areas not harvested, or deforested by natural disturbances during the first commitment period (units of land subject to activities under Art. 3.3) and b) areas harvested, or deforested by natural disturbances followed by re-establishment of forest (units of land subject to activities under Art. 3.3 which would otherwise be included in land subject to elected activities under Art. 3.4). Germany has no areas, however, which have been afforested since 1990 and were already harvested again. Short rotation coppices do not fall within the national definition of forest under the greenhouse gas reporting (cf. Chapter 7.2.3.1).

In Germany, as a general rule, clear-cut or cleared forest areas have to be reforested or replenished (cf. Art. 11 (1) p. 2 Federal Forest Act (BWaldG)). Areas that have been afforested since 1990, but temporarily have no forest cover as a result of natural disasters, continue to fall within the definition of forest and must be reforested. Deforestation as a result of natural disasters does not occur in Germany.

11.1.2 Elected activities under Article 3, paragraph 4 of the Kyoto Protocol

In keeping with its initial report under the Kyoto Protocol, Germany has elected the option of crediting forest management pursuant to Article 3 (4) of the Kyoto Protocol.

11.1.3 Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

The definitions used by Germany for afforestation, reforestation and deforestation are in accordance with the Marrakesh Accords (MA). Pursuant to the MA, "Afforestation is the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and / or the human-induced promotion of natural seed sources[92]." Reforestation differs from afforestation solely with regard to the time since the area was last forested and occurs on land that has not been forest since 31 December 1989[93]. Since the reporting period for Germany begins with the reference year 1990, and since adequate data for differentiation of land-use forms did not become available until 1970, afforestation and reforestation are considered together in the present context (hereafter both referred to as afforestation). Afforestation means the establishment of trees on abandoned land, if the relevant rejuvenation suffices for producing forest in accordance with the national forest definition. In general, the time of afforestation is the time at which the first activity in the relevant regeneration process was carried out. In the case of spontaneous regeneration of trees, an area is considered afforested if it corresponds to the German definition of forest adopted, i.e. when the natural forest cover has reached an average age of five years, and a crown cover of at least 50 % (cf. Chapter 7.2.3.1).

The category "afforestation" corresponds to the following categories within the reporting under the Convention:

92 Annex A Paragraph 1 lit. b to Decision 16/CMP.1 (FCCC/KP/2005/8/Add.3, page 5).

93 IPCC LULUCF GPG (2003), Section 4.2.5.1.

Table 284: Afforestation in KP and UNFCCC categories

Category for KP reporting	Category pursuant to UNFCCC	
Afforestation under Art. 3.3 KP	5.A.2.1 Cropland converted to forest land	
	5.A.2.2. Grassland converted to forest land	5.A.2.2.1 Grassland (i.t.n.s.) converted to forest land
		5.A.2.2.2 Woody grassland converted to forest land
	5.A.2.3. Wetlands converted to forest land	5.A.2.3.1 Wetlands (terrestrial) converted to forest land
		5.A.2.3.2 Waters converted to forest land
	5.A.2.4. Settlements converted to forest land	
	5.A.2.5. Other land converted to forest land	

The IPCC defines deforestation as "the direct human-induced conversion of forested land to non-forested land"[94]. In accordance with the provisions of IPCC [95] harvest that is followed by regeneration is not considered deforestation, since harvesting is a forest management activity pursuant to Art. 3.4. Forest cover loss resulting from natural disturbances, such as wildfires, insect epidemics or wind storms, are also not considered as deforestation, since these areas will regenerate naturally or with human assistance. Such areas also fall within the category of forest management pursuant to Art. 3.4 or, if the areas were afforested, within the category of afforestation pursuant to Art. 3.3.

Where, since 1990, human activities have taken place on such areas temporarily without forest cover – activities such as road construction, settlement construction or other forms of land use (management of grassland or wetlands) – and such activities prevent forest regeneration, then such areas are considered deforested in accordance with IPCC.

The category deforestation corresponds to the following categories within the reporting under the Convention (NO = not occurring):

[94] Annex A No 1 lit. d FCCC/CP/2001/15/Add.1, page 58.

[95] Cf. IPCC LULUCF GPG (2003), Section 4.2.6.1.

Table 285: Deforestation in KP and UNFCCC categories

<table>
<tr><th>Category in KP reporting</th><th colspan="2">Category pursuant to UNFCCC</th></tr>
<tr><td rowspan="8">Deforestation under Art. 3.3 KP</td><td>5.B.2.1. Forest land converted to cropland</td><td></td></tr>
<tr><td rowspan="2">5.C.2.1. Forest land converted to grassland</td><td>5.C.2.1.1 Forest land converted to grassland (i.t.n.s)</td></tr>
<tr><td>5.C.2.1.2 Forest land converted to woody grassland</td></tr>
<tr><td rowspan="2">5.D.2.1. Forest land converted to wetlands</td><td>5.C.2.1.1 Forest land converted to wetlands (terrestrial)</td></tr>
<tr><td>5.C.2.1.2 Forest land converted to waters</td></tr>
<tr><td>5.E.2.1. Forest land converted to settlements</td><td></td></tr>
<tr><td>5.F.2.1. Forest land converted to other land</td><td>(NO)</td></tr>
</table>

All forest areas in Germany that have been forest since 1990 are considered managed within the meaning of the Marrakesh Accords[96] and are reported under *forest management* pursuant to Art. 3.4 KP. A detailed justification is presented in Chapter 11.5.1.

Table 286: Forest management in KP and UNFCCC categories

Category in KP reporting	Category pursuant to UNFCCC
Forest management under Art. 3.4 KP	5.A.1 Forest land remaining forest land

Since every land-use change to forest is considered afforestation, every land-use change from forest land to a different land-use category is considered deforestation, and all forest areas not afforested are subject to forest management, there is no possibility that the manner in which the relevant definitions are applied could change over time.

11.1.4 Description of precedence conditions and/or hierarchy among Article 3.4 activities, and how they have been consistently applied in determining how land was classified

Since Germany has elected only the activity *forest management* under Art. 3.4 KP, no hierarchy needs to be defined.

Pursuant to the provisions of GPG LULUCF (2003)[97], forest management can take place only on lands that meet the definition of forest. The forest areas reported under FM are those reported within the Convention under *forest land remaining forest land*. All German forest areas are considered managed within the meaning of the provisions of the Marrakesh Accords. The definition of forest management is interpreted in a broad way (cf. for a detailed discussion Chapter 11.5.1).

11.2 Land-related information

11.2.1 Spatial assessment unit used for determining the area of the units of land under Article 3.3

The method used to derive activity data (areas) is described in Chapter 7.1.3. It corresponds to report method 1 pursuant to the GPG for LULUCF (IPCC 2003). The area reference unit is

[96] Paragraph 1 lit. f of Annex A of Decision 16/CMP.1

[97] IPCC LULUCF GPG (2003), Section 4.1.2

Germany. The areas in the "forest" land-use category, and their additions and removals, are derived primarily from the point data of the National Forest Inventories (BMELV 2005). For the new German Länder, the National Forest Inventory (BWI) data have been supplemented with data from the project GSE FM-INT (GSE 2003, GSE 2006, GSE 2007, GSE 2009) (cf. also Chapters 7.2.2 and 7.2.3).

11.2.2 Methodology used to develop the land transition matrix

The method used to define forest areas, and to derive areas for the "change" classes, is described in detail in Chapters 7.1.3 and 7.2.3.2. Table 287 provides an overview of land-use changes leading to forest land (afforestation), of land-use changes leading away from forest land (deforestation), and of managed areas (forest management) for the period 1990 to 2010. Conversion areas remain in their relevant conversion classes until the end of the commitment period for the 2012 Kyoto Protocol. As a result, the annual areas accumulate.

Table 287: Areas in the categories afforestation, deforestation and forest management, 1990 to 2010

Year	Afforestation/ Reforestation (KP 3.3) [kha]	Deforestation (KP 3.3) [kha]	Forest Management (KP 3.4) [kha]
1990	28.086	15.142	10,738.559
1991	56.173	30.284	10,723.418
1992	84.259	45.426	10,708.276
1993	112.346	60.568	10,693.134
1994	140.432	75.710	10,677.992
1995	168.519	90.852	10,662.850
1996	196.605	105.994	10,647.708
1997	224.692	121.136	10,632.566
1998	252.778	136.278	10,617.424
1999	280.865	151.420	10,602.282
2000	308.951	166.562	10,587.140
2001	318.630	170.166	10,583.536
2002	328.309	173.769	10,579.932
2003	337.988	177.373	10,576.328
2004	347.667	180.977	10,572.724
2005	357.346	184.581	10,569.121
2006	363.117	187.963	10,565.738
2007	368.889	191.345	10,562.356
2008	374.660	194.728	10,558.974
2009	375.802	195.767	10,557.935
2010	376.944	196.806	10,556.895

11.2.3 Maps and/or databases to identify the geographical locations, and the system of identification codes for the geographical locations

The following data sources were used in determination of activity data:

- National Forest Inventory 1 (Bundeswaldinventur; BWI 1)
- National Forest Inventory 2 (Bundeswaldinventur; BWI 2)
- Inventory Study 2008 (Inventurstudie; IS08)
- Datenspeicher Waldfonds (DSW)
- Forest Soil Inventory I (Bodenzustandserhebung im Wald I; BZE I)

- Forest Soil Inventory II (Bodenzustandserhebung im Wald II; BZE II)
- Soil-inventory data from the project BioSoil (BioSoil)
- GSE Forest Monitoring: Inputs for national greenhouse-gas reporting (GSE FM-INT)
- Official topographic-cartographic information system (Amtliches Topographisch-Kartographisches Informationssystem; ATKIS®)
- CORINE Land Cover (CLC)
- soil map for the Federal Republic of Germany 1:1,000,000 (Bodenübersichtskarte der Bundesrepublik Deutschland; BÜK 1000)
- Forest-fire statistics of the Federal Republic of Germany
- Fertiliser statistics of the Federal Statistical Office

Detailed descriptions of the data sources are presented in Chapters 7.2.2 and 7.1.3.2.1.

11.3 Activity-specific information

11.3.1 Methods for carbon stock change and greenhouse gas emission and removal estimates

11.3.1.1 Description of methodologies and the underlying assumptions used

11.3.1.1.1 Summary

For the period 1987 to 2002 in the old German Länder, and for the period 2002 to 2008 in all German Länder, up-scaling was carried out for this category on the basis of individual-tree data from the National Forest Inventories and from the Inventory Study 2008 (samples, Tier 2). In addition, the C stocks for deforestation areas were estimated (cf. Chapter 11.3.1.1.2). The C stocks of the old German Länder, in this category for the period from 1987 to 2002, were applied to the forest land converted to other land areas in the new German Länder, since the Datenspeicher Waldfonds forest database does not provide any information in this regard. The C emissions that are assigned to these areas are higher, as a result of their stock accumulations, than C binding by new forest lands. All in all, carbon stocks of some -32.63 Mg ha^{-1} were lost from biomass (not including the biomass of the converted land) in this category in 2010. As a simplification, it was assumed that C stocks are emitted into the atmosphere in the year in which the land was converted.

The emission factors derived from biomass losses, and from the areas calculated for each relevant year since 1987, decreased continuously, for purposes of reporting under the Kyoto Protocol, from 1990 to 2010. This is due solely to the fact that the relevant areas remain in the deforestation category as of 1990, with the result that the total area increases in each report year.

The C-stock differences between the five "forest land converted to other land" LULUCF categories (5.B.1 through 5.F.1) were not studied in detail, since too few sampling elements are available for that purpose. Such study, in other words, would provide illusory precision, i.e. "precision" that would disappear within sampling errors and in the other error categories.

In addition to losses of biomass in connection with conversion of forest land, other types of losses must be considered as well, including losses in the areas of dead wood, litter, mineral soils and organic soils. In the case of dead wood and litter, it is assumed that the pertinent losses take the form of emissions in the year of conversion. Emissions from organic soils take place each year on the entire deforestation area. For mineral soils, a transition time of

20 years is assumed. Table 288 provides an overview of carbon-stock losses, for deforestation, for the period as of 2008.

Table 288: Carbon-stock losses from biomass (including the biomass of the converted land), dead wood, litter and mineral and organic soils, for deforestation as of 2008; positive: C sink; negative: C emissions

Pool	Carbon-stock loss [Gg]		
	2008	2009	2010
Biomass	-54.548	-8.441	-8.491
Dead wood	-10.977	-3.470	-3.567
Litter	-62.986	-19.306	-19.260
Mineral soils	53.756	54.095	50.255
Organic soils	-51.150	-51.219	-51.259
Total	**-125.906**	**-28.341**	**-32.322**

11.3.1.1.2 Biomass

Information on methods used for calculating carbon stocks, and carbon-stock changes, in above-ground and below-ground biomass is presented in the following chapters:

- Forest Land remaining Forest Land cf. Chapter 7.2.4.1.1.
- Land converted to Forest Land cf. Chapter 7.2.4.1.2.

Deforested areas:

With regard to deforested areas, an individual-tree calculation was carried out on the basis of the BWI (NFI) 1, BWI 2 and IS08 inventories. For the period between the BWI 1 and BWI 2 inventories, only trees in the old German Länder were considered, since the BWI 1 inventory was carried out only there. The wood-stocks data for the old German Länder were applied to the new German Länder. For the period as of 2002, an individual-tree calculation, spanning the BWI 2 and IS08 inventories, was carried out for Germany as a whole. The carbon stocks were calculated for each LULUCF class and then, at the end of the process, combined within a deforestation class. The stocks of subsequent final-use classes were deducted – and thus taken into account. The carbon stocks released upon deforestation are counted, completely, as "emissions" in the same year.

Additional methodological descriptions are presented in the following chapters:

- Derivation of individual-tree biomass, cf. Chapter 7.2.4.1.3.
- Conversion to above-ground individual-tree biomass, cf. Chapter 7.2.4.1.4.
- Conversion to below-ground biomass, cf. Chapter 7.2.4.1.5.
- Conversion of individual-tree biomass to carbon, cf. Chapter 7.2.4.1.6
- Procedures for scaling up to relevant states in 1987, 2002 and 2008, cf. Chapter 7.2.4.1.7.
- Up-scaling procedures for obtaining changes between 1987 and 2002, and between 2002 and 2008 (derivation of stock changes via the "stock-change method"), cf. Chapter 7.2.4.1.8.
- Interpolation of time periods, to obtain annual-change estimates, cf. Chapter 7.2.4.1.9.

11.3.1.1.3 Dead wood

Information on methods used for calculating carbon stocks and carbon-stock changes in dead wood is presented in the following chapters:

- Forest land remaining Forest Land, cf. Chapter 7.2.4.2.1.
- Land converted to Forest Land, cf. Chapter 7.2.4.2.2.

Deforested areas:

The C stocks in dead wood were calculated with data of the BWI 2 survey and the Inventory Study 2008 (IS08). According to those calculations, the average carbon stocks in dead wood amounted to 2.68 Mg ha^{-1} in 2002 (BWI 2) and to 3.25 Mg ha^{-1} in 2008 (IS08). For the years 2003 to 2007, the stocks were derived by interpolating the status data for the times 2002 and 2008. For the period 1990 to 2001, and for the period as of 2009, the stocks were derived via extrapolation of the same status data. In each case of deforestation, the carbon stocks in dead wood, for the relevant year, were taken into account immediately as C emissions.

11.3.1.1.4 Litter

Information on methods used for calculating carbon stocks and carbon-stock changes in litter is presented in the following chapters:

- Forest land remaining Forest Land, cf. Chapter 7.2.4.3.1.
- Land converted to Forest Land cf. Chapter 7.2.4.3.2.

Deforested areas:

Calculations relative to the litter ground cover were carried out with the status data of BZE I and the status data of BZE II / BioSoil soil inventories. According to the relevant calculations, the average carbon stocks in litter amounted to 19.4 Mg ha^{-1} in 1990 (BZE I) and to 18.7 Mg ha^{-1} in 2006 (BZE II / BioSoil). For the years 1991 to 2005, the stocks were derived by interpolating the status data for the times 1990 and 2006. For the period as of 2007, the stocks were obtained via extrapolation. In each case of deforestation, the carbon stocks in litter, for the relevant year, were taken into account immediately as C emissions.

Additional methodological descriptions are presented in the following chapters:

- Derivation of litter carbon stocks in 1990 (BZE I) and 2006 (BZE II/BioSoil), cf. Chapter 7.2.4.3.3.
- Derivation of carbon-stock changes in litter in the period from 1990 (BZE I) to 2006 (BZE II/Biosoil), cf. Chapter 7.2.4.3.4.

11.3.1.1.5 Mineral soils

Information on methods used for calculating carbon stocks and carbon-stock changes in mineral soils is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 7.2.4.4.1.
- Land converted to Forest Land cf. Chapter 7.2.4.4.2.

Deforested areas:

For land converted to forest land, the carbon-stock changes in mineral soils were calculated in keeping with the procedures in Table 289 and Chapter 19.5.2. The area-weighted emission factor for deforestation in 2010 is 0.271 MgC ha^{-1}.

Table 289: Emission factors for mineral soils of deforestation categories (negative = loss; positive = sink)

Land-use change	Emission factor [MgC ha^{-1} a^{-1}]
Forest land converted to cropland	-0.100
Forest land converted to grassland	0.770
Forest Land converted to woody gl.	0.558
Forest land converted to wetlands	0.598
Forest land converted to water	0.000
Forest land converted to settlements	-0.168
Forest land converted to other land	NO

Additional methodological descriptions are presented in the following chapters:

- Derivation of carbon stocks and carbon-stock changes, cf. Chapter 7.2.4.4.3.
- Results of derivation of carbon stocks and carbon-stock changes, cf. Chapter 7.2.4.4.4.

11.3.1.1.6 Organic soils

Information on methods used for calculating carbon stocks and carbon-stock changes in organic soils is presented in the following chapters:

- Forest Land remaining Forest Land, cf. Chapter 7.2.4.5.1.
- Land converted to Forest Land cf. Chapter 7.2.4.5.2.

<u>Deforested areas:</u>

For land converted to non-forest land, the carbon-stock changes in organic soils were calculated in keeping with the procedures in Table 290 and Chapter 7.1.6. The area-weighted emission factor for deforestation in 2010 is -4.643 MgC ha^{-1}. It is important to remember that these calculations do not yield the carbon-stock difference between forest land and the subsequent use; they yield the emissions for the new use, in keeping with drainage intensity. Organic soils under forest already emit 0.68 MgC ha^{-1} a^{-1}.

Table 290: Emission factors for organic soils of deforestation categories (negative = loss; positive = sink)

Land-use change	Emission factor [MgC ha^{-1} a^{-1}]
Forest land converted to cropland	-11.00
Forest land converted to grassland	-5.00
Forest Land converted to woody gl.	-0.68
Forest land converted to wetlands	0.00
Forest land converted to water	0.00
Forest land converted to settlements	-5.00
Forest land converted to other land	0.00

11.3.1.1.7 Other greenhouse-gas emissions from forests

Information related to calculations of other greenhouse-gas emissions from forests is presented in the following chapters:

- Liming cf. Chapter 7.2.4.6.1.
- Wildfires cf. Chapter 7.2.4.6.2.

- Drainage cf. Chapter 7.2.4.6.3.
- Land-use changes from forest land to cropland cf. Chapter 7.2.4.6.4.

11.3.1.2 Justification when omitting any carbon pool or of greenhouse gas emissions / removals from activities under Article 3.3 and elected activities under Article 3.4

For mineral soils of forest land remaining forest land, it was shown, from current data, that that pool is not a source for purposes of the greenhouse-gas inventories. A detailed pertinent description is presented in Chapter 7.2.4.4. Since the pertinent data are still incomplete, they have not been included in the CRF tables in which NO (not occurring) has been entered.

No dead wood occurs on new forest land. Since the dead wood pool thus cannot be a source, NO (not occurring) is entered in the CRF tables. A detailed justification for this approach is presented in Chapter 7.2.4.2.2.

No fertilisation of forest areas, with mineral fertilisers, takes place in Germany. For this reason, fertilisation with mineral fertilisers is listed as NO (not occurring) in the CRF tables.

No areas with mineral soils that are subject to drainage are known; for this reason, NO (not occurring) is entered for this category in the CRF tables (cf. Chapter 7.2.4.6.3).

11.3.1.3 Information on whether or not indirect and natural greenhouse gas emissions and removals have been factored out

No indirect or natural greenhouse-gas emissions or sinks were taken into account.

11.3.1.4 Changes in data and methods since the previous submission (recalculations)

In the report, new data sources and methods were taken into account, and recalculations were carried out for selected time series. Details on the new data sources used, and on the pertinent new calculations, are presented in Chapter 7.2.7.1 for forest land remaining forest land.

As a result of recommendations made in the 2010 in-country review UNFCCC, 2011), recalculation of the land-area matrix for the entire LULUCF sector was required. Table 291 compares the current land-use matrix for purposes of reporting under the Kyoto Protocol to last year's matrix.

Table 291: Comparison of the land-use matrices, as reported in 2012 and 2011, for reporting under the Kyoto Protocol [kha]

[kha]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Afforestation, 2012	28.086	56.173	84.259	112.346	140.432	168.519	196.605	224.692	252.778	280.865
Afforestation, 2011	17.851	35.701	53.552	71.402	89.253	107.104	124.954	142.805	160.655	178.506
Deforestation, 2012	15.142	30.284	45.426	60.568	75.710	90.852	105.994	121.136	136.278	151.420
Deforestation, 2011	6.977	13.954	20.930	27.907	34.884	41.861	48.837	55.814	62.791	69.768
Forest management, 2012	10,738.559	10,723.418	10,708.276	10,693.134	10,677.992	10,662.850	10,647.708	10,632.566	10,617.424	10,602.282
Forest management, 2011	10,998.900	10,991.924	10,984.947	10,977.970	10,970.993	10,964.017	10,957.040	10,950.063	10,943.086	10,936.109
[kha]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Afforestation, 2012	308.951	318.630	328.309	337.988	347.667	357.346	363.117	368.889	374.660	375.802
Afforestation, 2011	196.357	214.207	232.058	249.908	267.759	285.609	303.460	321.311	339.161	357.012
Deforestation, 2012	166.562	170.166	173.769	177.373	180.977	184.581	187.963	191.345	194.728	195.767
Deforestation, 2011	76.744	83.721	90.698	97.675	104.652	111.628	118.605	125.582	132.559	139.535
Forest management, 2012	10,587.140	10,583.536	10,579.932	10,576.328	10,572.724	10,569.121	10,565.738	10,562.356	10,558.974	10,557.935
Forest management, 2011	10,929.133	10,922.156	10,915.179	10,908.202	10,901.226	10,894.249	10,887.272	10,880.295	10,873.318	10,866.342

The reasons for recalculations relative to land converted to forest land are described in Chapter 7.2.7.2, and a comparison of the current relevant values and the corresponding values from the 2010 Submission is presented in Table 292.

Table 292: Comparison of emissions [Gg CO_2], as reported in 2012 and 2011, from afforestation A/R (KP 3.3)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**1,138.875**	**703.647**	**245.579**	**-172.592**	**-628.677**	**-1,064.519**	**-1,498.753**	**-1,936.227**	**-2,381.358**	**-2,815.633**
Total, 2011	**934.199**	**628.829**	**323.458**	**18.088**	**-287.282**	**-592.652**	**-898.022**	**-1,203.392**	**-1,508.763**	**-1,814.133**
Mineral soils, 2012	29.369	58.738	88.107	117.475	146.844	176.213	205.582	234.951	264.320	293.689
Mineral soils, 2011	-4.034	-8.069	-12.103	-16.137	-20.171	-24.206	-28.240	-32.274	-36.308	-40.343
Organic soils, 2012	4.351	8.703	13.054	17.405	21.756	26.108	30.459	34.810	39.162	43.513
Organic soils, 2011	2.902	5.803	8.705	11.607	14.509	17.410	20.312	23.214	26.116	29.017
Above-ground biomass, 2012	857.959	545.551	214.281	-85.903	-416.920	-731.239	-1,044.233	-1,360.668	-1,683.292	-1,997.117
Above-ground biomass, 2011	398.227	194.966	-8.296	-211.557	-414.819	-618.080	-821.342	-1,024.603	-1,227.865	-1,431.126
Below-ground biomass, 2012	297.170	190.376	79.380	-23.030	-132.747	-239.143	-345.482	-451.845	-559.901	-666.126
Below-ground biomass, 2011	569.830	501.580	433.330	365.080	296.830	228.580	160.330	92.080	23.830	-44.420
Litter, 2012	-49.973	-99.720	-149.243	-198.540	-247.612	-296.458	-345.079	-393.475	-441.646	-489.591
Litter, 2011	-32.726	-65.452	-98.178	-130.904	-163.630	-196.357	-229.083	-261.809	-294.535	-327.261
[Gg CO_2 a^{-1}]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Total, 2012	**-3,261.354**	**-4,720.597**	**-4,885.027**	**-5,051.886**	**-5,181.820**	**-5,344.629**	**-5,390.040**	**-5,479.618**	**-5,567.851**	**-5,897.210**
Total, 2011	**-2,119.503**	**-2,424.873**	**-2,730.243**	**-3,035.614**	**-3,340.984**	**-3,646.354**	**-3,976.441**	**-4,407.083**	**-4,476.402**	**-4,779.192**
Mineral soils, 2012	323.058	329.952	336.391	342.327	347.702	352.451	356.370	360.027	363.377	361.868
Mineral soils, 2011	-44.377	-48.411	-52.445	-56.480	-60.514	-64.548	-68.582	-72.617	-76.651	-80.685
Organic soils, 2012	47.864	48.951	50.038	51.124	52.211	53.298	53.848	54.398	54.948	55.057
Organic soils, 2011	31.919	34.821	37.723	40.624	43.526	46.428	49.330	52.231	55.133	58.035
Above-ground biomass, 2012	-2,320.363	-3,402.853	-3,520.484	-3,639.533	-3,728.726	-3,844.341	-3,874.891	-3,938.592	-4,001.096	-4,247.744
Above-ground biomass, 2011	-1,634.388	-1,837.650	-2,040.911	-2,244.173	-2,447.434	-2,650.696	-2,866.567	-3,117.212	-3,223.052	-3,428.566
Below-ground biomass, 2012	-774.602	-1,143.780	-1,182.628	-1,222.060	-1,253.940	-1,291.726	-1,302.591	-1,324.255	-1,345.511	-1,426.381
Below-ground biomass, 2011	-112.670	-180.920	-249.170	-317.420	-385.671	-453.921	-534.277	-680.415	-610.036	-673.454
Litter, 2012	-537.311	-552.866	-568.344	-583.744	-599.066	-614.311	-622.776	-631.195	-639.568	-640.011
Litter, 2011	-359.987	-392.713	-425.439	-458.165	-490.891	-523.617	-556.343	-589.070	-621.796	-654.522

The following methodological changes were made with respect to deforestation areas:

- Via a new method, new emission factors were derived for mineral soils. Further pertinent information is provided in Chapter 7.1.5.
- In the biomass category, the change in methods produced new emission factors for the relevant subsequent uses (cf. Chapter 7.1.7).
- The emission factors for the litter category were adjusted to take account of the expanded BZE II / BioSoil database (cf. Chapter 7.2.4.3).
- All changes in emissions, in addition to the aforementioned adjustments of emission factors, are also the result of use of changed activity data (cf. Chapter 7.1.3).

Table 293 compares the current values to the previous year's relevant values.

Table 293: Comparison of emissions [Gg CO_2 equivalents], as reported in 2012 and 2011, from deforestation D (KP 3.3)

[Gg CO_2 a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2012	**2,101.719**	**2,100.661**	**2,110.859**	**2,101.697**	**2,111.147**	**2,110.828**	**2,109.835**	**2,110.533**	**2,115.077**	**2,114.433**
Total, 2011	**1,168.800**	**1,165.922**	**1,163.044**	**1,160.166**	**1,157.288**	**1,154.410**	**1,151.532**	**1,148.654**	**1,145.776**	**1,142.898**
Mineral soils, 2012	-14.943	-29.885	-44.828	-59.771	-74.714	-89.656	-104.599	-119.542	-134.484	-149.427
Mineral soils, 2011	14.155	14.155	14.155	14.155	14.155	14.155	14.155	14.155	14.155	14.155
Organic soils, 2012	15.013	30.027	45.040	60.054	75.067	90.080	105.094	120.107	135.121	150.134
Organic soils, 2011	4.685	4.685	4.685	4.685	4.685	4.685	4.685	4.685	4.685	4.685
Above-ground biomass, 2012	746.460	742.845	748.435	738.854	744.320	741.638	738.309	736.659	738.030	735.106
Above-ground biomass, 2011	480.566	480.566	480.566	480.566	480.566	480.566	480.566	480.566	480.566	480.566
Below-ground biomass, 2012	191.036	190.747	192.509	190.080	191.218	190.735	190.224	189.725	190.052	189.485
Below-ground biomass, 2011	38.607	38.607	38.607	38.607	38.607	38.607	38.607	38.607	38.607	38.607
Litter, 2012	1,077.654	1,075.225	1,072.796	1,070.367	1,067.938	1,065.509	1,063.080	1,060.651	1,058.222	1,055.793
Litter, 2011	590.933	585.656	580.380	575.104	569.828	564.552	559.275	553.999	548.723	543.447
Dead wood, 2012	86.498	91.703	96.908	102.112	107.317	112.522	117.727	122.932	128.137	133.342
Dead wood, 2011	39.854	42.253	44.651	47.049	49.447	51.845	54.244	56.642	59.040	61.438
[Gg CO_2 a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total, 2012	**2,119.485**	**588.604**	**559.917**	**560.762**	**558.458**	**558.787**	**465.398**	**463.749**	**461.656**	**103.917**
Total, 2011	**1,140.020**	**1,137.142**	**1,077.340**	**1,074.462**	**1,071.584**	**1,068.706**	**1,038.480**	**1,069.724**	**1,076.042**	**1,061.797**
Mineral soils, 2012	-164.370	-168.162	-171.980	-175.829	-179.713	-183.635	-187.974	-192.455	-197.105	-198.349
Mineral soils, 2011	14.155	14.155	14.155	14.155	14.155	14.155	14.155	14.155	14.155	14.155
Organic soils, 2012	165.147	168.262	171.369	174.467	177.556	180.633	183.126	185.442	187.552	187.803
Organic soils, 2011	4.685	4.685	4.685	4.685	4.685	4.685	4.685	4.685	4.685	4.685
Above-ground biomass, 2012	736.780	241.143	201.539	202.272	200.527	200.976	145.432	145.346	145.208	20.806
Above-ground biomass, 2011	480.566	480.566	402.703	402.703	402.703	402.703	389.852	406.827	407.820	406.313
Below-ground biomass, 2012	190.017	63.022	73.990	74.192	73.766	73.831	54.855	54.837	54.803	10.145
Below-ground biomass, 2011	38.607	38.607	59.545	59.545	59.545	59.545	45.048	62.195	70.399	60.539
Litter, 2012	1,053.364	250.126	249.548	248.970	248.391	247.813	232.036	231.493	230.950	70.789
Litter, 2011	538.171	532.895	527.618	522.342	517.066	511.790	506.514	501.237	495.961	490.685
Dead wood, 2012	138.547	34.213	35.452	36.691	37.930	39.169	37.923	39.086	40.248	12.723
Dead wood, 2011	63.837	66.235	68.633	71.031	73.429	75.828	78.226	80.624	83.022	85.420

11.3.1.5 Uncertainty estimates

The following error calculations were carried out:

- Uncertainties in estimation of areas with land-use changes (cf. Chapter 7.2.5.1)
- Uncertainties in estimation of above-ground and below-ground biomass, cf. Chapter 7.2.5.2.
- Uncertainties in estimation pertaining to litter and mineral soils, cf. Chapter 7.2.5.3.

A total-error calculation for the entire LULUCF sector is presented in Chapter 19.5.4.

11.3.1.6 Information on other methodological issues

11.3.1.6.1 Comparison with results of neighbouring countries

A by-country comparison of carbon-stock changes in the living above-ground biomass (Table 294) related to afforestation shows that Germany has the largest carbon sink. High sinks also occurred in the UK, the Netherlands, Poland and Switzerland. Germany also has the highest values in the pool below-ground biomass. The value reported by the Netherlands comes close to the Germans'. In the area of deforestation, Germany shows far and away the lowest carbon losses for the pools above-ground and below-ground biomass. In the above-ground biomass the highest emissions occurred in Switzerland, followed by the UK, Poland and the Netherlands. In the below-ground biomass pool, the largest losses occurred in Poland, the

Netherlands and the Czech Republic. In the category forest management, Germany has a low carbon sink. In the above-ground biomass pool, only Switzerland shows an even lower sink, while the largest sinks occur in the UK. For the below-ground biomass, Poland and France report the largest carbon pool.

Germany's value for carbon stock related to litter (Table 295) pursuant to afforestation ranks in the middle. The highest value – and, thus, the largest sink – occurs in Austria. Germany has the second-lowest carbon losses, after Belgium, in the category deforestation. The highest emissions from deforestation occurred in the Netherlands and in Switzerland.

Germany and Denmark show small carbon losses in the dead wood pool related to the category deforestation (Table 296). Only Belgium has even smaller losses. By far the largest carbon losses occurred in Switzerland. The highest carbon sinks resulting from forest management for the dead wood pool occurred in Switzerland and France. Germany, followed by Denmark, shows the lowest stocks in this category.

The largest carbon losses in mineral soils (Table 297) related to afforestation occurred in Germany. Denmark also shows carbon losses in this category. The largest carbon sinks occurred in Poland and Austria. In the deforestation category, Germany shows the largest carbon sinks in the mineral soils pool. Sinks also occurred in Denmark and the Netherlands. The largest C losses in this category, on the other hand, occurred in Poland.

In the area of organic soils (Table 298), Germany has carbon losses in all three categories. The Netherlands have by far the largest losses resulting from afforestation. Only the UK shows a carbon sink in this category. All comparable countries also show carbon losses in organic soils related to deforestation. Germany's value in this category ranks in the middle. The largest C losses show the Netherlands and in Switzerland again. The smallest losses occur in Denmark. In the category of forest management, Germany has the largest carbon losses. The UK, by contrast, even has a C sink in this category.

Table 294: Carbon-stock changes in living biomass (Germany, for 2010; other countries, for 2009)

Country[98]	Afforestation/ Reforestation [Mg C ha^{-1}]		Deforestation [Mg C ha^{-1}]		Forest Management [Mg C ha^{-1}]	
	above-ground	below-ground	above-ground	below-ground	above-ground	below-ground
AUT	1.00	0.18	-0.74	-0.19	NA	NA
BEL	1.92	0.38	-1.97	-0.39	NA	NA
CHE	2.07	IE	-5.58	IE	0.13	IE
CZE	1.54	0.31	-2.75	-0.55	0.70	0.14
DNK	0.46	0.13	-0.92	-0.19	0.83	0.17
FRA	0.91	0.38	-2.29	-0.50	0.55	0.24
GBR	2.43	IE	-4.07	**IE,NO**	1.04	IE
GER	**3.08**	**1.04**	**-0.03**	**-0.01**	**0.33**	**0.10**
NLD	2.24	0.97	-3.09	-0.59	NA	NA
POL	2.13	0.60	-3.30	-0.66	0.61	0.25

Source: UNFCCC 2011

[98] AUT = Austria, BEL = Belgium, CHE = Switzerland, CZE = Czech Republic, DNK = Denmark, FRA = France, GBR = UK, GER = Germany, NLD = the Netherlands, POL = Poland

Table 295: Carbon-stock changes in litter (Germany, for 2010; other countries, for 2009)

Country[98]	Afforestation/ Reforestation [Mg C ha^{-1}]	Deforestation [Mg C ha^{-1}]	Forest Management [Mg C ha^{-1}]
AUT	0.75	-0.75	NA
BEL		0.00	NA
CHE	NO	-1.12	NO
CZE	IE	IE,NA	NE
DNK	0.13	-0.22	0.33
FRA	0.30	-0.20	NO
GBR	0.10	IE,NO	0.36
GER	**0.46**	**-0.10**	**NO**
NLD	NE	-1.61	NA
POL	IE	IE	IE

Source: UNFCCC 2011

Table 296: Carbon-stock changes in dead wood (Germany, for 2010; other countries, for 2009)

Country[98]	Afforestation/ Reforestation [Mg C ha^{-1}]	Deforestation [Mg C ha^{-1}]	Forest Management [Mg C ha^{-1}]
AUT	NO	IE	NA
BEL	NO	0.00	NA
CHE	NO	-0.31	0.15
CZE	NO	-0.07	NO
DNK	0.35	-0.02	0.01
FRA	0.05	-0.09	0.13
GBR	IE	IE,NO	IE
GER	**NO**	**-0.02**	**0.09**
NLD	NE	-0.07	NA
POL	NA	0.09	IE

Source: UNFCCC 2011

Table 297: Carbon-stock changes in mineral soils (Germany, for 2010; other countries, for 2009)

Country[98]	Afforestation/ Reforestation [Mg C ha^{-1}]	Deforestation [Mg C ha^{-1}]	Forest Management [Mg C ha^{-1}]
AUT	1.35	-1.66	NA
BEL	0.80	-0.10	NA
CHE	0.15	-1.81	NO
CZE	0.16	-0.07	NE
DNK	-0.16	0.14	NA,NR
FRA	0.07	-0.86	NO
GBR	0.12	-1.68	0.56
GER	**-0.26**	**0.27**	**No.**
NLD	0.20	0.03	NA
POL	1.98	-2.71	0.53

Source: UNFCCC 2011

Table 298: Carbon-stock changes in organic soils (Germany, for 2010; other countries, for 2009)

Country[98]	Afforestation/ Reforestation [Mg C ha^{-1}]	Deforestation [Mg C ha^{-1}]	Forest Management [Mg C ha^{-1}]
AUT	NO	NO	NA
BEL	NO	NO	NA
CHE	NO	-6.00	NO
CZE	NO	NO	0.00
DNK	-0.34	-2.52	-0.34
FRA	NO	NO	NO
GBR	0.37	IE,NO	0.58
GER	**-0.68**	**-4.64**	**-0.68**
NLD	-6.46	-6.52	NA
POL	NO	NA	NO

Source: UNFCCC 2011

11.3.1.7 The year of the onset of an activity, if after 2008

Table 297 shows the relevant area sizes of KP 3.3 activities that began after 2008. The activity *Forest Management* (KP.3.4) is included only for those areas that have been forest since 1990. As the table indicates, there are no areas on which forest management began after 2008.

Table 299: Relevant area sizes for activities that began after 2008

KP 3.3 Activity	Year of onset	
	2009	2010
Afforestation/Reforestation [ha]	1142.08	1142.08
Deforestation [ha]	1039.14	1039.14

11.4 Article 3.3

11.4.1 Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are directly human-induced

As described in Chapter 7.1.3, the procedure for determining land-use changes from and to forest land identifies land conversions as of 1970, while the methods used for purposes of reporting under the Kyoto Protocol take account only of changes as of 1990. Currently, the third National Forest Inventory is in progress; it is referenced to 2012. That inventory will provide the database for recalculations at the end of the first commitment period. All included activities in this context thus fall within the period 1 January 1990 to 31 December 2012.

While each land-use change from and to forest land is detected primarily by the National Forest Inventory (Bundeswaldinventur; BWI), such changes are also detected by additional data sets. The relevant sample points form a grid that covers Germany completely. Via repeated surveying of the sample points, all changes can be mapped on a large scale. If a point is mapped as forest that was mapped as non-forest in the previous inventory, it represents a specific area of afforestation. The BWI differentiates between afforestation through planting / seeding and natural afforestation through natural rejuvenation. However, natural rejuvenation is classified as *afforested* only when the relevant stand has an average age of five years and crown cover of at least 50 % (cf. Chapter 7.2.3.1).

Agricultural land can change from managed cropland to unmanaged land and, via spontaneous establishment of trees (natural rejuvenation), to forest land. Pursuant to GPG

(IPCC 2003), afforestation may be reported only if it is directly human-induced. "It is *good practice* to provide documentation that all afforestation and reforestation activities included (…) are direct human-induced. Relevant documentation includes forest management records or other documentation that demonstrates that a decision had been taken to replant or to allow forest regeneration by other means."[99]. German law requires a "permit from the competent authority under the law of the Länder" (Art. 10 (1) Federal Forest Act (BWaldG)) for each afforestation. Pursuant to Para. 2, no permit is required only in those cases in which "afforestation has been mandated in a legally binding way, on the basis of other public legal provisions, or the requirements of spatial and land-use planning are not affected". Germany is a densely populated, intensively managed country and all over subject to planning. In addition, Germany has different planning levels, ranging from large-scale planning (e.g. regional planning) to specific small-scale planning (e.g. landscape plans, operational plans for forest management). Preparation of, and compliance with, plans is monitored by the relevant competent authorities in each case, including authorities of the Federal Government, of the Länder and of individual municipalities. Thus it may be assumed that all afforested areas fulfill the "direct human-induced" requirement, since the act of permission, as well as the act of mandating in a legally binding manner and the preparation and establishment of regional and landscape plans all presuppose active decisions by humans.

11.4.2 Information on how harvesting or forest disturbance that is followed by the re-establishment of forests is distinguished from deforestation

Pursuant to Art. 11 (1) Federal Forests Act (BWaldG), "forests should be properly and sustainably managed, in the framework of their purposes. The forest acts of the German Länder have enacted at least the provision that all clear-cut or cleared forest areas have to be

9. reforested, or
10. replenished, in cases in which natural rejuvention remains incomplete,

within a reasonable period of time, unless conversion to another type of use has been approved or otherwise permitted."

In general, every forest area that is still to be used as forest has to be reforested. That is a legal provision, and it is common practice in the German forestry sector. Forest land that is temporarily unstocked thus continues to fall within the scope of required reporting on forest management pursuant to Art. 3.4 KP. The situation is different in cases in which forest land becomes unstocked and planning calls for subsequent use of the land to fall within the category "non-forest land". Such land is to be considered direct human-induced deforested, regardless of whether the deforestation was caused by harvesting or by natural disturbances.

[99] Cf. IPCC LULUCF GPG (2003), Section 4.2.5.2.

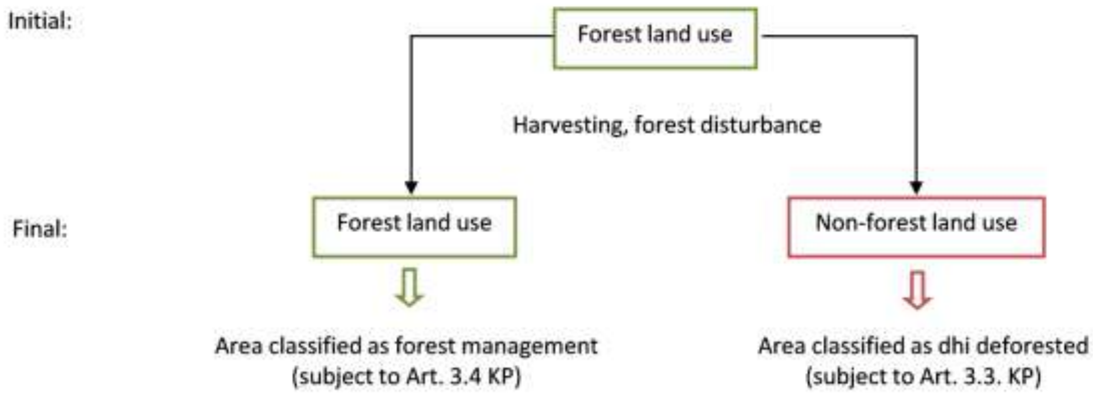


Figure 75: Scheme showing how harvesting or forest disturbance that is followed by forest regeneration is distinguished from deforestation.

11.4.3 Information about the size and geographic location of forest areas that have lost forest cover but which are not yet classified as deforested

Forest management generates small un-stocked areas in forests (bare areas). Pursuant to the data of the BWI 2 (2002), their total area is about 66,000 ha, which is equivalent to 0.6 % of the total forest area. As explained above in Chapter 11.4.2, these areas are still considered as forest in line with the national forest definition. and are included in calculations relative to carbon stocks and their changes.

11.5 Article 3.4

11.5.1 Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

Since an integrated procedure is used for surveying forest lands, land-use changes and the carbon-stock changes caused by relevant activities, the statements made in Chapter 11.4.1 apply for the activity forest management accordingly.

Pursuant to Art. 1 No. 1 Federal Forest Act (BWaldG), "forests are to be preserved, to be enlarged as necessary and to be properly and sustainably managed, in light of their economic value (utility function) and of their importance with regard to the environment, especially the long-term vitality of natural systems and cycles, and with regard to climate, water cycles, air quality, soil fertility, landscape beauty, agrarian structures and infrastructure and the population's needs for rest and recreation (conservation and recreation functions)".

Forests are thus assigned three key basic functions, namely utility, conservation and recreation functions, in light of which they are to be preserved and properly and sustainably managed. In addition, Art. 11 (1) p. 1 BWaldG sets forth that "forests should be properly and sustainably managed, in the framework of their purposes." While that formulation does not state that forests "must" be managed, and thus it does not establish a general obligation, it is important to note that it does not use "may" phrasing, which would rule out any obligation.

The wording chosen thus clearly reveals a basic orientation – namely, that forests should be managed. An obligation to manage forest lands thus applies to the entire country[100].

In order to protect the forests' three basic functions, forests, pursuant to Art. 1 No. 1 in conjunction with Art. 11 (1) p.1 BWaldG, should be preserved and properly and sustainably managed. The aim of proper forest management as set forth by the Marrakesh Accords thus agrees with the requirements set forth by the Federal Forest Act (BWaldG). In both cases, management is aimed at ensuring that forests continue to fulfill their functions long-term.

The Marrakesh Accords define forest management as "a system of practices". That indicates that management involves actions / measures. A forest area that is left untouched, and for which no measures are taken, is thus not a managed forest area. For a forest area to qualify as unmanaged, however, no human activities may take place in it, i.e. no active human interventions may be permitted in it (equivalent to MCPFE conservation category 1.1). Forest areas meeting those criteria are "practically non-existent" in Germany (BMELV, 2009). In 2007, forest conservation areas in which permitted human interventions are restricted to a minimum, i.e. fully protected areas (MCPFE conservation category 1.2), accounted for 1.1% of Germany's total forest area, and were tending to be enlarged (BMELV, 2009). The primary focus with regard to such forest areas is on biotope and species conservation (for example, protected forests, natural forest reserves, core zones of national parks and biosphere reserves). Certain types of interventions are expressly permitted, however (for example, measures to control wildfires, hoofed game, diseases or insect calamities[101]). For protected forests, as for all protected areas, concepts are to be prepared that set forth / define / describe the object/focus of protection, the protection purpose, the necessary requirements and prohibitions for achieving the protection purpose and the necessary relevant care, management, development and restoration measures[102] (for example, in ordinances or guidelines on protected areas; cf. for example, Art. 23 (2) State Forest Act (LWaldG) of Mecklenburg – West Pomerania). In addition, some 23% of Germany's forest area consists of protected areas whose conservation purpose is actively assured by management measures (MCPFE conservation category 1.3); 56 % consist of forests whose primary management purpose is to conserve landscapes and specific natural elements (MCPFE conservation category 2); and 34 % have the primary management purpose of provide protective functions (MCPFE conservation category 3). In MCPFE conservation categories 1.3 through 3, management is to be aligned with the relevant conservation purpose. Such categories thus fulfill the criteria for forest management. Human activities for protecting conservation areas are also certainly allowed in MCPFE category 1.2. Pursuant to IPPC GPG LULUCF (2003), such areas therefore fulfill forest-management criteria in accordance with Art. 3.4 KP: "For example forested national parks (…) where these parks are managed to fulfill relevant ecological (including biodiversity) and social functions, and are subject to forest management activities such as fire suppression, a country may choose to include these forested national parks as lands subject to forest management"[103]. It should be noted that the aforementioned percentage of areas in the different forest-conservation categories

[100] Häusler and Scherer-Lorenzen (2002) speak of an obligation, for all forest owners, "to carry out sustainable, proper management"; the citation appears in: Nachhaltige Forstwirtschaft in Deutschland im Spiegel des ganzheitlichen Ansatzes der Biodiversitätskonvention. BfN – Skripten 62, p. 5 and 15.

[101] In addition, environmentally compatible measures to develop forests for recreational purposes and for nature-compatible research are permitted.

[102] Cf. for example, Art. 22 (1) Federal Nature Conservation Act (BNatSchG).

[103] IPPC Good Practice Guidance LULUCF (2003) Chapter 4.2.7.2, p. 4.62 f.

cannot simply be summed, since they overlap to some extent. In some cases, the same forest area will have been repeatedly included (BMELV, 2009).

Large parts of Germany's forest lands are subject to planning. According to assessments of the BMELV, forest management plans (economic plans, operational plans or reports) exist for about ¾ of the country's forests (BMELV, 2009). In addition to such operational plans, in many cases forest landscape plans (forest framework plans) are also prepared for forests, in the framework of landscape planning[104]. The aim of forest framework planning is to "safeguard the forest functions necessary for the development of ecological and economic conditions pursuant to Art. 1 No. 1 (BWaldG)". That accords precisely with the aim prescribed by IPCC GPG with respect to forest management. To that end, measures may be, or must be, prescribed (cf. for example, Art. 6 (3) No. 4 p. 2 BWaldG old version; Art. 6 (1) No. 2 Bavarian Forest Act (BayWaldG); Art. 9 (4) State Forest Act (LWaldG) of Mecklenburg – West Pomerania; Art. 6 p. 2 Forest and Landscape Act of the State of Lower Saxony (NWaldLG); Art. 7 (1) State Forest Act for the State of North Rhine – Westphalia (LFoG NRW); Art. 6 (2) Forest Act of the State of Saxony-Anhalt (WaldG Sachsen-Anhalt)[105]). In some cases, requirements explicitly call for such planning to serve as a guideline for management, inter alia (cf. Art. 8 (3) LFoG NRW).

All in all, it thus must be considered confirmed that all forests in Germany are managed in accordance with forest-management criteria as set forth by the Marrakesh Accords and by IPCC GPG LULUCF (2003).

A compilation of excerpts from the forest acts of the Länder, relative to requirements for forest management and for forest framework planning, is provided by STEUK (2010). A pertinent summary is presented in Table 300.

[104] Until 2005, the Federal Forest Act (BWaldG) required the preparation of forest framework plans. Because the Länder differ widely in their planning structures, those provisions were eliminated, however. Cf. BMELV (2009) Waldbericht der Bundesregierung (Forest Report of the Federal Government), p. 28.

[105] For definition of measures in operational plans, cf. Art. 5 (6) p. 3 State Forest Act (LWaldG) of Schleswig-Holstein.

Table 300: Overview of obligations relative to forest management, preparation of plans and use of forest framework plans, as set forth by the forest acts of the Länder

State (Land)	Forest-management obligations			Obligations to prepare plans (economic plans, operational plans, operational reports or other specialised forest-management plans)			Obligations to prepare forest framework plans
	State forest	Municipal forest	Private forest	State forest	Municipal forest	Private forest	
Baden-Württemberg	X	X	X	X	X	(X)	(X)
Bavaria	X	X	X	X	[X]		(X)
Berlin	X	X	X				X
Brandenburg							X
Bremen	X	X	X				
Hamburg	X	X	X				X
Hesse	X	X	X	X	X	[X]	
Mecklenburg – West Pomerania	X	X	X				X
Lower Saxony	X	X	X	[X]	[X]		X
North Rhine – Westphalia	X	X	X		X		X
Rhineland-Palatinate	X	X	X	[X]	[X]	[X]	X
Saarland	X	X	X	X	X	(X)	X
Saxony	X	X	X	X	X		(X)
Saxony-Anhalt	X	X	X	X	X		X
Schleswig-Holstein				[X]	[X]		
Thuringia	X	X	X	X	X	[X]	X

Legend:

X Binding requirement (includes "should" requirements)

[X] Requirement is binding only under certain conditions (for example, conditions pertaining to minimum size)

(X) Optional guideline / not binding (a "can" requirement)

11.5.2 Information relating to Cropland Management, Grazing Land Management and Revegetation, if elected, for the base year

Germany has elected for crediting of forest management pursuant to Article 3.4 KP only (cf. Chapter 11.1.2).

No information about other activities is available.

11.5.3 Information relating to Forest Management

As explained above in Chapter 11.5.1, the German forests have to be properly and sustainably managed by law. National provisions on forest management are set forth in the Federal Forest Act (BWaldG), which is made more specific through the forest acts of the Länder. A comparison of Germany's national provisions with the relevant international definition shows broad agreement.

International definition pursuant to the Marrakesh Accords[106]*:*

"'Forest management' is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner."

[106] Paragraph 1 lit. f of Annex A of Decision 16/CMP.1

National definitions pursuant to BWaldG and the forest acts of the Länder (Landeswaldgesetze - LWaldG):

Pursuant to Art. 1 No. 1 Federal Forest Act (BWaldG), the purpose of the Act is, in particular, "to conserve forest for the sake of its economic value (utility function) and for the sake of its (…) (conservation and recreation function), to increase it, if necessary, and to assure its proper management for the long term". Pursuant to Art. 11 (1) p. 1 BWaldG, forests are to be "managed properly and sustainably, in the framework of their purposes." In keeping with the Federal Government's restricted legislative competence in this regard, the Federal Government simply provides a framework which have to be implemented and can be defined by the Länder in greater detail (cf. Art. 5 and Art. 11 (1) p. 2 BWaldG). As a result, the Länder define in detail what "proper and sustainable forest management" is to be. A compilation of relevant sections of the forest acts of the Länder is provided by STEUK (2010).

The forest-management requirements pursuant to Länder forest acts are comparable to those set forth by international forest legislation. The requirement that forests have to be sustainably managed in order to fulfill ecological (including biological diversity), economic and social functions[107], is stated in all LWaldGs. In Germany, ecological, economic and social functions are often referred to as "conservation, utility and recreation" functions[108] (cf. Table 302). Where the ecological, economic and social functions – which have to be assured by management – are not explicitly referred to in LWaldGs, they add the phrase "within the framework of its [their] purposes"[109]. Thus forests have to be sustainably managed, within the framework of their purposes. The provision refers to Art. 1 BWaldG (purpose of the act), which is set forth verbatim in every Land forest act. In addition, Art. 1 No. 1 BWaldG stipulates that forests are to be preserved especially "in light of their economic value (utility function) and their (…) (conservation and recreation functions)". The aim of protecting the economic, ecological and social functions has thus been established throughout the country. Furthermore, both the Federal Forest Act and the forest acts of the Länder warrant the sustainability of forest management.

Table 301: Comparison of forest functions pursuant to the Federal Forest Act and the IPCC

Forest functions pursuant to BWaldG	Forest functions pursuant to MA
Utility function	Economic functions
Conservation function	Ecological functions
Recreation function	Social functions

11.6 Other information

11.6.1 Key category analysis for Article 3.3 activities and any elected activities under Article 3.4

In connection with analysis for the UNFCCC inventory, key-category analysis was also carried out for activities pursuant to Article 3.3 and for selected activities pursuant to 3.4. The results are presented in tabular form in Chapter 1.5.2 of this report. The procedures, bases and methods used are described in detail in Chapter 17.1.4.

[107] Cf. Art. 4 No. 1 BayWaldG; Art. 1a LFoG NRW; a similar meaning also is seen in Art. 6 (1) LWaldG RLP; and a similar meaning is seen in Art. 18 (1) in conjunction with Art. 19 (1) p. 2 ThürWaldG.

[108] Cf. Art. 1 No. 1 BWaldG; Art.13 LWaldG BW; Art. 11 (2) No. 1 LWaldG B; Art. 4 (2) LWaldG Bbg; Art.5 (1) BremWaldG, Art. 6 (1) HeFoG; Art. 6 (1) No. 1 LWaldG MV; Art. 11 (1) NWaldLG; Art. 5 (1) LWaldG SH.

[109] Cf. Art. 6 (1) LWaldG Ha; Art. 11 (1) LWaldG SL; Art. 17 SächsWaldG; Art. 4 (1) WaldG LSA; Art. 18 (1) ThürWaldG.

11.7 Information relating to Article 6

Pursuant to Paragraph 5 (1) Sentence 1 of the Project Mechanisms Act (Projekt-Mechanismen-Gesetz; ProMechG), no projects in the area of LULUCF may be approved in Germany that are to be carried out in Germany.

12 INFORMATION ON ACCOUNTING OF THE KYOTO PROTOCOL UNITS

12.1 Background information

Chapter 12 and 13 include information on the German emission trading registry. The accounting on Kyoto units and the public availability of information is described in chapter 12. Any significant changes in the national registry are reported in chapter 13.

According to decision 15/CMP.1, annex, part 1, section E each Party must include information on its aggregate holdings and transactions of Kyoto units in its annual report. The information has to be reported in the Standard Electronic Format (SEF), which is an agreed format, embodied in a special report, for reporting on Kyoto units.

The SEF for 2011 has been generated with the SEF application version 1.2, provided by the secretariat at 9th of January 2009. The German registry was tested on the generation of the SEF by the UNFCCC. The secretariat awarded a SEF test certificate of conformity to the German registry, dated 2nd January 2009.

12.2 Summary of information reported in the SEF tables

The German SEF for 2011 contains the information required in paragraph 11 of the annex to decision 15/CMP.1 and adhere to the guidelines of the SEF. The SEF has been submitted to the UNFCCC Secretariat electronically and the contents of the report can also be found in annex 6 (chapter 22) of this document.

At the end of 2011, AAUs amounting to 4,932,839,750 were contained in the German registry. The largest proportion or 3,112,267,083 AAUs, were recorded in party holding accounts, 1,273,092,585 AAUs were in the retirement account, 547,477,254 in the entity holding accounts and 2,828 in other cancellation accounts. Besides AAUs the registry contained in total 33,868,624 ERUs and 134,057,322 CERs; no RMUs, tCERs or lCERs.

In total for 2011, the German registry received 207,943,064 AAUs, 38,212,452 ERUs and 109,134,582 CERs. Conversely, 200,351,177 AAUs, 8,363,527 ERUs and 61,624,932 CERs were transferred to foreign national registries. Transactions with most European countries within the European Emissions Trading Schemes (ETS) took place. In addition, ERU and CER have been received from outside the ETS (Japan, Russia, Ukraine).

More details are available in the SEF, which is shown in annex 6 (chapter 22) of this document.

12.3 Discrepancies and Notifications

15/CMP.1 annex I.E paragraph 12 List of discrepant transactions	No discrepant transactions occurred in 2011.
15/CMP.1 annex I.E paragraph 13 and 14 List of CDM notifications	No CDM notifications occurred in 2011.
15/CMP.1 annex I.E paragraph 15 List of non-replacements	No non-replacements occurred in 2011.
15/CMP.1 annex I.E paragraph 16 List of invalid units	No invalid units exist as at 31 December 2011.
15/CMP.1 annex I.E paragraph 17 Actions and changes to address discrepancies	No actions were taken or changes made to address discrepancies because no discrepant transaction occurred for the period under review.

12.4 Publicly accessible information

13/CMP.1 annex II paragraph 45 Account information	The requested information is publicly available for all accounts in the German registry. The data of operator holding accounts (account type 120) can be viewed online at: https://www.register.dehst.de/crweb/report/public/accountOh.do The data of all accounts can be viewed online at: https://www.register.dehst.de/crweb/report/public/account.do Representative name and contact information is classified as confidential due to Article 75 paragraph 8 and 9 Registry Regulation No. 920/2010. Comprehensive search functionality is available.
13/CMP.1 annex II paragraph 46 Joint implemention project information	A list of all German JI projects for which an issuance in the German registry occurred as well as how many ERUs were generated is accessible through: https://www.register.dehst.de/crweb/report/public/project.do The complete documentation of the JI projects is presented in the German JI project database which is accessible at the following URL. The database also contains already registered but not yet approved JI projects. https://jicdm.dehst.de/promechg/pages/project1.aspx In 2011, ERU for ten JI projects were converted from AAU to ERU. No ERU converted from RMU were issued. In total for 2011, 3,697,267 ERU were generated:

JI Project ID	Converted Amount	Unit Type
1000014	77,046	ERU converted from AAU
1000016	11,400	ERU converted from AAU
1000017	619,419	ERU converted from AAU
1000018	1,639,994	ERU converted from AAU
1000023	3,260	ERU converted from AAU
1000024	127,324	ERU converted from AAU
1000050	5,996	ERU converted from AAU
1000168	244,102	ERU converted from AAU
1000182	391,746	ERU converted from AAU
1000183	576,980	ERU converted from AAU
Sum	3,697,267	

<table>
<tr>
<td>13/CMP.1 annex II paragraph 47
Unit holding and transaction information</td>
<td>The information requested in (a), (d), (f) and (l) is classifed as confidential due to Article 75 paragraph 1 Registry Regulation No. 920/2010 as well as national data protection law and therefore not publicly available.
Transactions of units within the most recent five year period are also classified as confidential, therefore the transactions provided are only those completed more than five years in the past.
The information requested in (b), (c), (e), (g), (h), (i), (j) and (k) is publicly available at
https://www.register.dehst.de/crweb/report/public/publicFigures.do
(b) In 2011 there was no issuance of AAU.
(c) In 2011, 3,697,267 ERU were issued.
(e) No RMU was issued in the reported year.
(g) No RMU was cancelled on the basis of activities under Article 3, paragraph 3 and 4 in the reported year.
(h) No ERU, CER, AAU and RMU were cancelled on the basis of activities under Article 3, paragraph 1 in the reported year.
(i) In 2011, 634 AAU, 7,495 ERU and 202,878 CER were voluntary cancelled. No RMU was cancelled.
(j) In 2011, 4,194,506 ERU, 33,374,387 CER, 418,523,027 AAU, and no RMU, tCER, lCER were retired.
(k) There were no carry over of ERU, CER, AAU or RMU from the previous commitment period.</td>
</tr>
<tr>
<td>13/CMP.1 annex II paragraph 48
Authorized legal entities information</td>
<td>The following legal entities are authorized by the Member State to hold Kyoto units:
<table>
<tr><th></th><th>Legal entities authorised by Germany to hold units</th></tr>
<tr><td>AAU</td><td>Federal Government only</td></tr>
<tr><td>ERU</td><td>Each account holder of OHA, PHA and NHA
Contact information:
https://www.register.dehst.de/crweb/report/public/account.do</td></tr>
<tr><td>CER</td><td>Each account holder of OHA, PHA and NHA
Contact information:
https://www.register.dehst.de/crweb/report/public/account.do</td></tr>
<tr><td>RMU</td><td>Federal Government only</td></tr>
<tr><td>tCER</td><td>Federal Governmentonly</td></tr>
<tr><td>lCER</td><td>Federal Governmentonly</td></tr>
</table>
OHA: Operator Holding Account
PHA: Person Holding Account
NHA: National Holding Account</td>
</tr>
</table>

12.5 Calculation of the Commitment Period Reserve

Germany's Commitment Period Reserve (CPR) is calculated as 90 percent of Germany's assigned amount (4,868,096,694 tonnes CO_2 equivalent) calculated pursuant to Article 3 paragraphs 7 and 8 of the Kyoto Protocol. The initial CPR of the current commitment period did not change and is still 4,381,287,024 tonnes CO_2 equivalent (or AAU).

The German registry software is prepared for keeping the CPR. If a transfer proposal would result in an infringement of the CPR, the German registry will reject it internally before the transaction proposal is send to the ITL. This functionality has been thoroughly tested by the German registry administrators in collaboration with the UNFCCC secretariat (DES, Annex H). Consequently, the German registry did not violate the CPR during the reported year.

The development of the Commitment Period Holdings (CPH) in 2011 is shown in figure Figure 76. Each CPH relevant transaction was taken into account.

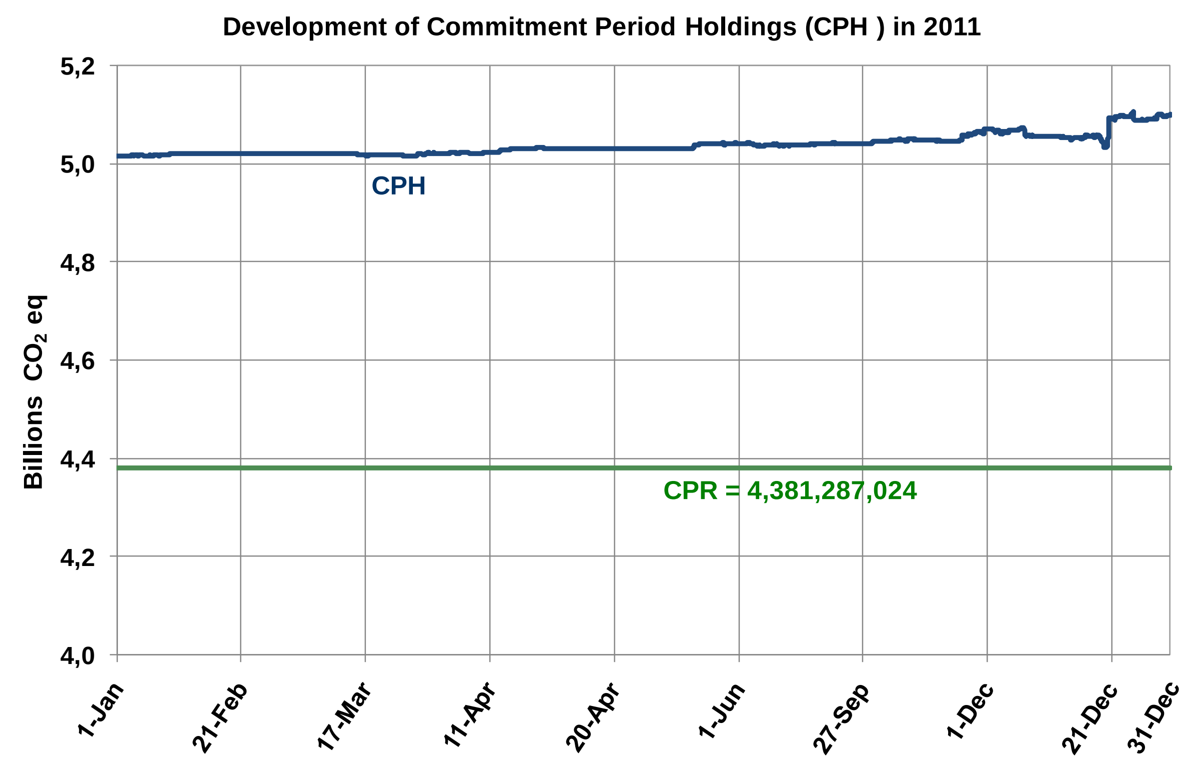


Figure 76:

The present status of the CPR as well as the current holdings of Kyoto units is publicly available at:

https://www.register.dehst.de/crweb/report/public/cpr.do

13 INFORMATION ON CHANGES IN THE NATIONAL SYSTEM

Work over the past year has been concentrated on institutional implementation of the action plan for solving the problems identified by the ERT, in the In-Country Review, in the area of KP-LULUCF.

In addition, the improvements made in 2009 in institutionalising the National System have been implemented further and consolidated. In particular, the administrative agreement with the Federal Statistical Office was implemented for the first time, and the relevant data requirements for emissions reporting were again reviewed and updated. Furthermore, new gaps that had appeared in the data flows were closed.

Implementation of the institutional aspects of the action plan for solving the problems identified in the area of KP-LULUCF:

For the 2012 submission, extensive institutional improvements were made in the National System, for implementation of the action plan, as called for by ERT in the In-Country Review 2010, for solving problems identified in the area of KP-LULUCF.

All of the action-plan measures slated to be accomplished by the Submission 2012 have been implemented. The institutional framework for LULUCF and KP-LULUCF reporting has been strengthened, and made more transparent, via a concept of the BMELV (2012) for preparation of GHG-emissions and carbon inventories of source/sink groups 4 and 5 within the BMELV's sphere of responsibility. That measure has fulfilled Art. 24 of the ARR 2010.

In the interest of implementation of the QA/QC concept, a quality-management system has been established within the vTI, in consultation with the Single National Entity, that reflects the Single National Entity's own quality-management system. This has strengthened QA/QC procedures for agricultural-sector and LULUCF reporting and has further improved the vTI's integration within the National System. Via the vTI's internal quality-management system, recommendations provided in Arts. 24(c), 39, 46(f) and 156(d) of the ARR 2010 have been implemented and enshrined in the National System.

Similarly, institutionalisation of regular working and consultation meetings between the Single National Entity (SNE) and the working group on emissions inventories within the vTI has strengthened integration of agricultural and LULUCF experts within the National System and fulfilled Arts. 27 and 46(a) of the ARR 2010.

Cooperation agreement with the Wirtschaftsvereinigung Stahl (German steel industry association), for provision of data on the iron and steel industry

As a result of the expiration of the relevant legal basis (Act on raw materials statistics – Rohstoffstatistikgesetz), the Federal Statistical Office (STATISTISCHES BUNDESAMT) discontinued data collection for, and publication of, Fachserie 4 Reihe 8.1 (statistics on the iron and steel sector) as of 31 December 2009. That move considerably reduced the availability of the bases for calculations in that area, and it created a significant gap in the pertinent data flows.

To close this data gap, until a pertinent new legal provision is in place, the Federal Ministry of Economics and Technology (BMWi), the responsible ministry, acting in cooperation with the Single National Entity, has concluded a cooperation agreement with the Wirtschaftsvereinigung Stahl (German steel industry association), the key industrial association in this area. In addition to providing for data deliveries from member companies, the agreement provides for data deliveries from non- member companies, as required for purposes of emissions reporting. On the basis of this agreement, the Wirtschaftsvereinigung Stahl has delivered a first set of data to the Single National Entity for the 2012 submission. The data, are in the same format used by the now-expired Fachserie 4 Reihe 8.1 of the Federal Statistical Office. This has prevented a data-flow gap and has ensured full data provision in this area.

Expiration of the voluntary commitment of the German Electrical and Electronic Manufacturers' Association (ZVEI), as of 31 December 2010:

On 31 December 2010, a commitment entered into voluntarily in 2001 by semiconductor manufacturers with production sites in Germany, calling for reduction of emissions of certain fluorinated gases, expired. With that expiry, the voluntary data-provision commitment of the German Electrical and Electronic Manufacturers' Association (ZVEI) also expired. The data delivery for the year 2010 was the last under the commitment. At present, the Single National Entity is completing negotiations with the ZVEI relative to the conclusion of a cooperation agreement on provision of the required data. That agreement will also prevent a gap in the data streams for reporting.

14 INFORMATION ON CHANGES IN NATIONAL REGISTRY

15/CMP.1 annex II.E paragraph 32. (a) Change of name or contact	No change in the name or contact information of the registry administrator occurred during the reported period.
15/CMP.1 annex II.E paragraph 32. (b) Change of cooperation arrangement	Germany does not cooperate by maintaining national registries in a consolidated system. No change of cooperation arrangement occurred during the reported period.
15/CMP.1 annex II.E paragraph 32. (c) Change to database or the capacity of national registry	In 2011 a new application server type was introduced to increase the safety and performance of the system. Whereas an application server is a program on a computer that runs mostly web applications like the registry application. Due to the implemention of a new server type, system adjustments were necessary. For test purposes and conformity an Annex H test was executed on the request of Germany from 18 Feburary until 1 March 2011. The Annex H testing was successfully accomplished. The test results are provided in an updated recommendation document which is attached in Annex 6 (22.2.3) of this document. The adjustments to the system are merely technical and have no impacts on the usability. From the “normal” user’s perspective the system did not change. Together with a new application server, an additional optional two-factor authentication besides the smsTAN procedure by means of the German electronic ID card was implemented. It is only available for registry administrators for now. To login to the registry a registry administrator can chose the second factor: smsTAN or eID card. The gradual introduction of the German eID card started on 1 November 2010 and it will take up to ten years to reach a widely spread. The eID application allows to authenticate through the internet. Within the German registry the eID card is used for login only. The smsTAN procedure is used in parallel to confirm a transaction out-of-band. The smsTAN procedure was implemented in the German registry for all users in November 2010 (it was reported in the last SIAR process).
15/CMP.1 annex II.E paragraph 32. (d) Change of conformance to technical standards	No change in the registry’s conformance to technical standards occurred for the reported period.
15/CMP.1 annex II.E paragraph 32. (e) Change of discrepancies procedures	No change of discrepancies procedures occurred during the reported year.
15/CMP.1 annex II.E paragraph 32. (f) Change of security	For registry administrators a new two-factor authentication besides the smsTAN procedure was implemented in 2011. For more information please see the description to 15/CMP.1 annex II.E paragraph 32. (c) above. The smsTAN procedure was implemented in November 2010 (reported in the last SIAR process).
15/CMP.1 annex II.E paragraph 32. (g) Change of list of publicly available information	No change to the list of publicly available information occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32. (h) Change of Internet address	No change of the registry Internet address occurred during the reporting period.
15/CMP.1 annex II.E paragraph 32. (i) Change of data integrity	No change to data integrity measures occurred during the reporting period.

measures	
15/CMP.1 annex II.E paragraph 32. (j) Change of test results	The registry initialization recommendation was updatet in 2011. The document is attached in Annex 6 (22.2.3) of this document.
The previous Annual Review recommendations	*The German SIAR Part 2 Assessment report did not state any recommendations.* *Within the centralized review of the 2011 annual submission of Germany, the ERT recommends that the Party report in its next annual submission any change(s) in its national registry in accordance with chapter I.G. of the annex to decision 15/CMP.1.* In the 2012 annual submission Germany include in its national inventory report information on any changes that have occurred in its national registry in accordance with chapter I.G. of the annex to decision 15/CMP.1. Therefore the recommendation is implemented.

15 INFORMATION REGARDING MINIMISATION OF NEGATIVE IMPACTS PURSUANT TO ARTICLE 3 (14)

Most of the measures that would be carried out in Germany would not be expected to have direct effects on developing countries. In the case of other measures, the expected effects are largely considered to be positive. Such effects, for example, would include establishment of technical and administrative structures for climate protection.

Almost all of the possible indirect effects are also considered to be positive. Such effects would include beneficial impacts on energy supplies and prices in co-operating countries.

Promotion of biofuels:

Promotion of non-sustainably produced biofuels could have negative impacts. Such promotion could leading to destruction of, or adverse shifts in, resources in developing countries. In future, such effects are to be prevented via implementation of pertinent sustainability ordinances. The ordinances define sustainability standards and relevant certification systems (e.g. the 2009 Ordinance on requirements pertaining to sustainable production of fuels (Biokraftstoff-Nachhaltigkeitsverordnung (Biokraft-NachV)), in the version amended on 22 June 2010) and thus transpose the Directive of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources (2009/28/EC).

It needs to be emphasised that the certification systems should be designed to ensure that production of biofuels in developing countries does not lead to food-security conflicts, at either the local or international levels.

The criteria enshrined in the relevant European laws cover the following:

- Minimum requirements pertaining to reduction of greenhouse-gas emissions;
- Prohibition on use of biofuels produced on land of value with regard to biodiversity aspects, and
- Prohibition on use of biofuels produced on land with high CO_2 removals (wetlands, peat bogs and forests).

What is more, intensified use of second-generation biofuels helps to prevent food-security conflicts.

Germany is taking an active role in relevant international forums for cooperation, such as the "Global Bioenergy Partnership", a G8 initiative. The "Bioenergy and Food Security" project of the United Nations Food and Agriculture Organization (FAO), which is financed by Germany, is oriented to implementation of minimum ecological and social standards. The aim is the project is to develop criteria, in cooperation with decision-makers of potentially affected countries, for assessment of the opportunities and risks of bioenergy use in rural regions.

Reduction of hard-coal subsidies:

Reduction of subsidies for Germany's own fossil fuels helps prevent climate-protection measures from having negative impacts on third countries. On 7 February 2007 in Germany, the Federal Government, the Land (state) of North Rhine – Westphalia and the Land Saarland, and the RAG AG coal corporation and the IG BCE industrial union (for the mining, chemicals and energy sectors) reached an agreement calling for socially-compatible termination of subsidised hard-coal production in Germany by the end of 2018. In 2012, the German Bundestag (Parliament) will review this decision on the basis of a joint report of the Federal Government and the governments of the Länder in which the relevant mining districts are located.

Policies and measures at the EU level, especially EU emissions trading:

In addition to designing its own policies and measures for climate protection in Germany, the Federal Government plays an active role in shaping climate-protection measures at the European level. European emissions trading is of special importance in this context. The energy-sector and industrial companies in Germany that are participating in the European emission trading scheme (ETS) account for nearly half of all German greenhouse-gas emissions. In and of itself, the ETS has no direct impacts on third countries. On the other hand, since 2008 part of the proceeds generated in Germany from auctioning of emissions certificates within the ETS system have been used to support climate-protection projects in developing countries. The International Climate Initiative (ICI), which is responsible for the pertinent funding allocations, finances projects in the areas of emissions reduction, adaptation to climate change and protection of tropical rain forests. Such efforts are in line with the Emissions Trading Directive, which provides for part of the auction proceeds to be used for climate-protection and adaptation measures in developing countries.

As of the beginning of 2012, international air transports are being included within the European emissions trading scheme. This could have negative impacts on third countries, since now both European airlines and airlines from third countries require certificates for flights to and from the EU. The relevant legislation underwent an intensive process including careful analysis, hearings for experts and hearings for potentially affected parties. A working group established especially for this issue, within the framework of the "European Climate Change Programme", found that the measure would be a cost-effective way to reduce air-transport emissions. The pertinent quantitative analyses carried out explicitly considered the possible impacts on developing countries (European Commission 2006).

Analyses on the basis of Eurocontrol data showed that airlines from third countries contribute only moderately to the air transports falling within the emissions trading regime and thus would be only moderately affected by relevant cost increases. What is more, most of the flights between the EU and third countries are flights between the EU and other industrialised countries, with the result that the total burdens on companies from developing countries would be considerably lower than those in industrialised countries. Furthermore, the Emissions Trading Directive makes it possible, in cases in which third countries carry out comparable climate-protection measures in their own air-transport sectors, for flights from their territories into the EU to be exempted from the EU-ETS.

In addition, due to possibilities for using CDM certificates, integration of air transports within the ETS can be expected to boost demand for CDM projects, which will have indirect positive effects for developing countries in the form of additional investments in climate-protection technologies.

Support for developing countries in energy-sector diversification:

Germany is making a broad range of efforts aimed at supporting developing countries in diversifying their energy sectors and thus lessening their vulnerability to trends in world market prices for energy. Especially noteworthy efforts in this context include cooperation in the area of renewable energies in the Mediterranean region and with the Gulf countries, inter alia via the EU-GCC Energy Experts Group; cooperation in resarch and development; the Mediterranean Solar Plan; the Regional Center for Renewable Energy and Energy Efficiency (RCREEE); and the EU's contributions to the Maghreb Electricity Market Integration Project (IMME).

In addition, Germany is involved in financing for the Global Energy Efficiency and Renewable Energy Fund (GEEREF), a regional programme for investments in developing countries in the areas of renewable energies and energy efficiency. GEEREF is aimed at accelerating transfer of environmentally friendly technologies into poorer regions of the world.

Overview:

The following tables list various policies and measures (sorted by sectors), along with their direct and indirect effects on developing countries.

Table 302: Cross-cutting measures

Measure	Direct effects	Indirect effects
Emissions trading	none	Positive: Auction proceeds are being partly used for climate protection and adaptation measures in developing countries
Air transports in emissions trading	Negative: Higher costs for airlines from third countries, for flights to and from the EU	Positive: Auction proceeds are being partly used for climate protection and adaptation measures in developing countries
CDM	Positive: Addition investments in climate-protection measures in DC	none
JI	none	none
Energy/CO_2 taxes	none	none

Table 303: Energy-policy measures

Measure	Direct effects	Indirect effects
Promotion of renewable energies	none	Positive: Potential reduction of dependence on fossil fuels; Potential improvement of electricity supplies in rural areas; Improvement of air quality
Promotion of biofuels	none	Negative: If biofuel imports lead to destruction of forests and other CO_2 sinks, or if biofuel-biomass cultivation leads to food shortages / food-price increases in developing countries. Positive: Economic development
Promotion of energy efficiency	none	Positive: Can lead to reduced energy costs and improved air quality
Promotion of CHP systems	none	Positive: Helps reduce energy costs

Table 304: Agriculture

Measure	Direct effects	Indirect effects
Orienting of subsidies to food security and animal-welfare standards instead of to production quantities	Positive: Encourages competition in agriculture	none
Improved management of animal waste	none	none
Biogas use / anaerobic fermentation	none	Positive: Comparatively cheap energy source.

Table 305: Forestry

Measure	Direct effects	Indirect effects
Reforestation	none	Positive: Less deforestation
Sustainable forest management	none	none

Table 306: Waste recycling / treatment

Measure	Direct effects	Indirect effects
CH_4 separation from waste and sewage sludge	none	Positive: Cost-effective energy source
Composting	none	none

16 OTHER INFORMATIONEN

This Chapter is currently not required.

17 ANNEX 1: KEY CATEGORIES WITHIN THE GERMAN GREENHOUSE-GAS INVENTORY

In accordance with the *"IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories"*[110] (*Good Practice Guidance*), the Parties to the Framework Convention on Climate Change, and, in future, the Parties to the Kyoto Protocol as well, are obliged to calculate and publish annual emissions data.

These emissions inventories must be readily comprehensible (transparency); must be calculated in a consistent manner in the time series since 1990 (consistency); must be evaluated uniformly at international level via application of the prescribed calculation methods (comparability); must contain all the relevant emission sources and sinks in the reporting country (completeness); must be evaluated with error specification; and must undergo ongoing internal and external quality management (accuracy).

To facilitate concentrating the many and detailed activities and resources required for this purpose on the inventory's principal source categories, the IPCC has introduced the term "key category". Key categories are source categories which are highlighted in the national inventory system because their emissions have a significant influence on total emissions of direct greenhouse gases, either in terms of absolute emissions, or as a contribution to the emissions trend over time, or in both ways.

In its chapter 7, the Good Practice Guidance specifies the methods to be applied for identifying key categories. These methods include inventory analysis for one year (Tier 1 Level Assessment), time-series analysis of inventory data (Tier 1 Trend Assessment), detailed analysis of inventory data with error evaluation (Tier 2 Trend Assessment with consideration of inaccuracies) and assessment of qualitative criteria (pursuant to Chapter 7.2.2 GPGAUM)

Tier 1 analyses must always be carried out using two procedures. In a first procedure, only emissions from sources are evaluated, and storage in sinks is not considered. In a second procedure, emissions storage in sinks is then included (without any consideration of whether it is positive or negative). As would be expected, the two results differ. Pursuant to the Good Practice Guidance, both results must be taken into account in determination of key categories.

For identified key categories, the Parties are then required to use highly detailed calculation methods (Tier 2 or higher; the relevant methods are also specified in the Good Practice Guidance). Should direct use of such methods prove impossible, for whatever reason (e.g. data are not available for the required input variables, etc.), Parties are required to prove that the methods applied nationally achieve at least a comparable degree of accuracy in the calculation result. Such proof, as well as the key-source analysis performed overall, must be outlined in the national inventory report to be prepared annually.

17.1 Description of the method for identifying key categories

The results of key-source analysis via the two Tier 1 methods (Level and Trend), the Tier 2 method and the method calling for assessment of qualitative criteria are outlined below. In this

110 This Report was produced as a response to a suggestion by the UN Framework Convention on Climate Change to the Intergovernmental Panel on Climate Change (IPCC). The relevant effort called for completing determination of uncertainties in inventories and for preparing a report on "good practice" in inventory management.
It was prepared with the aim of supporting countries in preparing their own emissions inventories. The aim was to avoid over-valuation or under-valuation of the results and to reduce the inaccuracies of the inventories as far as possible.
This report is published on the Internet at : http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm

context, we call attention to the description of the underlying methods in the *Good Practice Guidance*. In a departure from that source's proposal for structuring included source categories, a greater degree of detail was chosen for the present analysis. Annual emissions inventories were divided, with regard to their CO_2-equivalent emissions, into a total of 120 individual activities.

17.1.1 Tier 1 procedure

Level analysis has the purpose of identifying those source categories responsible for 95 % of total national emissions (as CO_2-equivalent emissions), in the Kyoto Protocol's base year and in the current year; those sources are then defined as key categories (●). Calculations were performed using formula 7.1 from the Good Practice Guidance.

In the source category summary used in this analysis, a total of 31 key categories were identified in 2010 using this approach (cf. Table 7, Chapter 1.5).

Trend analysis identifies as key categories (●) those source categories which have made a particular contribution to changes in total greenhouse gas emissions in 2010, in terms of the development of their contribution since the base year. In this respect, it is irrelevant whether such changes have led to a reduction or an increase in total emissions. Calculations were performed using formula 7.2 from the Good Practice Guidance.

Tier 1 Trend analysis, using source-category structuring as described, identified a total of 33 key categories (cf. Table 7, Chapter 1.5).

17.1.2 Tier 2 procedure

Key-source analysis pursuant to the Tier 2 approach is based on the results of current uncertainties determination in accordance with Tier 1. Because of the high level of overhead it entails, detailed Tier 2 uncertainties analysis is carried out only every 3 years in Germany.

The results have provided extensive confirmation of the results of the pertinent Tier 1 key-source analyses. Seven additional categories also have to be considered, however (cf. Table 8, Chapter 1.5.1).

17.1.3 Assessment of qualitative criteria

In keeping with a review recommendation, for the Submission 2012 Germany has for the first time carried out key-source assessment by applying qualitative criteria. Chapter 7.2.2 of the GPGAUM provides recommendations relative to the criteria to be applied. The criteria allow assessment on the basis of use of emissions-reduction equipment, of expected disproportionate emissions increases, of a high level of uncertainty or of unexpectedly lower or higher emissions in a given category. The criteria may be used as a basis for defining additional categories as key categories.

In the category adipic acid production (2.B.3), a redundant waste-gas-treatment system was installed. In light of that installation, the category has been classified as a key category, on the basis of qualitative criteria. 2.B.3 is already a key category, however, in terms of Tier 1 Level and Trend assessment. SF_6 emissions from soundproof windows are reported in 2.F.9. Even though such a trend cannot yet be recognized, it is clear that SF_6 emissions must be expected to increase sharply in coming years as disposal of old windows increases. For that reason – i.e. on the basis of qualitative criteria – the category has already been identified as a key category. That classification leads to no change, however, since 2F is already a key category, by Tier 1

Level and Trend, for SF_6. Qualitative assessment on the basis of large uncertainties is not required, since Germany carries out Tier 2 key-source analysis for the entire inventory every three years. No unexpectedly low or high emissions have been seen in the inventory.

Use of qualitative criteria has not identified any additional key categories in Germany.

Germany uses all recommended procedures for identifying and evaluating source categories. The IPCC Guidelines require 95% of emissions from sources / removals in sinks to be classified in key categories. In keeping with the fact that Germany identifies key categories by combining the results of all analysis procedures and evaluations, emission-causing activities accounting for 97.6% of the inventory have been identified as key categories.

17.1.4 Key-source analysis for Kyoto reporting

The following CRF Table NIR.3 summarises information relative to key-source analysis in Kyoto reporting. Additional information is presented in Chapter 1.5.2.

Table 307: KP CRF Table NIR.3: Summary Overview for Key Categories for Land Use, Land-Use Change and Forestry Activities under the Kyoto Protocol

Key Categories of Emissions and Removals	**Gas**	**Criteria used for Key Category Identification**			**Comments [3]**
		Associated category in UNFCCC inventory[1] is key (indicate which category)	**Category contribution is greater than the smallest category considered key in the UNFCCC inventory [1], [4] (including LULUCF)**	**Other[2]**	
Specify key categories according to the national level of disaggregation used[1]					
Forest Management	CO_2	Forest land remaining forest land	Yes		
Afforestation and Reforestation	CO_2	Land converted to forest Land	Yes		

(1) See section 5.4 of the IPCC good practice guidance for LULUCF.

(2) This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.

(3) Describe the criteria identifying the category as key.

(4) If the emissions or removals of the category exceed the emissions of the smallest category identified as key in the UNFCCC inventory (including LULUCF), Parties should indicate YES. If not, Parties should indicate NO.

18 ANNEX 2: DETAILED DISCUSSION OF THE METHODOLOGY AND DATA FOR CALCULATING CO_2 EMISSIONS FROM COMBUSTION OF FUELS

18.1 The German Energy Balance

In the Federal Republic of Germany, energy statistics are published by numerous agencies, and these statistics can differ in terms of their presentation, scope and aggregation. The Energy Balances of the Federal Republic of Germany are the central data foundation for determining/preparing energy-related emissions, scenarios and forecasts of the impacts of energy-policy and environmental-policy measures. On an annual basis, the associations in the German energy sector, working in co-operation with economic research institutes, and in the framework of the Working Group on Energy Balances (AGEB), combine the relevant data to form a complete picture. They then make the data available to the public in the form of Energy Balances.

The complete Energy Balances for the years since 1990 are available in the Internet at:

http://www.ag-energiebilanzen.de/viewpage.php?idpage=63

The AGEB's Web site presents a foreword for the Energy Balances, in German and English, that describes the structure of the Energy Balance.

The members of the Working Group on Energy Balances (AGEB) include (as of: October 2011):

- Bundesverband der deutschen Energie- and Wasserwirtschaft e.V. (BDEW) (Association of the German Energy and Water Industry), Berlin
- Deutscher Braunkohlen-Industrie-Verein e.V. (DEBRIV) (German Lignite Industry Association), Cologne,
- EEFA GmbH, Münster
- Gesamtverband des deutschen Steinkohlenbergbaus (GVSt) (Association of the German hard-coal mining industry), Herne,
- Mineralölwirtschaftsverband (MWV) (Association of the German Petroleum Industry), Berlin,
- Deutsches Institut für Wirtschaftsforschung (DIW) (German Institute for Economic Research), Berlin,
- Energiewirtschaftliches Institut an der Universität Köln (EWI) (Institute of Energy Economics at the University of Cologne), Cologne,
- Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI) (Rhine-Westphalian Institute for Economic Research), Essen.
- Verein der Kohlenimporteure e.V. (German Coal Importer Association), Hamburg

Since the 1994 balance year, overall responsibility for preparation of Energy Balances has lain with the German Institute of Economic Research (DIW; Berlin); since 2002, the DIW has carried out relevant work in co-operation with EEFA (Energy Environment Forecast Analysis GmbH) and with Mr. Rossbach from the Association of the German Petroleum Industry (MWV; for the section on petroleum). Overall, with due regard for the available data, the Energy Balances provide a comprehensive picture of energy production and use quantities/structures in the German economy.

The most important sources are listed in Table 308. In a number of categories, furthermore, experts personally provide relevant data – in categories, for example, such as non-energy-related consumption by the chemical industry.

Table 308: Data sources for the Energy Balances:

All energy resources	Federal Office for Statistics 43 Manufacturing industry: Energy, gas and water supply 433 Specialised statistics in the area of energy and water supply 43311 Monthly report on the electricity sector (066) 43321 Monthly report on the gas sector (068) 43331 Survey of electricity sales, revenue (083) 43341 Survey of gas deliveries, imports and exports and gas-based revenue (082) 43351 Survey of electricity generation systems in the mining and manufacturing sectors (067) 43371 Annual survey of network operators with regard to electricity feed-in (070) 43381 Annual survey on sewage gas (073) 43391 Annual survey on liquefied petroleum gas (075) 434 Specialised statistics in the area of energy and water supply: heat supply 43411 Annual survey of production, use, purchases and sale of heat (064) 43421 Survey of geothermal systems (062) 435 Other specialised statistics in the area of energy and water supply 43511 Monthly survey of coal imports and exports (061) 43521 Survey of bio-fuels (063) 43531 Annual survey of energy use in the mining and manufacturing sectors (060) Wolfgang Bayer (2003): Amtliche Statistik (official statistics), newly organized, in: Wirtschaft und Statistik, Vol. 1, p. 33-40. Bundesverband der deutschen Energie- and Wasserwirtschaft e.V. (BDEW) (Association of the German Energy and Water Industry) BDEW annual statistics (Jahresstatistik) BDEW surveys on use of renewable energy resources Market research results, company data, calculations by the Working Group on Energy Balances (AGEB)
Hard coal and lignite	Statistics from the Kohlenwirtschaft e.V. (Coal Industry Association) Coal mining in the energy industry of the Federal Republic of Germany – annual reports Coal industry statistics Sales statistics and other unpublished energy statistics
Petroleum	Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle) Official Petroleum Statistics for the Federal Republic of Germany Mineralölwirtschaftsverband e.V. (MWV) (Association of the German Petroleum Industry) Petroleum Statistics – Annual Reports Wirtschaftsverband Erdöl- and Erdgasgewinnung e.V. (Association of the Petroleum and Natural Gas Extraction Industry) Annual reports Federal Ministry of Food, Agriculture and Consumer Protection

(AGEB, 2010)

18.2 Structure of the Energy Balances

The Energy Balances, which are structured in matrix form, provide an overview of the interconnections within the energy sector. As a result, they not only provide information about consumption of energy resources in the various source categories, they also show the relevant flows of such resources, from production to use in the various production, transformation and consumption areas (cf. Figure 77). The ***production balance*** shows:

- Domestic production
- Imports
- Removals from stocks

- Exports
- Maritime bunkering
- Additions to stocks

of energy resources, and it summarises them under ***primary energy consumption***. The primary Energy Balance provides the basis for calculations under the IPCC reference procedure (PROGNOS, 2000). The ***usage balance*** provides a key basis for preparation of emissions inventories. The usage balance can also be used for determination of primary energy consumption. It comprises:

- The transformation balance
- Flaring and line losses
- Non-energy-related consumption, and
- Final energy consumption.

Differences between the production and usage balances are compensated for in the position "Statistical differences".

The ***transformation balance***, part of the usage balance, shows what energy resources are transformed, as well as what other resources they are transformed into. The transformation production shows the results of such transformation. Energy transformation can involve either substance modification – such as transformation of crude oil (transformation input) into petroleum products (transformation production) – or physical transformation – such as combustion of hard coal (transformation input) – in power stations, for production of electrical energy (transformation production). The energy consumption in the transformation sector shows how much energy was needed for operation of transformation systems (the transformation sector's own consumption). The transformation balance is broken down by facility type; a total of 12 different types of facilities are considered.

The Energy Balance until 1994			Line
Primary Energy Balance		Domestic production	1
		Imports	2
		Removals from stocks	3
		Domestic energy production	4
		Exports	5
		Bunker fuels	6
		Additions to stocks	7
		Domestic primary energy consumption	8
Transformation balance	Transformation input	Coking plants	9
		City gas works	10
		Hard-coal-briquetting plants	11
		Lignite-briquetting plants	12
		Public thermal power stations	13
		Mine and colliery power stations	14
		Other industrial thermal power stations	15
		Nuclear power stations	16
		Hydroelectric power stations	17
		Combined heat and power (CHP) stations, district heating stations	18
		Blast furnaces	19
		Refineries	20
		Other energy producers	21
		Total transformation inputs	22
	Transformation emissions	Coking plants	23
		City gas works	24
		Hard-coal-briquetting plants	25
		Lignite-briquetting plants	26
		Public thermal power stations	27
		Mine and colliery power stations	28
		Other industrial thermal power stations	29
		Nuclear power stations	30
		Hydroelectric power stations	31
		Combined heat and power (CHP) stations, district heating stations	32
		Blast furnaces	33
		Refineries	34
		Other energy producers	35
		Total transformation emissions	36
	Consumption in energy production and in transformation sectors	Hard-coal mines, hard-coal-briquetting plants	37
		Coking plants	38
		City gas works	39
		Lignite mines, lignite-briquetting plants	40
		Power stations (plants)	41
		Oil and gas production	42
		Refineries	43
		Other energy producers	44
		Total energy consumption in the transformation sector	45
		Flaring and line losses, evaluation differences	46
		Domestic energy supply, pursuant to transformation balance	47
		Non-energy-related consumption	48
		Statistiscal differences	49
Final energy consumption (Endenergieverbrauch)	by sections	Final energy consumption (Endenergieverbrauch)	50
		Other mining	51
		Non-metallic minerals	52
		Iron and steel industry	53
		Iron and steel foundries	54
		Drawing shops and cold-rolling mills	55
		Non-ferrous metal products and casting	56
		Chemical industry	57
		Pulp and paper	58
		Rubber processing	59
		Other production of basic materials and producer's goods	60
		Basic materials and producer's goods	52-60
		Machinery	61
		Automotive, aircraft and spacecraft	62
		Electrical engineering, precision mechanics, optics	63
		Ironware, tinware and metalware	64
		Other manufacture of capital goods	65
		Manufacture of capital goods	61-65
		Glass and fine ceramics	66
		Production of plastic goods	67
		Textiles	68
		Other manufacture of consumables	69
		Manufacture of consumables	66-69
		Sugar industry	70
		Other food production	71
		Food, drink and tobacco	72
		Food, drink and tobacco	70-72
		Other mining and manufacturing sector overall	73
		Railway transport	74
		Road transports	75
		Air transports	76
		Coastal and inland navigation	77
		Total transport	78
		Residential, institutional and commercial overall	79
		Military agencies	80

The Energy Balance as of 1995			Line
Primary Energy Balance		Domestic production	1
		Imports	2
		Removals from stocks	3
		Domestic energy production	4
		Exports	5
		Bunker fuels	6
		Additions to stocks	7
		DOMESTIC PRIMARY ENERGY CONSUMPTION	8
Transformation balance	Transformation input	Coking plants	9
		Hard-coal-briquetting and lignite-briquetting plants	10
		Public thermal power stations (not including CHP)	11
		Industrial thermal power stations	12
		Nuclear power stations	13
		Hydroelectric power stations, wind-power and photovoltaic systems	14
		Public combined heat and power (CHP) stations	15
		District heating stations	16
		Blast furnaces	17
		Refineries	18
		Other energy producers	19
		Total transformation inputs	20
	Transformation emissions	Coking plants	21
		Hard-coal-briquetting and lignite-briquetting plants	22
		Public thermal power stations (not including CHP)	23
		Industrial thermal power stations	24
		Nuclear power stations	25
		Hydroelectric power stations, wind-power and photovoltaic systems	26
		Public combined heat and power (CHP) stations	27
		District heating stations	28
		Blast furnaces	29
		Refineries	30
		Other energy producers	31
		Total transformation emissions	32
	Consumption in energy production and in transformation sectors	Coking plants	33
		Hard-coal mines, hard-coal-briquetting plants	34
		Lignite mines, lignite-briquetting plants	35
		Power stations (plants)	36
		Oil and gas production	37
		Manufacture of refined petroleum products	38
		Other energy producers	39
		Total energy consumption in the transformation sector	40
		Flaring and line losses	41
		DOMESTIC ENERGY SUPPLY, PURSUANT TO TRANSORMATION BALANCE	42
		NON-ENERGY-RELATED CONSUMPTION	43
		Statistiscal differences	44
Final energy consumption (Endenergieverbrauch)	by sections	FINAL ENERGY CONSUMPTION	45
		Production of non-metallic minerals; other mining	46
		Food and tobacco	47
		Paper	48
		Primary chemicals	49
		Other chemical industry	50
		Rubber and plastic products	51
		Glass and ceramics	52
		Processing of non-metallic minerals	53
		Metals production	54
		Non-ferrous metals, NFM foundries	55
		Metals processing	56
		Machinery	57
		Transport equipment	58
		Other economic sectors	59
		Mining, non-metallic minerals, manufacturing sector overall	60
		Railway transport	61
		Road transports	62
		Air transports	63
		Coastal and inland navigation	64
		Total transport	65
		Residential	66
		Commercial and institutional, and other consumers	67
		Residential, commercial and institutional	68

Source: AGEB, 2003:

Figure 77: Line structure of Energy Balances until 1994 and as of 1995

Non-energy-related consumption, as a component of the consumption balance, is shown as a total, without allocation to facility types or branches of industry. It describes which energy resources are used as raw materials (e.g. in the chemicals industry, transformation of energy resources into plastics).

Finally, the consumption balance indicates the final consumption sectors in which energy is transformed into the useful energy ultimately needed (such as power, light, room and process heating) (***final energy consumption***). This includes industry, sub-divided into 14 sectors, transport, households and commercial use, trade, services and other consumers (including agriculture).

Figure 77 shows the structure of the production and consumption balances in the energy balances until 1994 and as of 1995.

Energy resource structure in energy balances ...

Through 1994

Hard coal	HC coal
	HC coke
	HC briquettes
	HC raw tar
	HC pitch
	HC other
	Crude benzene
Lignite	L coal
	L briquettes
	L coke
	L coal dust
	Hard lignite
Other solid fuels	Firewood
	Peat
	Sewage sludge
Petroleum	Oil
	Gasoline
	Raw gasoline
	Avgas
	Jet kerosene
	Diesel
	Heating oil, light.
	Heating oil, heavy
	Petrol coke
	Other petroleum products
Gases	LP gas
	Refinery gas
	Coke-oven gas
	Blast-furnace gas
	Natural gas
	Petroleum gas
	Pit gas
	Landfill gas
Electricity and other energy resources	Electricity
	Hydropower
	Nuclear power
	District heat
	Other energy resources
Total energy resources	Primary energy resources
	Secondary energy resources
	Total

As of 1995

Hard coal	HC coal
	HC briquettes
	HC coke
	Other HC products
Lignite	L coal
	L briquettes
	Other L products
	Hard lignite
Petroleum	Oil
	Gasoline
	Raw gasoline
	Jet kerosine
	Diesel fuel
	Heating oil, light
	Heating oil, heavy
	Petrol coke
	LP gas
	Refinery gas
	Other petroleum products
Gases	Coke-oven and city gas
	Blast-furn. & converter gas
	Natural gas, petroleum gas
	Pit gas
Renewable energies	Hydropower
	Wind and photovol. systems
	Waste and other biomass
	Other renewable energies
Electricity and other energy resources	Electricity
	Nuclear power
	District heat
Total energy resources	Primary energy resources
	Secondary energy resources
	Total

Source: ZIESING et al, 2003

Figure 78: Energy resources in the Energy Balance of the Federal Republic of Germany

The energy flow in the Energy Balances is depicted for 30 energy resources. These energy resources can be allocated to the following main groups:

- Hard coal,
- Lignite,
- Petroleum (including LPG and refinery gas),
- Gases (coke oven and blast furnace gas, natural gas, firedamp, excluding landfill gas and the aforementioned gases),
- Renewable energy resources (including waste fuels),
- Electrical power and other energy resources.

Energy Balances have been drawn up for the years 1990 to 1994, both separately for the old and new Länder and for Germany as a whole. With the conversion of the official statistics to the classification of industrial sectors (*STATISTISCHES BUNDESAMT*, 2002c), since 1995 only Energy Balances for Germany as a whole (in the territorial delimitation of 3 October 1990) have been submitted. The main group structure (until 1994 and as of 1995) is shown in Figure 78. Via the "Renewable energies" satellite balance, renewable energies are further broken down as of 1996 (AGEB 2003).

As of the year 2000, the energy-resource structure in the area of renewable energies / waste was changed: hydroelectric and windpower systems, and photovoltaic systems, were combined, and waste/biomass was divided into renewable and non-renewable fractions. Since 2004, non-recyclable waste and waste heat are also listed under final-energy consumption within the Energy Balance.

In the Energy Balance, fuels / energy resources are listed in *natural units*, including tonnes (t) for solid and liquid fuels, cubic metres (m^3) for gases, kilowatt hours (kWh) for electrical power, and joules (J) for waste, renewable energy sources, nuclear power and district heating. In order to render the data comparable and suitable for addition, all values are converted into joules (J) using calorific value tables and conversion factors. Unlike gas statistics or international Energy Balances, the Energy Balance lists even gases in terms of calorific value.

To date, Energy Balances through 2009 have been published. Until the 2010 report, the Federal Environment Agency met requirements for currentness, in emissions reporting, by preparing provisional Energy Balances on the basis of the evaluation tables. As of the 2011 report, the Working Group on Energy Balances (AGEB) provides the Federal Environment Agency with a complete provisional Energy Balance, for purposes of inventory preparation.

18.3 Methodological issues: Energy-related activity rates

Essentially, the inventories for air pollutants and greenhouse gases prepared by the Federal Environment Agency are based on the Energy Balances for Germany prepared by the Working Group on Energy Balances (AGEB). The data required for emissions calculation can be read directly from Energy Balance lines 11, 12, 15, 16, 40, 60, 65 and 68. For biomass fuels, EB lines 14 and 19, depending or the fuel in question, also have to be used in calculation.

In a few cases, the special requirements pertaining to emissions calculation, and the need to assure the completeness of data, necessitate a departure from the above-described system, and additional data have to be added:

- The emissions-relevant fuel inputs for lignite drying have to be calculated out of EB line 10. A precise description of source category 1.A.1.c is provided in Chapter 3.2.8.2.

- Natural gas inputs in compressors, for the years 1995-2002, can be read directly from the Energy Balance (EB line 33). For the years 1990-1994, and for the period as of 2003, the values have to be calculated outside of the Energy Balance. The method is described in Chapter 3.2.10.5.2 (source category 1.A.3.e).
- For systematic reasons, and for reasons having to do with a focus on energy production, the Energy Balance does not list incinerated waste quantities completely for all relevant years. In this area as well, therefore, the lacking data have to be added from waste statistics. Relevant explanations are provided in Chapter 3.2.6.2 (source category 1.A.1.a) and in Chapter 3.2.9.11.2 (source category 1.A.2.f Other).
- Firewood use in the source categories commercial and institutional is not listed in the Energy Balance and has to be added. A description of source category 1.A.4 is provided in Chapter 3.2.11.2.

In the Energy Balance, inputs of reducing agents, in pig-iron production, are listed in part as energy-related consumption, in EB line 54, and in part as transformation inputs, in EB line 17 (top-gas equivalent). Use of the related blast-furnace gas for energy production is listed in the relevant Energy Balance lines, 11, 12, 15, 33 and 54. To prevent double counting, the fuel inputs from blast furnaces, as listed in EB line 54, and the relevant top-gas equivalent, are not reported.

18.4 Uncertainties, time-series consistency and quality assurance in the Energy Balance

In an endeavour to ensure that Energy Balances are always meaningful, it is necessary to make allowance for changes in the underlying statistics, for changes in the energy sector and for changes in requirements of data users. Such changes were made as early as the 1970s. Partly as a result of increasing energy-market liberalisation, and in conjunction with the formation of a European single market, the condition of the statistical energy database has worsened in recent years of change (ZIESING et al, 2003). With the introduction of the Act on Energy Statistics, which has been in force since 2003, the data basis has improved again, although the relevant other data collection has necessitated changes in the overall data structures. In 2009, the Energy Balances for the period 2003 to 2006 were revised. Changes were carried out in the areas of transformation inputs of natural gas, petroleum gas and renewable energies – in Energy Balance lines 11 (thermal power stations for the public power supply), 12 (industrial thermal power stations), 14 (hydroelectric power, wind-power, photovoltaic and other systems), 15 (heat/power stations for the public heat/power supply), 16 (district heating stations), 19 (other energy producers), 66 (residential) and 67 (commercial and institutional and other consumers). These changes also have impacts on the sum of transformation inputs and primary energy consumption (cf. DIW, EEFA, 2009: "Dokumentation zur Revision der Energiebilanzen für die Bundesrepublik Deutschland für die Jahre 2003 bis 2006" ("Documentation on revision of Energy Balances for the Federal Republic of Germany, for years 2003 to 2006")).

The changes affect both the data sources used – extensive transitions were made on the basis of public statistics – and allocation of fuel inputs to heat and power production in CHP systems. Separate listing of CHP systems in public statistics led to recalculations of Energy Balances, with the help of the relevant Finnish method. In only a few cases – such as mine-gas inputs in public power stations and inputs of hard coal and natural gas in district heating stations – do these two effects lead to noticeable discontinuities in the time series between 2002 and 2003. The available data for the period prior to 2002 cannot be improved retroactively, however.

The revision was also used for the purpose of taking account of data updates of the *Federal Statistical Office* and the Federal Office of Economics and Export Control (BAFA) that occurred after the publication of the Energy Balances. Also as part of the revision, the efficiencies for electricity production with use of biogenic fuels were adjusted, for the year 2003, to the efficiencies applied since 2004.

18.4.1 The balance year 1990 and the Energy Balances for 1991 to 1994

The base year 1990 plays a key role in national emissions inventories, and it is especially important as a reference year for agreed emissions-reduction targets under climate protection policy. For Germany, admittedly, this is linked to the problem that the country did not have the same national territorial status throughout the entire year of 1990. Radical changes in the territory of the GDR and the new Länder, including profound economic woes and fundamental organisational/structural problems, greatly complicated the process of collecting energy statistics in eastern Germany for 1990. This also had certain repercussions for the old Länder, for which the AGEB was still able to prepare and publish balances in the conventional manner (ZIESING et al, 2003).

For the GDR / new German Länder, the Institut für Energetik (IfE) in Leipzig assumed the tasks of preparing an Energy Balance for 1990 that would be compatible with western German balances (IFE, 1991). In this effort, the Institute had access to a study, carried out under the direction of DIW Berlin (German Institute for Economic Research), whose aims included preparing suitable Energy Balances for the GDR for the years 1970 to 1989 (DIW, 1991). The AGEB Energy Balances, for the old German Länder, and the IfE Energy Balances, for the new German Länder, are being aggregated for the new Energy Balances prepared in the framework of the EUROSTAT project (ZIESING et al, 2003) for the year 1990 and for Germany as a whole. In keeping with the system in force as of 1995, some changes have been made in the original balances for 1990 and for the years 1991 to 1994 (cf. ZIESING et al, 2003). Furthermore, in keeping with the procedure used by international organisations (IEA, EUROSTAT, ECE), the so-called "efficiency approach" is used, instead of the formerly used "substitution approach", for Energy Balances for Germany since 1995. In addition, recalculations with the efficiency approach have been carried out back to the year 1990.

Due to a lack of suitable data, it was not possible to adjust differentiation of final energy consumption, by source categories, in the manufacturing sector. The applicable system for this area changed considerably in 1995, when a transition was made from the SYPRO manufacturing-sector system (Systematik des produzierenden Gewerbes) to the Classification of Economic Activities, edition 1993 (*STATISTISCHES BUNDESAMT*, 2002c).

These Energy Balances are seen as the primary energy statistics to be used in determining energy-related CO_2 emissions in Germany.

In revision of activity rates for stationary combustion in 1990 in the new German Länder, some shifting of fuel inputs between Energy Balance lines resulted. The overall framework remained unchanged, however.

18.4.2 Quality report relative to the Energy Balance

To document its quality-assurance measures in preparation of Energy Balances, the Working Group on Energy Balances (AGEB) submits pertinent quality reports to the Federal Environment Agency (UBA).

- "Quality report of the German Institute for Economic Research (DIW) relative to preparation of the Energy Balances for the Federal Republic of Germany and to the currentness and ongoing availability of official statistics and association and other data" ("Qualitätsbericht des Deutschen Instituts für Wirtschaftsforschung zur Erstellung der Energiebilanzen für die Bundesrepublik Deutschland einschließlich Aktualität bzw. zeitliche Verfügbarkeit der amtlichen Statistiken und der Verbands- und sonstigen Daten") of August 2011, by Dr. Jochen Diekmann, Klaus Hilge and Ingrid Wernicke.
- "Quality report of the EEFA research institute relative to preparation of Energy Balances for the Federal Republic of Germany" ("Qualitätsbericht des EEFA-Forschungsinstituts zur Erstellung der Energiebilanzen für die Bundesrepublik Deutschland"), by Tina Baten and Hans Georg Buttermann, EEFA – Energy Environment Forecast Analysis GmbH & Co. KG

The following section presents excerpts of the current reports, in their original wording.

18.4.2.1 Background

In the framework of greenhouse-gas reporting, the National Co-ordinating Committee for the National System of Emissions Inventories has established minimum requirements pertaining to quality control and quality assurance (QC/QA) festgelegt […]. Those requirements are to be fulfilled on all levels of inventory preparation. One of the most important data sets for determination of greenhouse-gas emissions consists of the Energy Balances for the Federal Republic of Germany, which the Working Group on Energy Balances (AGEB) has been commissioned to prepare. The German Institute for Economic Research (DIW) also works on such Energy Balances, as a sub-contractor to the AGEB. The DIW staff involved in the effort are required to comply with minimum requirements pertaining to QC/QA, in areas such as transparency, consistency, comparability, completeness and accuracy.

The DIW Berlin is responsible for preparing Energy Balances and evaluation tables for the following energy areas:

- Natural gas, petroleum gas
- Hydroelectric power, windpower und photovoltaics,
- Biomass and renewable waste,
- Other renewable energy sources,
- Non-renewable waste, waste heat, etc.,
- Electricity,
- Nuclear energy and
- District heat (Fernwärme)

In addition, DIW Berlin awards a service contract to Mr. Ullrich Rossbach, who prepares the petroleum section of the Energy Balances.

Since the 2002 balance year, the EEFA research institute has been among the institutes charged with preparing Energy Balances.

The tasks of the EEFA research institute include preparing complete Energy Balances (including evaluation tables) for the following fuels:

- Hard coal, hard-coal coke, hard-coal briquettes and other hard-coal products,
- Lignite (raw), lignite briquettes, other lignite products and hard lignite and the gases
- Coking-plant gas and city gas, top gas and converter gas, and pit gas.

In the framework of its work on the Energy Balances, the EEFA institute also coordinates deliveries and reporting of energy-statistics data in the context of international obligations (IEA/EUROSTAT Joint Questionnaires).

Since Energy Balance year 2009, estimate balances have been prepared in the framework of work for the evaluation tables. They incorporate data from Statistik-Nr. 066 (Erhebung über die Elektrizitäts- und Wärmeerzeugung der Stromerzeugungsanlagen der allgemeinen Versorgung; Survey of electricity and heat generation of public-sector electricity generation systems) of the Federal Statistical Office (Statistisches Bundesamt), association data of the German Association of Energy and Water Industries (BDEW) and data of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat) relative to "Other renewable energy sources". The estimates are coordinated especially with the BDEW and the AGEE-Stat.

Clearly enough, at such an early stage in Energy-Balance preparation, important official data sources, such as surveys relative to energy consumption of industrial sectors, are not yet available. The pertinent data gaps are closed with the help of estimates. It is also clear that an Energy Balance estimate cannot fulfill the strict requirements pertaining to data quality that the corresponding final Energy Balance meets, a work published with a time lag of about one year.

Also in the framework of its Energy Balance work, the DIW Berlin coordinates the quarterly estimates of primary energy consumption for the Federal Republic of Germany, and it prepares estimates for the energy area "Other".

Measures for quality assurance and control cover the following areas:

- Assurance of data quality / transparency of methods and procedures,
- Mechanisms for checking and critically reviewing the Energy Balances, measures that assure the Balances' correctness, completeness and consistency, and
- Measures for documentation and archiving, designed to ensure the Balances' clarity and reproducibility,
- Expert responsibility for preparation of Energy Balances.

18.4.2.2 Quality of the data sources used

For preparation of the Energy Balances for the Federal Republic of Germany, the DIW Berlin makes use of the following data of the Federal Statistical Office:

- Survey of energy use of mining, quarrying and manufacturing companies,
- Survey of electricity generation systems in the mining and manufacturing sectors,
- Survey of electricity and heat generation of public-supply electricity generation systems,
- Survey of heat generation, demand, use and supply,
- Survey of network operators relative to electricity feed-in,
- Survey of production, use and supply of sewage gas,
- Survey of supply, import and export of natural gas and petroleum gas, and of revenue of producers,
- Survey of production, supply, import and export of gas, and of revenue of gas utilities and gas sellers, and

- The official mineral-oil statistics (Amtliche Mineralölstatistik (AMS)), for the mineral-oil section of the Energy Balances; and Table 9, for biofuels, of the Federal Office of Economics and Export Control (BAFA), for the renewable energy sources covered in the Satellite Balance.

The data of the Federal Statistical Office (Statistisches Bundesamt) and of the Federal Office of Economics and Export Control (BAFA) are subject to official quality requirements. The quality reports of the Federal Statistical Office are available in the Internet, at the Federal Statistical Office' Web site:
http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Navigation/Publikationen/Qualitaetsberichte/Qualitaetsberichte.psml (checked on 08 August 2011).

In additon to available official data, the DIW Berlin also uses the following association data:

- Data on petroleum and natural gas production (WEG – annual report of the Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry association)
- Data on gross electricity generation in the Federal Republic of Germany (BDEW)
- Data on electricity generation in nuclear power stations (Deutsches Atomforum e.V.)

and data of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat) relative to "Other renewable energy sources".

At regular intervals, the Federal Ministry of Economics and Technology (BMWi) commissions methodologically reliable studies that serve as a supplementary source of information on energy consumption of the residential and commercial / institutional sectors.

In preparing Energy Balances, the EEFA institute draws on a range of sources, in their order of importance, including official statistics, surveys and statistics of energy-sector associations and data from survey studies of research institutes. To close unavoidable data gaps, it relies on its own experts' assessments. The main official data sources used include the following:

- Survey of energy use of mining, quarrying and manufacturing companies,
- Monthly reports on coal imports,
- Survey of electricity generation systems of mining, quarrying and manufacturing companies,
- Survey of electricity and heat generation of electricity generation systems serving the public grid,
- Survey of heat generation, demand, use and supply,

In addition, in carrying out calculations for the Energy Balance, the EEFA institute uses numerous statistics provided by the Statistik der Kohlenwirtschaft coal-sector-statistics association. The Statistik der Kohlenwirtschaft association's key members include the Association of the German hard-coal mining industry (GVSt) and the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations. Examples of statistics that enter into calculations relative to the hard coal sector include

- Statistics on domestic sales, broken down by types of hard coal and consumer groups, and
- Statistics on production, use in transformation sectors and changes in stocks (form 4a).

With regard to lignite, the following data are used:

- Data on production, production of lignite products, producers' own consumption, sales (form 5) and information from production reports,

- Data on domestic sales / use, broken down by Länder and consumer groups, and
- Data from other unpublished statistics.

The coal-statistics data available in Germany have a semi-official status, and they are very precise and reliable. For more than 50 years, the Statistik der Kohlenwirtschaft coal-sector-statistics association has served as a liaison between coal-sector companies and official producers of statistics (cf. in the Internet: http://www.kohlenstatistik.de/download/Langfassung.pdf).

Official statistics in this area are based on surveys carried out by the Statistik der Kohlenwirtschaft association. Additional data on the coal sector, available to the general public, are provided in the annual publications "Der Kohlenbergbau in der Energiewirtschaft der Bundesrepublik Deutschland" ("Coal mining as a part of the energy sector of the Federal Republic of Germany") and "Zahlen zur Kohlenwirtschaft" ("Coal-industry statistics"), and on the Web site http://www.kohlenstatistik.de. The superior transparency of these data sources (in some cases, highly specific data items are provided) attests to the their reliability and accuracy. The Act on Energy Statistics (Energiestatistikgesetz) has no separate paragraph relative to surveys on the domestic coal sector; its refers instead explicitly to the functioning system of coal statistics.

For preparation of Energy Balances, the important aspects of these data sources, in addition to their quality, include their multi-year availability and their standardized, consistent presentations of time series. Such aspects play a critically important role in ensuring that the procedures and methods used for preparation of Energy Balances generate data that can be consistently integrated, without structural discontinuities, in the basic scheme for the Balances. Both the official sources and – especially – the coal-sector statistics have long histories. In some areas, they provide consistent time series that reach far into the past. Where breaks in time series cannot be avoided, as a result of reviews or changes in statistical foundations (for example in the Act on Energy Statistics), such breaks are well-documented in the sources used for preparation of Energy Balances. This ensures that methods are always properly adjusted.

Yet another supplementary information source consists of studies that, for selected reference years, collect primary statistical data on energy consumption of the residential and commercial / institutional sectors. Such studies document the quality of their up-scaling results. It should also be noted that the Federal Ministry of Economics and Technology (BMWi) commissions research institutes to carry out such surveys. As a result, once the final report for such a survey has been accepted, the survey acquires a semi-official status that guarantees that it meets certain quality standards.

18.4.2.3 Transparency of methods and procedures

The Act on Energy Statistics (Energiestatistikgesetz – (EnStatG) entered into force on 1 January 2003. This act Gesetz consolidates official energy statistics, from different legal frameworks, and adapts them to users' current information requirements. Since the act's entry into force, the Federal Statistical Office also collects and provides data for the areas heat market, combined heat / power generation (CHP) and renewable energy sources. As a result of the restructuring, the Federal Statistical Office, in addition to providing data on electricity and heat generation from combined heat / power generation (CHP), also provides data on all fuel inputs for CHP (broken down by energy sources).

Such changes in the available statistics have made it necessary to adjust the methods used for the Energy Balances – especially for their descriptions of industrial final energy consumption. As a consequence of the described expansion in the data supply, as of 2003 separate data on fuel inputs for generation of electricity only (including electricity generation in CHP systems) are no longer available for either general or industrial electricity generation.

The Federal Statistical Office does not collect data on breakdowns of fuel inputs by "electricity" and "heat" in industrial and public-supply combined heat / power generation (CHP) systems; such statistics are collected by the Working Group on Energy Balances (AGEB) and estimated by institutes it commissions. The "Finnish" method used for such purposes is based on Directive 2004/8/EC of the European Parliament and of the Council of 11 February 2004. That method is exactly defined, mathematically, and it is explained in the forewords to the Energy Balances.

With regard to quality assurance, the Finnish method makes calculations relative to power/heat production for the public supply and for industry logical and transparent. The necessary pertinent framework assumptions, such as the reference efficiencies of non-CHP generation as provided in the documentation for the Energy Balances, are clearly stated in the process. In sum, although Energy Balance preparation is a process that makes use of frequently complex transformational methods, its results can still be highly transparent and unambiguous. As a result, all Energy Balance entry fields can always be traced back to their primary statistical foundations.

Not surprisingly, primary data provided by official or association sources – regardless of its quality – can seldom simply be "plugged in" in the Energy Balance without undergoing the statistical processing normally used to prepare the Energy Balances. Description of relevant complex energy flows, using matrixes that conform to the formal parameters and methodological specifications for the Energy Balances, and on the basis of statistical raw data, requires numerous transformation steps, recalculations and reallocations. What is more, in some (few) areas of the Energy Balance primary statistics are no longer available, and thus data gaps have to be closed through use of formal estimation methods, applied in accordance with the requirements of each relevant individual case.

In preparing the Energy Balances, the EEFA research institute always uses the most current official statistics and association surveys. Nonetheless, sometimes – in areas of less importance with regard to energy consumption – it has to carry out its own estimates to close data gaps for completion of the balance system. The EEFA institute uses a broad range of methods and modelling instruments in carrying out such estimates within the framework of Energy Balance preparation. The most important elements of the EEFA system of models, in the framework of preparation of Energy Balances, include a power-station model and an energy-demand model. The energy-demand model alone comprises more than 1,500 equations. By adequately modelling all important substitution processes and technological changes, especially with regard to sectoral production processes, it is able to describe the energy consumption of the industrial and residential sectors. In formal terms, this energy model accords with the organisational principle used for the Energy Balances, since its sectoral organisation, apart from minor modifications in the area of energy-intensive economic sectors, accords with the standard classification of economic sectors (WZ), while its breakdown by energy sources / fuels is largely in line with the corresponding system found in the Energy Balances.

The EEFA energy model has been refined and tested in the framework of numerous scientific research projects. In addition, the estimation approaches and methods used in the model have been published in national and international trade journals and may thus be considered transparent, publicly accessible and generally accepted. On request, the EEFA research institute is happy to provide a list of the relevant model-related publications, along with short descriptions of the models.

18.4.2.4 Checking and verification of results

Critical discussion, verification and checking of results take place on various levels:

- The Energy Balances Group (Gruppe Energiebilanzen) of DIW Berlin carries out "four-eyes" checks of results and reviews them for plausibility on the basis of control figures (for example, changes in light of annual comparisons, implied net calorific values).
- In addition, the AGEB member associations carry out supporting checks.
- With regard to renewable energies, the Working Group on Renewable Energy Statistics (AGEE-Stat) carries out its own consultations and "four-eyes" checks.
- The EEFA research institute also cooperates in exchanging, and mutually checking, Energy Balance results.
- Furthermore, at early stages data and results are exchanged and discussed with the DIW's Energy Balance staff and with responsible experts of the Federal Environment Agency (UBA).

Only when the completed Energy Balance has successfully passed through all controlling bodies is it published on the AGEB's Web site and are provisional Energy Balance data provided to the Federal Environment Agency for further processing within the system for the national greenhouse-gas inventory.

With a view to preventing any errors in data calculation and estimation for the Energy Balances, the EEFA institute uses standardised procedures in preparing the annual balances. To that end, it has developed a broad range of instruments that automate proven estimation procedures, and formal calculation methods, within the context of Energy Balance preparation. This approach, which often permits simple entry of statistical raw data into the suitable calculation tools, largely eliminates calculation and transformation errors. What is more, its use of consistent, standardised methods plays an important role in assuring time-series consistency.

In spite of all its efforts to prepare Energy Balances that are error-free, properly executed and available promptly, the EEFA research institute cannot completely rule out the possibility of error. For that reason, the EEFA research institute carries out a range of checks. These include:

- Two EEFA staff members independently prepare the annual Energy Balance and then check each other's results,
- The EEFA research institute regularly verifies the Balances' time-series consistency. Where a time series shows implausible jumps that cannot be attributed to transfer or calculation errors, and that must be tied to developments in the underlying primary statistics, the problem is discussed constructively with the relevant data-supplying institution.
- The Energy Balances are cross-checked against the data provided to IEA/Eurostat.
- The AGEB's energy-sector member associations – relative to the Balance sections for which the EEFA research institute is responsible, i.e. the German Coal Importer Association, the Association of the German hard-coal mining industry (GVSt), the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations and the Statistik der Kohlenwirtschaft coal-sector-statistics association – provide constructive critical support, and review and discuss the Balance results.

- Beginning at early stages of Balance preparation, the EEFA Energy Balance staff regularly exchange information and engage in discussion with the responsible experts of the Federal Environment Agency (UBA).
- The Energy Balance results are shared with, and reviewed by, the research institutes that cooperate in the framework of this research contract (DIW Berlin)

18.4.2.5 Documentation and archiving

DIW Berlin and the EEFA research institute keep careful, detailed documentation relative to the annual Energy Balances. The documentation covers every Energy Balance entry, lists the statistical sources and surveys used and precisely describes the calculation methods and procedures used.

The purpose of the documentation is to ensure that all steps can be retraced, both by Energy Balance staff and by the persons who use the Energy Balances. Regular updating of the documentation contributes to data quality and helps to assure consistency in time series and methods.

All statistical data, calculation methods and estimation procedures used in preparation of Energy Balances for the Federal Republic of Germany are archived in both electronic and printed form. The pertinent electronic data are backed up automatically by the DIW's central IT department, on dedicated server space, and they are backed up manually at regular intervals.

For electronic archiving, EEFA uses portable media (CD-ROMs, DVD), external drives and network-based server systems. Data back-ups are carried out both automatically and manually (at regular intervals).

18.4.2.6 Qualified staff

For execution of the service project "Preparation of Energy Balances for the Federal Republic of Germany" ("Erstellen von Energiebilanzen für die Bundesrepublik Deutschland"), DIW Berlin and the EEFA research institute rely on experienced staff with solid backgrounds in the areas of statistics, economics and the energy sector.

Table 309: Federal Statistical Office surveys used in preparation of Energy Balances for the Federal Republic of Germany

Survey	No.	Survey period	Currentness, pursuant to quality report	Type of data	Group surveyed	Units surveyed
Survey of energy use by the mining, quarrying and manufacturng sectors	060	annually	End of the following year *(available as of the end of October / beginning of November)*	Electricity generation, deliveries and consumption **Fuels / energy sources, orders and consumption, by energy source / fuels** **Fuels / energy sources, deliveries and stocks, by energy source / fuels** Average net calorific value	Sections B "Mining and quarrying" and C "Manufacturing"	**Producing companies** (currently, at least 40,000) with **at least 20 employees** **Exception:** Plants of Manufacturing sector companies with **10 or more persons active in the relevant economic sectors**
Survey of heat generation, demand, use and supply,	064	annually	End of the following year *(available usually at the end of September)*	District heating: Net heat generation, demand, deliveries and network losses. No information on energy sources / fuels is provided Heating plants: **Fuel inputs and heat production, by energy sources / fuels**	Operators of **heating plants** with outputs of at least 1 MWth, and operators of **district heating networks** (only large networks that have grown "historically"). No **"island networks" for district heating are surveyed**	**Max. of 1,000 operators** of heating plants, including absorption systems for refrigeration and with outputs of **at least 2 MW_{th}**.
Survey of electricity and heat generation of electricity generation systems serving the public grid	066K	Monthly; annually	6 weeks after the end of the reporting period; End of June of the following year *(available in May)*	Number, net-electricity and net-heat production, by plant type, **Electricity and heat production, by energy sources / fuels** **Fuel inputs for electricity and/or heat production, by energy sources / fuels** (separate survey of CHP systems)	Companies and plants in the **electricity sector (public grid)**	**No more than 1,000 operators of plants with outputs of at least 1 MW_{el}.**
Survey of electricity generation systems of manufacturing, mining and quarrying companies	067	annually	9 weeks after the end of the reporting period *(available usually at the end of September)*	**Number and bottleneck capacity, by plant type** **Net-electricity and net-heat production (separate survey of CHP systems)** **Fuel inputs for electricity and/or heat production, by energy sources / fuels (separate survey of CHP systems)** Own consumption of electricity and heat	Sections B "Mining and quarrying" and C "Manufacturing"	Operators (currently, about 500) of systems serving their **own requirements**. Surveys cover systems for generating electricity, including systems for co-generation of electricity and heat (CHP) with **outputs of at least 1 MW_{el}**
Survey of network operators relative to electricity feed-in	070	annually	12 weeks after the end of the reporting period *(available usually at the end of September)*	**Electricity feed-in, by Länder and energy sources / fuels** **Power statistics, separately for Länder and energy sources / fuels**	Operators of electricity grids for the public supply	**Exhaustive survey**
Survey of production, use and supply of sewage gas	073	annually	8 weeks after the end of the reporting period *(available at the end of June / beginning of July)*	**Anaerobic sewage-gas collection** **Fuel inputs in power stations** **Fuel inputs for heating only or motors (drive units) only** **Electricity feed-in** **Own consumption**	Operators of wastewater-treatment plants	for no more than 6,000 operators of wastewater-treatment plants (currently, **about 1,300 operators**)
Survey of supply, import and export of natural gas and petroleum gas, and of revenue of producers	082P	annually	National results become available three months after the end of the period covered by the report	**Survey of supply, import and export of natural gas and petroleum gas, and of revenue of producers** **Sales of natural gas and petroleum gas, and revenue of producers, by Länder**	Producers of natural gas and petroleum gas	Exhaustive survey

Survey	No.	Survey period	Currentness, pursuant to quality report	Type of data	Group surveyed	Units surveyed
Survey of production, supply, import and export of gas, and of revenue of gas utilities and gas sellers	082	annually	National results become available 12 months after the end of the period covered by the report The result for 2009 became available in May 2011	**Extraction and production of gas, demand for gas, and value of relevant imports** **Deliveries and exports of gas, and relevant revenue** **Gas production, by gas types** **Gas deliveries, and revenue, by Länder**	Gas-sector companies	Exhaustive survey

Link to the nomenclature for classification of industrial sectors (Nomenklatur der Wirtschaftszweige; WZ 2008):

http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Klassifikationen/GueterWirtschaftklassifikationen/Klassifikationenwz2008__umsteiger__xls,property=file.xls

Link to the quality reports on energy statistics, including a questionnaire:

http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Navigation/Publikationen/Qualitaetsberichte/EnergieWasser.psml

18.4.2.7 Explanations regarding the currentness and ongoing availability of official statistics, association data and other data relative to preparation of Energy Balances

Official statistics

The final annual figures for monthly survey 066, and the annual survey 082 and 082P, become available in May of the following year; the annual surveys 064, 067 and 070 usually become available at the end of September of the following year; survey 073 becomes available at the end of May, or beginning of June, of the following year; survey 060 becomes available at the end of October / beginning of November of the following year (e-mail from Wolfgang Bayer, Federal Statistical Office, 8 August 2011).

The results of surveys 066 (electricity generation systems for the public supply) and 067 (electricity generation systems for industry) have to be converted via the "Finnish" method. Calculations, checking, consultations, etc. involving BDEW, AGEE-Stat, EEFA and MWV take at least three weeks; the pertinent data then enter the Energy Balance in June or October of the following year.

The Energy Balance can be completed only when the results of survey 060 (energy use by industry), which are an important Energy-Balance component, become available. That is the bottleneck for the process. Calculations carried out on a sectoral basis, plausibility checks, checking-related enquiries to the Federal Statistical Office (which then has to forward the requests to the Länder) and consultations with participating associations all take at least three weeks; the final Energy Balance is then prepared no earlier than the middle or end of November of the following year.

As a result of these time constraints, an estimate Balance is prepared in July (in a process first carried out for the 2009 report) that incorporates the available official data from survey 066. The remaining data are estimated and agreed on in cooperation with the AGEB member associations.

A second bottleneck is tied to the time of availability of biofuels data based on BAFA data from official petroleum statistics. Sectoral classification of transports is carried out in cooperation with the Association of the German Petroleum Industry (MWV) and the Länder. For the 2009 Balance year, the pertinent data did not become available until January 2011. Surveys 082P and 082, which provide the statistical basis for sectoral classification of (final-energy) consumption of natural gas and petroleum gas, became available in May 2011 for the year 2009. That data were the last official data entered into the Energy Balance 2009.

Association statistics

The final Energy Balance incorporates data of the associations BDEW, WEG and Deutsches Atomforum, data which become available at an early time (from BDEW, in July; from WEG, in June, from Deutsches Atomforum, in January).

Because quarterly estimates of primary energy consumption in Germany are carried out, provisional data in the relevant areas become available quickly. The BDEW provides important provisional data, dated as of August, that are also of relevance to final energy consumption as recorded in the estimate Balance. Every summer, that organisation publishes data under the heading "The German energy market – facts and figures on the gas, electricity and district-heating sectors" ("Energiemarkt Deutschland – Zahlen und Fakten zur Gas-, Strom- und Fernwärmeversorgung"). In addition, the estimate Balance incorporates BDEW data on gross electricity generation, data of Gesamtverband Steinkohle (GVSt; Association of the German hard-coal mining industry), of the DEBRIV Federal German association of lignite-producing companies and their affiliated organisations, of the Association of the German Petroleum Industry (MWV), of the Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry association and of the Deutsche Atomforum nuclear-energy association.

Other data

For the final Energy Balance, data of the Working Group on Renewable Energy Statistics (Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), relative to "renewable energy sources", are also used; those data become available in July/August.

Provisional data on renewable energy sources are discussed with AGEE-Stat and the BDEW. They enter into the estimate Balance and, thus, into the evaluation tables.

18.5 Uncertainties in the activity rates for stationary combustion systems

See NIR 2007, Chapter 13.6.

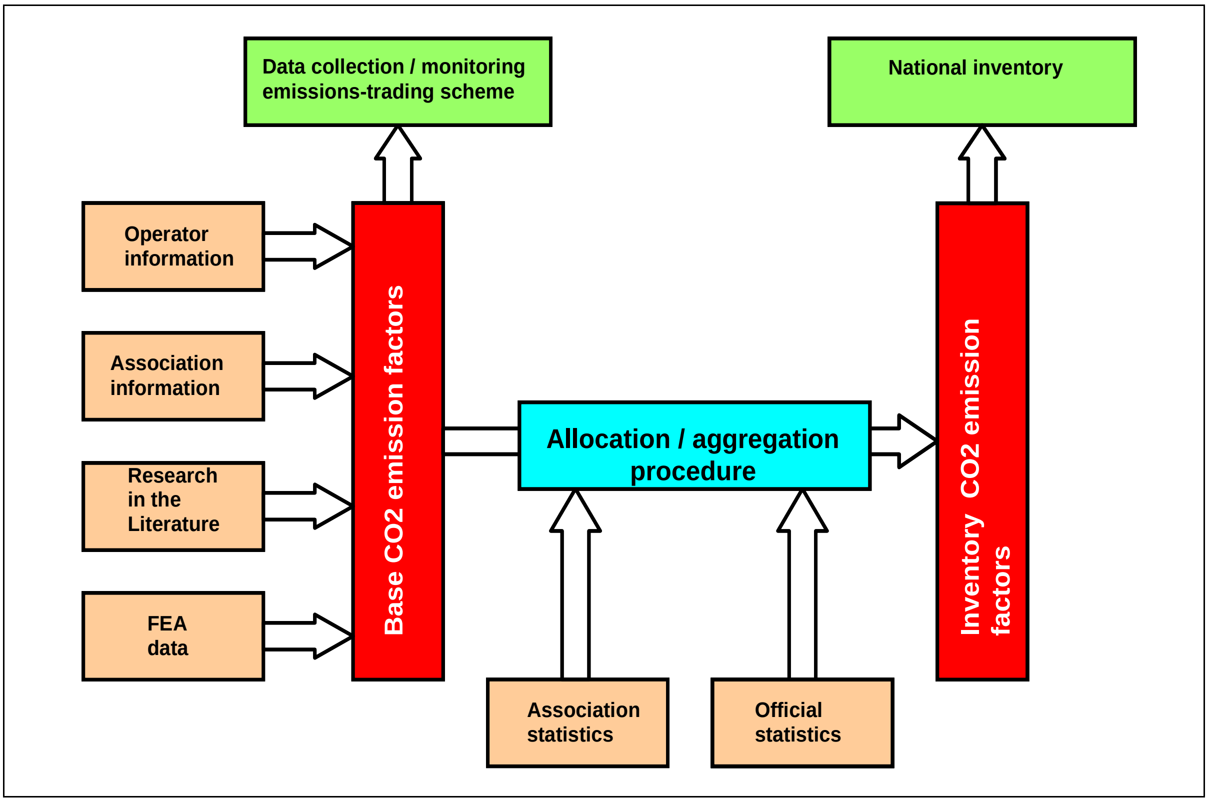
18.6 CO_2 emission factors

The emission factors on which the inventory is based were derived from the list of "*CO_2-Emissionsfaktoren für die Erstellung der nationalen CO_2-Inventare*" ("CO_2 emission factors for preparation of national CO_2 inventories"; Öko-Institut, 2004c).

18.6.1 Preliminary remarks on methods

In the framework of EU emissions trading, it is necessary to provide highly differentiated CO_2 emission factors for facility operators, to ensure that determination of facility-specific emissions is as precise as possible.

Since CO_2 emission factors for preparation of national inventories are considerably less finely differentiated, and emissions allowances must be allocated to facility operators on a cyclical basis, maximum consistency must be sought. Requirements pertaining to the ETS allocation periods thus fit with the need for consistency in inventory-calculation methods.



Source: Öko-Institut

Figure 79: Basic and inventory emission factors for CO_2

With this in mind, a consistent concept for CO_2 emission factors was developed (Figure 79).

The system is based on a set of differentiated CO_2 emission factors that – for the most part – are geared to the requirements of the emissions-trading scheme (so-called "basic" emission factors for CO_2). These emission factors were developed on the basis of a range of very different data sources. The data include operator data, data provided by associations and data gained from literature research. In addition, in some areas data of the Federal Environment Agency were used, and such data are now being enhanced via the ETS database.

With the help of structural data from association statistics and (quasi-) official statistics, the basic emission factors for CO_2 are allocated and aggregated in such a manner that they can fit with the activity data that can be used to prepare the national inventories. Emission factors on such an aggregation and allocation level are then referred to as "inventory emission factors" for CO_2.

18.6.2 Basic emission factors for CO_2

Current information on basic emission factors is available at the Federal Environment Agency's Web site, at the following URL:

http://www.umweltbundesamt.de/emissionen/publikationen.htm

18.6.3 Basic and inventory emission factors for CO_2

With the basic emission factors for CO_2 (not including the area of secondary fuels), along with data on energy-consumption structures, the CO_2 emission factors are determined at the differentiation level required for national CO_2 inventories (cf. Table 310).

With regard to *hard coal*, it is initially assumed that anthracite is used in small combustion systems, in residential heat-generation systems licensed in accordance with provisions of the Technical Instructions on Air Quality Control (TA Luft), in the small consumption sector (as of 1995: commerce, trade, services / commercial and institutional) and by military agencies. No further differentiation is carried out for anthracite. Neither is any further differentiation carried out for use of ballast coal.

For determination of CO_2 emission factors for hard coal, an energy-related mix of German hard-coal production, differentiated by districts (Ruhr, Saar, Aachen, Lower Saxony) is assumed; data for such a mix are available via the Statistik der Kohlenwirtschaft (coal-industry statistics). The relevant district-specific emission factors are then used, on this basis, to calculate a weighted average. Then, a mix consisting of domestic production and imports (broken down by countries of origin) is obtained. The relevant database consists of the aforementioned domestic-production figures and, initially, detailed data from the Association of Coal Importers (Verein der Kohlenimporteure). For calculation of the import mix, all hard-coal imports, broken down by supplier countries, are adjusted to take account of relevant amounts of coke and coking coal, and of the relevant (small) amounts of imports of other hard-coal products, and then converted to energy content.

The mix for domestic hard-coal production, and that for imports, are linked via the import fraction of hard coal used. This fraction is based on data, provided by the Association of Coal Importers (Verein der Kohlenimporteure), on fractions of imported coal found in the various areas of application. It does not include uses in the iron and steel industry and in coking plants.

The basis for country-specific CO_2 emission factors that enter into the CO_2 emission factor for the import mix consists of (unweighted) averages for the relevant countries of origin. For German hard coal, corresponding production data are used for weighting.

No further differentiation was carried out for hard-coal briquettes and hard-coal coke.

For use of raw lignite in public-sector power stations, the district-specific figures for CO_2 emission factors are used directly. A mixed value covering the different relevant districts (Rheinland, Lausitz, Mitteldeutschland, Helmstedt, Hessen) is calculated solely for the area of raw-lignite inputs in district-heating stations.

Through subtraction of crude-lignite quantities used in public power stations, and of quantities used in product production, from total production and import quantities (imports are significant only in connection with use of hard lignite), a difference is obtained that represents crude lignite use by industry and commerce, trade and services. This figure can then be broken down, via calculations, by areas of origin.

STATISTIK DER KOHLENWIRTSCHAFT (coal-sector statistics) production data are also used as a basis for calculating weighted averages, for the old and new German Länder and for Germany as a whole, from separate data sets for the various lignite products (lignite briquettes, fluidised-bed coal, pulverised lignite, dry lignite and lignite coke).

No further aggregation is carried out for the CO_2 emission factors for all other fuels; the values shown in Table 310 are used. The following should be noted with respect to allocations:

- For the period 1990 to 1994, during which separate balances are drawn up for the old and the new German Länder, weighted CO_2 emission factors, differentiated according to old and new German Länder, are used where appropriate.
- For the period until 1994, the CO_2 emission factor for Russian natural gas is assumed for the new German Länder.
- Gas separated under high pressure from natural gas is only relevant for West Berlin (until 1995).

In future, more emission factors from the ETS are to be used in the inventory. To prevent inconsistencies, it must be ensured that the fuel qualities involved are identical. Therefore, the net calorific values reported in national statistics are compared with the corresponding values reported for emissions trading, in order to determine which values can be used for the inventory. That work has not yet been completed.

Table 310: Emission factors for CO_2 as of 1990, as derived for emissions reporting: energy

Fuel-based emission factors [t CO_2/TJ]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Coal															
Hard coal (Steinkohle)															
Raw hard coal (power stations, industry)	93.3	93.4	93.4	93.4	93.4	93.4	93.5	93.6	93.7	93.7	93.7	93.9	94.0	94.0	94.0
Hard-coal briquettes	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0
Hard-coal coke	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
Anthracite (heat market for households, commerce, trade, services)	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0
Ballast hard coal, *old German Länder*	90.0	90.0	90.0	90.0	90.0										
Lignite (Braunkohle)															
Raw lignite															
Public district heating stations, Germany.						112.5	112.3	112.3	112.2	112.2	112.1	111.9	112.1	112.1	112.3
Industry, commerce, trade, services, Germany						109.5	111.9	112.9	112.8	111.8	112.4	111.9	112.1	112.0	111.9
Old German Länder	113.9	113.8	113.8	113.9	113.9										
New German Länder	108.8	108.1	107.8	108.0	108.3										
Public power stations; District:															
Rheinland	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0
Helmstedt	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
Hesse	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	NO
Lausitz	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0
Mitteldeutschland	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0
Lignite briquettes, Germany						100.0	100.0	99.9	99.7	99.7	99.7	99.7	99.7	99.7	99.7
Old German Länder	99.0	99.0	99.0	99.0	99.0										
New German Länder	99.7	100.0	100.0	100.0	100.3										
Lignite tar, *New German Länder*	97.0	97.0	97.0	97.0	97.0										
Lignite dust and fluidised bed coal, *Germany*						97.8	97.7	97.7	97.8	97.9	98.0	98.0	97.9	97.9	97.9
Old German Länder	98.0	98.0	98.0	98.0	98.0										
New German Länder	96.7	96.6	96.8	97.5	97.1										
Lignite coke	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0
Hard lignite	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0	97.0

Fuel-based emission factors [t CO_2/TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Petroleum															
Crude oil	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Petrol	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0
Raw gasoline *Germany*						80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Old German Länder	80.0	80.0	80.0	80.0	80.0										
New German Länder	74.0	74.0	74.0	74.0	74.0										
Kerosene	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
Avgas	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3	69.3
Diesel fuel, *Germany*						74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder	74.0	74.0	74.0	74.0	74.0										
New German Länder	73.0	74.0	74.0	74.0	74.0										
Light heating oil, *Germany*						74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder	74.0	74.0	74.0	74.0	74.0										
New German Länder	73.0	74.0	74.0	74.0	74.0										
Heavy heating oil	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0	78.0
Petroleum	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Petrol coke	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0
LP gas, *Germany*						65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0	65.0
Old German Länder	65.0	65.0	65.0	65.0	65.0										
New German Länder	64.0	65.0	65.0	65.0	65.0										
Refinery gas	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Other petroleum products, *Germany*						80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Old German Länder	80.0	80.0	80.0	80.0	80.0										
New German Länder	78.0	78.0	78.0	78.0	78.0										
Lubricants	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Gases															
Coking-plant and city gas, *Germany*						40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Old German Länder	40.0	40.0	40.0	40.0	40.0										
New German Länder	50.0	50.0	50.0	50.0	50.0										
Top gas, Old and new German Länder	264.0	264.0	264.0	264.0	264.0										
Top gas and converter gas, *Germany*						255.8	257.9	257.8	257.5	257.4	257.5	257.7	257.5	257.6	257.5
Fuel gas, *New German Länder*	49.0	49.0	49.0	49.0	49.0										
Other gases, *Germany*														60.0	60.0
Natural gases															
Natural gas, *Germany*						56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0	56.0
Old German Länder	56.0	56.0	56.0	56.0	56.0										
New German Länder	55.0	55.0	55.0	55.0	55.0										
Petroleum gas	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0
Pit gas	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0	55.0

Fuel-based emission factors [t CO_2/TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Waste															
Household waste / municipal waste	109.6	107.0	104.6	100.1	98.0	96.9	95.8	94.7	93.6	92.5	91.5	91.5	91.5	91.5	91.5
Industrial waste, *Germany*						71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Old German Länder [2)]	73.9	73.9	74.0	74.1	74.3										
New German Länder [2)]	74.9	74.8	74.7	74.6	74.6										
Special waste, *Germany*						83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0	83.0
Special fuels [1)]															
Used oil	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7	78.7
Recycled plastics						74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6	74.6
Recycled tyres	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4	88.4
Bleaching clay	NO	NO	NO	NO	NO	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3	82.3
Commercial waste - plastic	NO	NO	NO	NO	NO	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1	83.1
Commercial waste - paper	NO	NO	NO	NO	NO	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9
Commercial waste - other	NO	NO	NO	NO	NO	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1
Commercial waste - packaging	NO	NO	NO	NO	NO	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9	56.9
Sewage sludge	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	95.1	95.1
Solvents (waste)	NO	NO	NO	NO	NO	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
Oil sludge	NO	NO	NO	NO	NO	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0	84.0
Paper-industry residues	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2	86.2
Processed municipal waste	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8
Carpet waste	NO	NO	NO	NO	NO	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4	80.4
Textile waste	NO	NO	NO	NO	NO	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3	63.3

Fuel-based emission factors [t CO_2/TJ]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Biomass fuels [3]															
Spent liquors from pulp production	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
Fibre/de-inking residues	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9	54.9
Waste wood, wood scraps (industry)	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1	102.1
Waste wood, wood scraps (commercial/institutional)	NO	NO	NO	NO	NO	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1	95.1
Bark	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4	101.4
Animal meals and fats	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6	80.6
Animal fat	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	74.9	74.9	74.9	74.9
Firewood [4]	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4	71.4
Landfill gas, sewage gas, biogas [4]	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.6
Bioethanol	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0
Biodiesel [4]	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8	70.8
Other factors [kg/t]															
Flue-gas desulphurisation	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0	440.0

Fuel-based emission factors [t CO_2/TJ]	2005	2006	2007	2008	2009	2010
Coal						
Hard coal (Steinkohle)						
Raw hard coal (power stations, industry)	94.0	94.2	94.1	94.3	94.3	94.2
Hard-coal briquettes	93.0	93.0	93.0	93.0	93.0	93.0
Hard-coal coke	105.0	105.0	105.0	105.0	105.0	105.0
Anthracite (heat market for households, commerce, trade, services)	98.0	98.0	98.0	98.0	98.0	98.0
Ballast hard coal, *old German Länder*						
Lignite (Braunkohle)						
Raw lignite						
Public district heating stations, Germany.	112.3	112.2	112.3	112.3	112.2	112.3
Industry, commerce, trade, services, Germany	111.4	110.6	111.6	110.7	110.7	107.3
Old German Länder						
New German Länder						
Public power stations; District:						
Rheinland	114.0	114.0	114.0	114.0	114.0	114.0
Helmstedt	99.0	99.0	99.0	99.0	99.0	99.0
Hesse	NO	NO	NO	NO	NO	NO
Lausitz	113.0	113.0	113.0	113.0	113.0	113.0
Mitteldeutschland	104.0	104.0	104.0	104.0	104.0	104.0
Lignite briquettes, Germany	99.7	99.7	99.6	99.6	99.8	99.8
Old German Länder						
New German Länder						
Lignite tar, *New German Länder*						
Lignite dust and fluidised bed coal*, Germany*	98.0	98.0	97.9	98.0	98.0	98.0
Old German Länder						
New German Länder						
Lignite coke	108.0	108.0	108.0	108.0	108.0	108.0
Hard lignite	97.0	97.0	97.0	97.0	97.0	97.0

Fuel-based emission factors [t CO_2/TJ]	2005	2006	2007	2008	2009	2010
Petroleum						
Crude oil	NO	NO	NO	NO	NO	NO
Petrol	72.0	72.0	72.0	72.0	72.0	72.0
Raw gasoline *Germany*	80.0	80.0	80.0	80.0	80.0	80.0
Old German Länder						
New German Länder						
Kerosene	73.3	73.3	73.3	73.3	73.3	73.3
Aircraft fuel	69.3	69.3	69.3	69.3	69.3	69.3
Diesel fuel, *Germany*	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder						
New German Länder						
Light heating oil, *Germany*	74.0	74.0	74.0	74.0	74.0	74.0
Old German Länder						
New German Länder						
Heavy heating oil	78.0	78.0	78.0	78.0	78.0	78.0
Petroleum	74.0	74.0	74.0	74.0	74.0	74.0
Petrol coke	101.0	101.0	101.0	101.0	101.0	101.0
LP gas, *Germany*	65.0	65.0	65.0	65.0	65.0	65.0
Old German Länder						
New German Länder						
Refinery gas	60.0	60.0	60.0	60.0	60.0	60.0
Other petroleum products, *Germany*	80.0	80.0	80.0	80.0	80.0	80.0
Old German Länder						
New German Länder						
Lubricants	80.0	80.0	80.0	80.0	80.0	80.0
Gases						
Coking-plant and city gas, *Germany*	40.0	40.0	40.0	40.0	40.0	40.0
Old German Länder						
New German Länder						
Top gas, Old and new German Länder						
Top gas and converter gas, *Germany*	257.7	257.5	257.7	257.8	257.5	257.7
Fuel gas, *New German Länder*						
Other gases, *Germany*	60.0	60.0	60.0	60.0	60.0	60.0
Natural gases						
Natural gas, *Germany*	56.0	56.0	56.0	56.0	56.0	56.0
Old German Länder						
New German Länder						
Petroleum gas	58.0	58.0	58.0	58.0	58.0	58.0
Pit gas	55.0	55.0	55.0	55.0	55.0	55.0

Fuel-based emission factors [t CO_2/TJ]	2005	2006	2007	2008	2009	2010
Waste						
Household waste / municipal waste	91.5	91.5	91.5	91.5	91.5	91.5
Industrial waste, *Germany*	71.1	71.1	71.1	71.1	71.1	71.1
Old German Länder [2)]						
New German Länder [2)]						
Special waste, *Germany*	83.0	83.0	83.0	83.0	83.0	83.0
Special fuels [1)]						
Used oil	78.7	78.7	78.7	78.7	78.7	78.7
Recycled plastics	74.6	74.6	74.6	74.6	74.6	74.6
Recycled tyres	88.4	88.4	88.4	88.4	88.4	88.4
Bleaching clay	82.3	82.3	82.3	82.3	82.3	82.3
Commercial waste - plastic	83.1	83.1	83.1	83.1	83.1	83.1
Commercial waste - paper	64.9	64.9	64.9	64.9	64.9	64.9
Commercial waste - other	68.1	68.1	68.1	68.1	68.1	68.1
Commercial waste - packaging	56.9	56.9	56.9	56.9	56.9	56.9
Sewage sludge	95.1	95.1	95.1	95.1	95.1	95.1
Solvents (waste)	71.1	71.1	71.1	71.1	71.1	71.1
Oil sludge	84.0	84.0	84.0	84.0	84.0	84.0
Paper-industry residues	86.2	86.2	86.2	86.2	86.2	86.2
Processed municipal waste	59.8	59.8	59.8	59.8	59.8	59.8
Carpet waste	80.4	80.4	80.4	80.4	80.4	80.4
Textile waste	63.3	63.3	63.3	63.3	63.3	63.3

Fuel-based emission factors [t CO_2/TJ]	2005	2006	2007	2008	2009	2010
Biomass fuels [3]						
Spent liquors from pulp production	74.0	74.0	74.0	74.0	74.0	74.0
Fibre/de-inking residues	54.9	54.9	54.9	54.9	54.9	54.9
Waste wood, wood scraps (industry)	102.1	102.1	102.1	102.1	102.1	102.1
Waste wood, wood scraps (commercial/institutional)	95.1	95.1	95.1	95.1	95.1	95.1
Bark	101.4	101.4	101.4	101.4	101.4	101.4
Animal meals and fats	80.6	80.6	80.6	80.6	80.6	80.6
Animal fat	74.9	74.9	74.9	74.9	74.9	74.9
Firewood [4]	71.4	71.4	71.4	71.4	71.4	71.4
Landfill gas, sewage gas, biogas [4]	54.6	54.6	54.6	54.6	54.6	54.6
Bioethanol	72.0	72.0	72.0	72.0	72.0	72.0
Biodiesel [4]	70.8	70.8	70.8	70.8	70.8	70.8
Other factors [kg/t]						
Flue-gas desulphurisation	440.0	440.0	440.0	440.0	440.0	440.0

1) Designations of fuels as defined for the inventory data can diverge from other standards, and they are listed as such, and given EF as such, only in the inventory.

2) Designations of fuels as defined for the inventory data can diverge from other standards, and they are listed as such, and given EF as such, only in the inventory

3) Listed for selected fuels; calculated CO_2 emissions are reported only as memo items, and do not enter into the total inventory quantities; biomass fractions from special fuels (see above) are not listed separately, because their CO_2 EF are not differentiated.

4) Default values

Remark: The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

Table 311: Emission factors for CO_2 as of 1990, as derived for emissions reporting: industrial processes (last revised for NIR 2011)

Industrial processes [kg CO_2/ t (raw material or product)]	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
2.A.1 Production of cement clinkers	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
2.A.2 Production of burnt lime	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00	785.00
2.A.2 Production of dolomite lime	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00	913.00
2.A.3 Use of limestone	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00
2.A.4.b Use of soda ash	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00	415.00
2.A.7.a Production of container glass	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00	193.00
2.A.7.a Production of flat glass	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00	208.00
2.A.7.a Production of household and table glassware	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00	120.00
2.A.7.a Production of special glass (mix)	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00	113.00
2.A.7.a Production of glass fibres (mix)	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00	198.00
2.A.7.a Production of rock wool (mix)	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00	299.00
2.A.7.a Production of glass (mix not differentiated for new German Länder)	174.00	174.00	174.00	174.00	174.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.A.7.a Production of glass (mix for Germany, including cullet inputs)	106.01	101.80	99.34	96.79	83.97	101.63	99.75	97.09	94.99	94.56	97.41	100.58	97.47	96.37	98.27
2.A.7.b Production of masonry bricks	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10	29.10
2.A.7.b Production of roof tiles	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60	28.60
2.B.1 Production of ammonia	2,124.10	2,139.00	2,154.20	2,469.70	2,441.40	2,410.30	2,349.30	2,411.70	2,366.60	2,419.00	2,340.80	2,347.80	2,394.10	2,381.20	2,422.20
2.B.4 Production of calcium carbide	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
2.B.5 Coke burn-off in catalyst regeneration	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.42
2.B.5 Production of carbon black	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196
2.B.5 Production of methanol	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00	670.00
2.C.1 Production of electric steel	8.50	8.00	7.50	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374	7.374
2.C.1 Production of oxygen steel; limestone input	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00	440.00
2.C.2 Ferroalloys production	1500.00	1222.00	944.00	527.00	249.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00	110.00
2.C.2 Ferroalloys production (new German Länder)	1500.00	1500.00	1500.00	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.3 Production of foundry aluminium	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00

Industrial processes [kg CO_2/ t (raw material or product)]	2005	2006	2007	2008	2009	2010
2.A.1 Production of cement clinkers	530.00	530.00	530.00	530.00	530.00	530.00
2.A.2 Production of burnt lime	785.00	785.00	785.00	785.00	785.00	785.00
2.A.2 Production of dolomite lime	913.00	913.00	913.00	913.00	913.00	913.00
2.A.3 Use of limestone	440.00	440.00	440.00	440.00	440.00	440.00
2.A.4.b Use of soda ash	415.00	415.00	415.00	415.00	415.00	415.00
2.A.7.a Production of container glass	193.00	193.00	193.00	193.00	193.00	193.00
2.A.7.a Production of flat glass	208.00	208.00	208.00	208.00	208.00	208.00
2.A.7.a Production of household and table glassware	120.00	120.00	120.00	120.00	120.00	120.00
2.A.7.a Production of special glass (mix)	113.00	113.00	113.00	113.00	113.00	113.00
2.A.7.a Production of glass fibres (mix)	198.00	198.00	198.00	198.00	198.00	198.00
2.A.7.a Production of rock wool (mix)	299.00	299.00	299.00	299.00	299.00	299.00
2.A.7.a Production of glass (mix not differentiated for new German Länder)	NO	NO	NO	NO	NO	NO
2.A.7.a Production of glass (mix for Germany, including cullet inputs)	101.59	100.88	100.46	100.31	101.06	103.94
2.A.7.b Production of masonry bricks	29.10	29.10	29.10	29.10	29.10	29.10
2.A.7.b Production of roof tiles	28.60	28.60	28.60	28.60	28.60	28.60
2.B.1 Production of ammonia	2,372.80	2,310.70	2,364.20	2,382.90	2,492.10	2,377.50
2.B.4 Production of calcium carbide	C	C	C	C	C	C
2.B.5 Coke burn-off in catalyst regeneration	62.42	62.42	62.42	62.42	62.42	62.42
2.B.5 Production of carbon black	0.00196	0.00196	0.00196	0.00196	0.00196	0.00196
2.B.5 Production of methanol	670.00	670.00	670.00	670.00	670.00	670.00
2.C.1 Production of electric steel	7.374	7.374	7.374	7.374	7.374	7.374
2.C.1 Production of oxygen steel; limestone input	440.00	440.00	440.00	440.00	440.00	440.00
2.C.2 Ferroalloys production	110.00	110.00	110.00	110.00	110.00	111.00
2.C.2 Ferroalloys production (new German Länder)	NO	NO	NO	NO	NO	NO
2.C.3 Production of foundry aluminium	1367.00	1367.00	1367.00	1367.00	1367.00	1367.00

C Confidential data

Remark: The information and FAQ provided by the German Emissions Trading Authority (DEHSt) must be taken into account in any use of substance data from the NIR in the context of the ETS.

18.7 Analysis of CO_2 emissions from non-energy-related use of fuels

The great majority of the coal, oil and gas that Germany uses is used for energy-related purposes. The remainder of the coal, oil (about 20 % in 2007) and gas is used as feedstock for production processes. This consumption enters into the balance as "non-energy use" (NEU).

In the German Energy Balance, this consumption is listed separately, in line 43. The chemical industry is the leading user of fossil fuels for non-energy-related purposes. The German chemical sector uses such fuels in production of basic chemicals such as ammonia, ethylene und propylene, which are used, in additional production steps, to make such important products as fertilisers and plastics. Additional applications include production of graphite electrodes, asphalt for road construction and a range of waxes and lubricants.

Table 312 (see below) presents a comparison of a) the consumption listed in line 43 and b) reported emissions of CO_2 and NMVOC from use of fossil fuels in non-energy-related applications. Emissions from non-energy-related applications were correlated with the various relevant fuels in keeping with Table 1.3 from Volume 3 of IPCC-GL 2006 and in accordance with information provided by producers and experts. In some cases, we had to make our own estimates of the applicable correlation with individual fuels.

The comparison highlights a discrepancy between the carbon quantities reported in line 43 and the relevant emissions, especially in the case of mineral oils. In 2007, NMVOC and CO_2 emissions correlated with about 14 % of non-energy-related consumption; some 86 % of non-energy-related consumption is tied to indirect emissions.

To compare a) the carbon used in connection with the fuels and b) the resulting emissions, one must also take relevant products' entire life cycles into account. Such life cycles include production, use and disposal of products – and exports. In source category CRF 1.A, Germany reports (inter alia) emissions from waste incineration for energy-related purposes. Many products are not disposed of in the same year in which they are produced. In some products, carbon can be bound up for considerable periods of time. In asphalt, for example, bitumen carbon can remain stored for especially long periods. Other products, such as plastics, are exported as tradeable goods. Waste is also exported to other countries. Such products, along with the carbon they contain, cannot be taken into account in the carbon balance for Germany considered in the present context. They are responsible for a significant discrepancy between the carbon quantities used, and those emitted, in non-energy-related consumption in Germany. The carbon quantities used in non-energy-related consumption are considerably greater than the carbon quantities that would correspond to the reported CO_2 and NMVOC emissions from non-energy-related use of fossil fuels.

To determine whether the quantities listed in the Energy Balance as "non-energy use" actually show up in the relevant feedstock quantities, the fossil-fuel carbon stored in relevant products was balanced. In the chemical industry, fossil fuels are used in crackers, reforming processes and production of synthetic gases. In crackers and reforming, the most important products resulting from such processes are ethylene, propylene, 1,3-butadiene, benzene, toluol and xylene; in production of synthetic gases, the most important such products are ammonia and methanol. The products produced in refineries include bitumen, lubricants and paraffins, waxes and vaseline. Bitumen is used in a range of applications, including road surfaces and bitumen sheeting for roofs. Lubricants are used in road vehicles and machines (inter alia). For purposes of comparison with line 43, the produced quantities of the listed products were obtained from data of the Federal Statistical Office. Those data were then stoichiometrically converted into proportional CO_2 equivalents.

For methanol, ethylene, propylene, 1,3-butadiene, benzene, toluene and xylene, the carbon content was stoichiometrically converted, via the molar masses of the products and of CO_2, into CO_2 equivalents. Then, the pertinent CO_2 equivalent emissions were distributed among the three feedstocks used in Germany (naphta, LP gas and other mineral-oil products). The possible relevant distributions include distribution of emissions and products' carbon content among the various fuels involved. Below, conversion into CO_2 equivalents is illustrated with the example of ethylene (C_2H_4):

M (CO_2) = 44 g/mol
M (C_2H_4) = 28
CO_2 equivalents = AR *2*44/28.

In the case of carbon black, the product is assumed to consist of pure carbon. That carbon was also converted into CO_2 equivalents, via the applicable stoichiometric relationship.

The production quantities of lubricants, waxes, paraffins, vaseline and other products were converted via the following values, taken from the monitoring guidelines used in emissions trading (Table 4, p. 33).

	EF **t CO_2/TJ**	**Lower net calorific value TJ/Gg**
Bitumen	80.6	40.2
Paraffin wax	73.3	40.2
Lubricating oil	73.3	40.2

For 2007 in the Submission 2011,, the sum of the carbon from the pertinent emissions and of the carbon stored in products amounts to 103 % of the non-energy-related consumption given in line 43 of the Energy Balance. The total share for the chemical industry is about 75 %, and the total share for refinery products is about 24 %.

Table 312: Verification of completeness of reported CO_2 from non-energy use of fossil fuels

			Coal						Petroleum									Gas	
Year	2007	Unit	Hard coal	Hard-coal coke	Other hard-coal products	Lignite	Other lignite products	Total solids	Raw gasoline (naphtha)	Diesel fuel	Heating oil, light	Heating oil, heavy	Petroleum coke	LP gas	Refinery gas	Other petroleum products	Total liquids	Natural gas	Total gas
A: Declared NEU (Energy Balance line 43)		**TJ**	1,661	1,833	2.780	392	10.082		466.479	1	42.761	154.925	7.903	55.442	23.369	150.279		87.221	
B: Carbon content		**kg C/GJ**	26.8	29.2	26.8	27.6	27.6		20.0	20.2	20.2	21.1	26.6	17.2	15.7	20.0		15.3	
C: Total supplied for feedstock/non-energy		**Gg C**	44.5	53.5	74.5	10.8	278.3	461.6	9,329.6	0.0	863.8	3,268.9	210.2	953.6	366.9	3,005.6	17,998.6	1,334.5	1,334.5
D: Total supplied for feedstock/non-energy		**Gg CO_2**	163.2	196.3	273.2	39.7	1,020.3	1,692.6	34,208.5	0.1	3,167.2	11,986.0	770.8	3,496.5	1,345.3	11,020.5	65,994.8	4,893.1	4,893.1
E: Implied carbon fraction oxidised				3.90				0.45	1.00			0.87	0.02	1.00		1.85	1.04	1.06	1.06

	AD	EM	Gg CO_2																
	Gg	Gg CO2																	
T: Total fossil IPPU CO_2 reported		**7,773.1**		**765.1**				**765.1**	**34,206.3**			**10,418.3**	**17.5**	**3,497.5**		**20,350.1**	**68,489.7**	**5,183.4**	**5,183.4**
2 Industrial processes																			
2.A: Mineral industry																			
2.B: Chemical industry		**7,008**							**34,206**			**10,418**	**18**	**3,497**		**5,001**	**53,140**	**5,183**	**5,183**
2.B.1: Ammonia production	3,266	4,331										2,887.3					2,887.3	1,443.7	1,443.7
CO_2 for further use	3,390											3,390.0					3,390.0		
2.B.5: Carbide production	C	18											17.5				17.5		
2.B.5: Other																			
Methanol CH3OH	2,025	1,357										4,141.0					4,141.0		
Ethylene C2H4	5,097								12,832.5					1,312.1		1,876.0	16,020.6		
Propylene C3H6	3,492								8,790.8					898.8		1,285.2	10,974.8		
1,3-butadiene C4H6	1,149								3,000.1					306.7		438.6	3,745.4		
Benzene C6H6	2,214								6,003.0					613.8		877.6	7,494.4		
Toluene C7H8	760								2,039.2					208.5		298.1	2,545.9		
Xylene C8H10	579								1,540.6					157.5		225.2	1,923.3		
Carbon black	665	1,303																3,739.7	3,739.7
2.C: Metal industry		765		**765.1**				**765.1**											
2.C.1: Iron and steel production (1)	IE	IE																	
2.C.2: Production of ferroalloys	72	8		8				7.9											
2.C.3: Primary aluminium production	554	757		757				757.2											
2.C.5: Other																			
Lead production	NE	NE																	
Zinc production	NE	NE																	
2.D: Other production:																			
3. Solvent and other product use																			
3.A-D: Solvents (2)	IE	IE							IE										

			Coal						Petroleum									Gas	
Year	AR [Gg]	EM [Gg CO_2]	Hard coal	Hard-coal coke	Other hard-coal products	Lignite (Braunkohle)	Other lignite products	Total solids	Raw benzene (naphtha)	Diesel fuel	Heating oil, light	Heating oil, heavy	Petrol coke	Liquid gas	Refinery gas	Other petroleum products	Total liquids	Natural gas	Total gas
EXCEPTIONS REPORTED ELSEWHERE																			
1.A FUEL COMBUSTION ACTIVITIES																**15,349.4**	**15,349.4**		
1.A.1.b: Petroleum refining																			
Lubricants	1,056															3,110.3	3,110.3		
Waxes, paraffins, vaseline, etc.	305															898.7	898.7		
Bitumen	3,500															11,340.4	11,340.4		
1.A.3 Lubricants in road transports (3)	IE	IE														IE			

(1) Since coke inputs in the iron and steel industry are not included in the Energy Balance, the relevant CO_2 emissions are not included here.

(2) Since over 90 % of solvents from basic chemicals are produced in steam crackers, it is assumed that carbon emitted from NMVOCs comes from products of such crackers.

(3) Use of lubricants is already covered by the total quantity of produced lubricants.

19 ANNEX 3: OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR INDIVIDUAL SOURCE OR SINK CATEGORIES, INCLUDING KP-LULUCF ACTIVITIES

19.1 Other detailed methodological descriptions for the source category "Energy" (1)

19.1.1 Revision of the activity rates for stationary combustion systems of the new German Länder for the year 1990 and for subsequent years (1.A.1 and 1.A.2)

Problems with the GDR's official statistics in 1990, the year of German reunification, along with the creation of a standardised system of official statistics for all of Germany, had a noticeable effect on the quality of figures, as reported in past inventories, for activity rates of stationary combustion systems of the new German Länder for the year 1990 (and for subsequent years). For this reason, these figures have been revised. This work was carried out by the Institute for Energy and Environment (Institut für Energetik und Umwelt gGmbH; IE gGmbH). In work package 1 of the research project "Base year and update" ("Basisjahr und Aktualisierung"; UBA, 2005c: FKZ 20541115), "the activity rates for stationary combustion systems of the new German Länder, in their role as a basis for emissions inventories and the report relative to determination of allocated quantities, were explicitly reviewed for any gaps, completed and corrected as necessary and substantiated". For a detailed description of the procedure used for revising the activity rates for stationary combustion systems, please see the 2010 NIR.

19.1.2 Energy industry (1.A.1)

19.1.2.1 Methodological aspects of determination of emission factors (Chapter 3.2.6.2)

This section of the Annex describes the main steps carried out in the research project RENTZ et al (2002) for determination of emission factors. (This description does not apply to the CO_2 emission factors whose determination is described in Annex 2 (Chapter 18.6).)

Determination of emission factors requires detailed analysis of all operational facilities with regard to technologies used and design-specific emission behaviour. Three overarching source categories are formed: large combustion systems, combustion systems within the scope of application of the Technical Instructions on Air Quality Control (TA Luft) and gas turbines. Existing plants are classified in terms of emissions-relevant characteristics, and the pertinent emission factors are determined. These so-called "technology-specific" factors can then be aggregated in an adequate manner. This database also provides the basis for estimating future emissions (changes in the overall make-up of the entire group of facilities, in terms of percentage shares for various facility types). This procedure thus consists of the following steps:

1. Characterisation of the technology-specific emissions behaviour of combustion systems.
   In a first step, the combustion and emissions-reduction technologies used in Germany are briefly described, and the relevant emissions-determining factors are explained. On

the basis of this characterisation, emission factors are derived for the various different relevant technologies, differentiated by size class and fuel type. The chosen classification is also oriented to applicable provisions under immissions-control law, an orientation that permits derived emission factors to be compared with limits applicable now or in the future.

2. Analysis of the relevant source-category structure

   Emissions calculations must be carried out using emission factors that have the same references as the pertinent energy-input data. The latter (data) are broken down by source categories that are derived from the national energy balance – cf. Chapter 3.2 – and are not based on the combustion technologies used. The project has defined and analysed the following source categories: Public electricity and heat production (CRF 1.A.1a), Industrial power stations (CRF 1.A.1c for mining-sector power stations; otherwise CRF 1.A.2), District-heating stations (CRF 1.A.1a), Refinery power stations (CRF 1.A.1b), Industrial combustion systems (CRF 1.A.1c and 1.A.2) and residential, institutional and commercial (small consumers) (CRF 1.A.4 and 1.A.5).

   In the analysis, the various technologies' contributions to total energy use must be determined. The most important data sources for this include the power-station database of the DFIU, relevant statistics, communications of industry associations (VGB, VDEW, VIK), operator information and technical publications. Furthermore, excerpts of emissions declarations from the year 1996, as provided by some Länder authorities, were also evaluated in the present context.

3. Aggregation of emission factors

   On the basis of the percentage contributions for the various technologies – which were determined separately for the old and new Länder – the technology-specific emission factors are aggregated to form source-category-specific factors. Finally, factors for Germany as a whole are formed. The source-category-specific factors are sub-divided in accordance with the categories "large combustion systems", "TA Luft combustion systems" and "gas turbines", as well as by fuel type. Aggregated emission factors are formed first for the reference year 1995.

4. Projections for the years 2000 and 2010

   Technology-specific emission factors are defined for purposes of describing continuing technological progress. These are derived from characterisation of modern technologies. An increasing contribution of low-emissions technologies to total relevant activity, thus, can be represented by suitably changing the percentage shares for the technologies under consideration. Applicable immission-control laws are used as a framework for updating for the year 2000. It is assumed that the requirements of the amended TA Luft (Technical Instructions on Air Quality Control) and of the EU directive on large combustion systems were met by the reference year 2010.

The above-described methods, beginning with characterisation of the emissions behaviour of relevant combustion technologies and gradually leading to aggregated factors at various regional and source-category-specific levels, make it possible to represent the required factors transparently.

The chosen methods for deriving emission factors for a given reference year are shown in Figure 80 below.

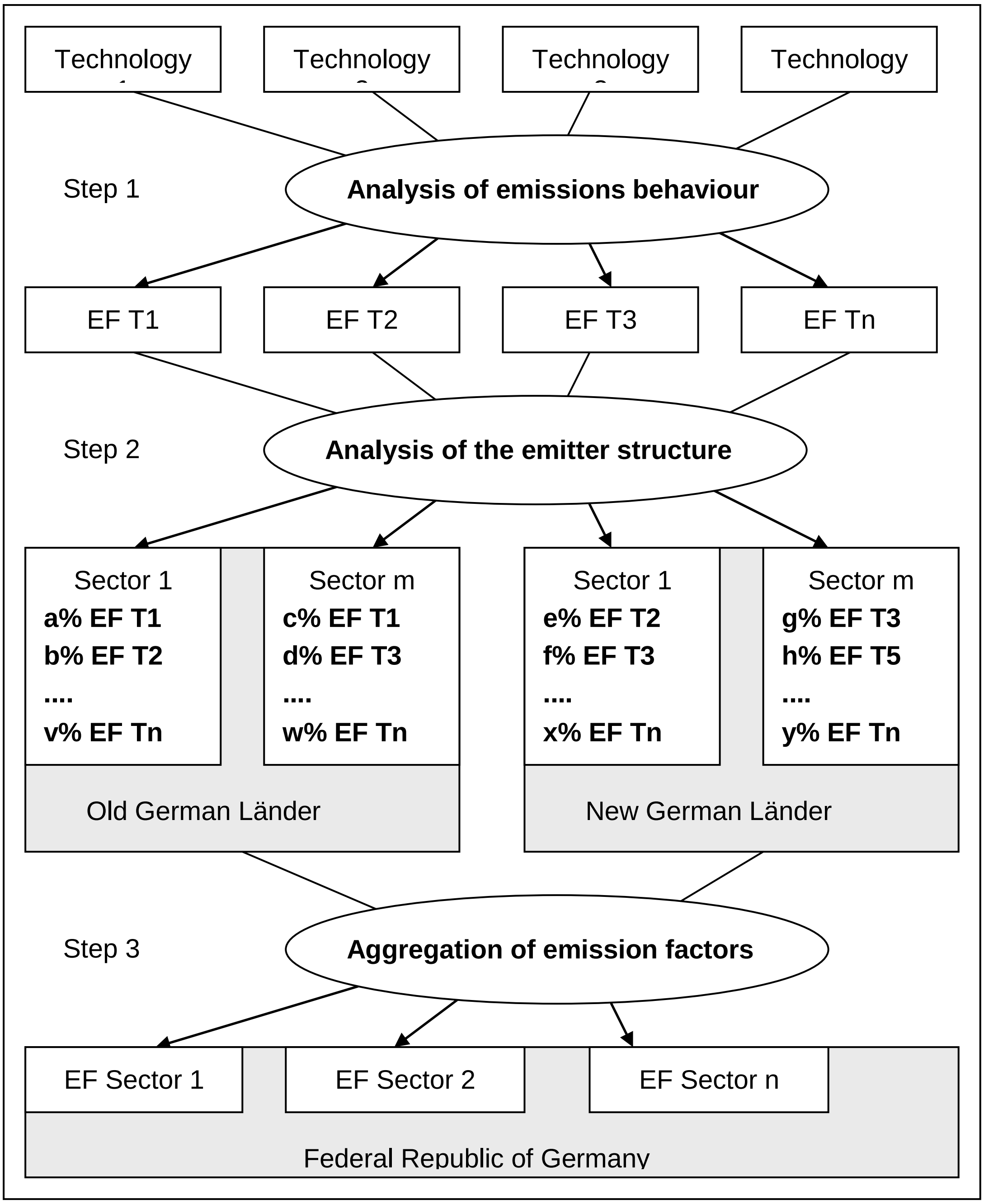


Figure 80: Methods for calculating emission factors

The origins and quality of the data are described in detail in the project report (RENTZ et al, 2002). A large portion of the data has been obtained from emissions declarations of the German Länder Baden-Württemberg, Brandenburg, North Rhine – Westphalia and Thuringia for the year 1996. The annual pollutant-load data included in those data are based, depending on the pollutant in question, on measurements from continuous monitoring, on individual measurements or on calculations based on physical laws, mass balances or emission factors. In the following, the emissions declarations of the state of Baden-Württemberg are used to show, by way of illustration, what data-determination methods tend to be used for the various types of combustion systems and substances in question. Such analysis makes it possible to classify the quality of the underlying data with regard to the derived technology-specific emission factors. At the same time, the description illustrates the data-evaluation procedure. Where a sufficient amount of data for a source category is available, the relevant value range is characterised via the median and the percentile is characterised at 25 % and 75 %[111]. This produces a robust estimate that, unlike characterisation via the mean value, is not distorted by extreme values. In general, percentiles at 5 % and 95 % are also listed, to describe the distribution of values. Similar percentile evaluations were also carried out for the emissions declarations of the other Federal Länder.

In the following, a distinction is made between measured data (either continuous measurements or individual measurements) and data based on calculations or emission factors. In evaluation, therefore, individual data items are first classified as either "measurements" (M) or "assumptions" (A). This general overview, in turn, is divided into the categories of large combustion systems, TA Luft combustion systems and gas turbines. These are then further subdivided, with regard to declaration obligations, into facilities subject to abbreviated (K) or complete (V) declarations. For each of the three groups of systems, evaluation and derivation of emission factors is carried out, using the sample data from Baden-Württemberg and with classification by "measurements" and "assumptions".

Table 313 provides an overview of the facility types considered, grouped on the basis of their numbers under the 4th Ordinance Implementing the Federal Immission Control Act (BImSchV) and of the type of declaration concerned.

111 For the entire value range of a variable X, the sum-frequency distribution can be used to estimate what percentage of all units considered will have a maximal value of x. That value is referred to as a *quantile* or, when percentage values are being considered, as a *percentile*. The best-known percentile, the one that separates the lower half of all values from the upper half, is the 50th percentile, the so-called *median*. The 25th and 75th percentiles cut off the upper and lower quarters of the distribution. They are thus also referred to as upper and lower *quartiles* or as the first and third *quartile* (with the median being a sort of second quartile).

Table 313: Facility types pursuant to Annex of 4th BImSchV (4th Ordinance on Execution of the Federal Immission Control Act)

Index	**Large combustion systems (Großfeuerungsanlagen)**		**Type of declaration required**
1 01 1	Power stations	≥ 50 MW for solid, liquid and gaseous fuels	V
1 02A 1	Combustion systems	≥ 50 MW for solid and liquid fuels	V
1 02B 1	Combustion systems	≥ 50 MW for gaseous fuels	V
Index	**TA Luft installations**		**Type of declaration required**
1 02A 2	Combustion systems for heating oil EL)	1 - < 50 MW, solid and liquid fuels (except	V
1 02B 2	Combustion systems	5 - < 50 MW heating oil EL	K
1 02C 2	Combustion systems Combustion systems installations	10 - < 50 MW for natural gas 10 - < 50 MW, except for natural gas	K V
1 03 1	Combustion systems	> 1 MW, other fuels	V
Index	**Gas turbine systems**		**Type of declaration required**
1 05 1	Gas turbines Gas turbines installations	≥ 50 MW for natural gas ≥ 50 MW, except for natural gas	K V
1 05 2	Gas turbines Gas turbines installations	< 50 MW for natural gas < 50 MW, except for natural gas	K V

In the analyses, emissions data is differentiated by combustion technologies. Table 314 provides an overview of this technology classification based on types. Categories 110 to 118 apply mainly to solid fuels, while 120 to 125 apply to liquid fuels and 130 to 132 apply to gaseous fuels.

Table 314: Classification of sources by type of combustion system

Technology	
Type	**Meaning**
110	Combustion systems for solid fuels / waste
111	Filled-shaft combustion systems
112	Combustion with throw feed
113	Combustion systems with pneumatic feed
114	Under-thrust combustion
115	Combustion with mechanically moved grids
116	Dust incineration with dry-ash ventilation
117	Dust incineration with wet-ash ventilation
118	Fluidised-bed combustion
120	Combustion systems for liquid fuels / waste
121	With evaporative burner
122	With pressure-atomising burner
123	With steam-atomising burner
124	With rotation-atomising burner
125	With air-atomising burner
130	Combustion systems for gaseous fuels / waste
131	With atmospheric gas burner
132	With gas-blower burner
141	Multiple-substance combustion systems
142	Mixed combustion
815	Gas turbines

19.1.2.2 Methane emission factors in the research project RENTZ et al, 2002

The following Table 315 summarises the emission factors shown in Tables 3, 4 and 5 of Annex E of the research project RENTZ et al (2002):

Table 315: Methane emission factors for combustion systems < 50 MW furnace thermal output and for gas turbines, pursuant to RENTZ et al, 2002

Facility type	Fuel	Länder	CH_4 emission factor [kg/TJ]
Combustion systems < 50 MW furnace thermal output	Hard coal (Steinkohle)	ABL	3.4
		NBL	3.3
	Hard-coal coke	ABL/NBL	19
	Lignite (Braunkohle)	NBL, Lausatian district (Lausitz)	269
		NBL, Central German district (Mitteldeutschland)	184
	Heating oil EL	ABL	0.02
	Natural gas	ABL/NBL	0.02
Gas turbines	Heating oil EL	D	0.5
	Natural gas	D	2

ABL old German Länder
NBL new German Länder
D Federal Republic of Germany as a whole

19.1.2.3 CO_2 emissions from flue-gas desulphurisation (CRF 1.A.1, Limestone balance)

In the framework of the research project "limestone balance" ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02), data for CO_2 emissions from flue-gas desulphurisation were determined for the source category Electricity and heat production in public power stations (cf. 4.2.3). Flue-gas desulphurisation systems have the task of converting sulphur dioxide in combustion gases, via chemical and physical processes, into substances that are less harmful.

Limestone is commonly used as a reagent in flue-gas desulphurisation. Desulphurisation systems are tailored to the applicable requirements under immissions-control law and to the economic value of the resulting residual substances (plaster). The predominant process used in electricity generating plants is limestone scrubbing. Some 87 % of all power stations in Germany, in terms of installed output, use this process (RENTZ et al. 2002b).

Desulphurisation with $CaCO_3$ consists of several sub-reactions. For stoichiometric calculation of limestone inputs in the limestone-scrubbing process, the relevant chemical gross-reaction equation for the process is used (STRAUSS 1998):

$$CaCO_3 + SO_2 + 1/2O_2 + 2H_2O ==> CaSO_4.2H_2O + CO_2$$

This equation can be used to derive the limestone/plaster molar mass ratio. Such derivation shows that 581.39 kilograms of limestone are used per produced tonne of plaster. Plaster-production figures thus can be used to obtain the theoretically maximal limestone inputs for flue-gas desulphurisation in hard-coal-fired and lignite-fired power stations. The plaster-production figures do not indicate whether limestone or lime has been used, however. This problem was resolved with the help of statistics of the German Lime Association (BV Kalk) relative to sales of burnt and unburnt lime for the air-quality-control sector. Using the above reaction equation, the pertinent process-related CO_2 emissions can be determined from the mass relationship between $CaCO_3$ and CO_2. The results of the calculation are shown in the following table. They take account of figures for plaster production in all years between 1990 and 2008. To calculate plaster production for the years 2009 and 2010, we have used the 2008 plaster-production figure as a provisional input figure for the calculation.

Table 316: CO_2 emissions from flue-gas desulphurisation in public power stations

Year **CRF 1.A.1**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
						Figures in Gg					
CO_2 from flue-gas desulphurisation in public power stations	618	652	629	662	616	683	867	878	1,005	966	1,135
Year **CRF 1.A.1**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	
						Figures in Gg					
CO_2 from flue-gas desulphurisation in public power stations	1,069	1,094	1,156	1,162	1,142	1,076	1,017	985	995	1,003	

Source: Calculation on the basis of of the "limestone balance" project (UBA 2006, FKZ 20541217/02); updated in 2008 (cf. NIR 2009)

In the inventory, these CO_2 emissions were assigned to emissions from use of solid fuels, because such use is the reason for operation of the flue-gas desulphurisation systems and for the systems' CO_2 emissions. Pursuant to expert estimates of the group carrying out the pertinent research, the uncertainty for limestone use and, thus, the uncertainty for related CO_2 emissions, is +/- 10 %.

19.1.3 Transport (1.A.3)

19.1.3.1 Transport – Civil aviation (1.A.3.a)

19.1.3.1.1 Derivation of additional emission factors (1.A.3.a)

Kerosene

Emissions of *sulphur dioxide* depend directly on the sulphur content of the jet kerosene being used. That, in turn, is subject to regional and chronological fluctuations. The emission factor used by Eurocontrol for sulphur dioxide, 0.84 kg SO^2/t jet kerosene, lies between the values used to date in the German inventory for the years 1990 to 1994 (1.08 to 1.03 kg SO_2/t jet kerosene) and the value used by the German inventory for subsequent years (0.4 kg SO_2/t jet kerosene). The figures given in IPCC 2006b, which, at 1 kg SO_2/t kerosene, are of an order similar to the old inventory values, are based on a sulphur content of 0.05 % by weight. According to current information of the Fachausschuss für Mineralöl- und Brennstoff-Normung[112] (FAM; technical committee for petroleum and fuels standardisation), jet kerosene in Germany typically has a total sulphur content of about 0.01 % by weight, i.e. one-fifth of the content given by the IPCC. The 2009 inventory report uses a sulphur-content figure of 0.021 % by weight for jet kerosene, on the basis of measurements from the year 1998 (DÖPELHEUER 2002). It seems plausible that the emission factor would decrease over time as a result of improved procedures and reduced maximum permitted levels. Consequently, a linear reduction is included here between the framework years 1990 (1.08 g SO_2 / kg kerosene), 1998 (0.4 g) and 2009 (0.2 g). In addition, it is assumed that all of the sulphur in the fuel is converted into sulphur dioxide. Because the emission factor depends directly and solely on the sulphur content of the jet kerosene, this emission factor is used for both flight phases.

For *water vapour*, the emission factor used by EUROCONTROL(2004) is 1,230 g H_2O / kg jet kerosene. CORINAIR (2006) uses a somewhat higher figure, 1,237 g H_2O / kg jet kerosene. In the interest of limiting the number of emission-factor sources, the CORINAIR figure (2006) is used. Since that emission factor is solely fuel-specific, it is applied to both flight phases, for both national and international air transports.

NO_X and CO emissions are calculated with the help of emission factors based on AV calculations. Those results, in turn, are based on aircraft-type-specific and operational-state-specific emission factors taken largely from the EMEP-EEA database. As in the previous year, adjusted emission factors had to be used with regard to some aspects of specific aircraft types that it was not possible to classify directly for these purposes, even by analogy to aircraft types with similar technical data. Those emission factors were determined via emissions functions, in the context of regression calculations, that calculate the emission factor for each engine type as a function of take-off weight. The basis for those functions consisted of the emission factors for existing aircraft types (cf. in this regard IFEU and ÖKO-INSTITUT 2010).

Ammonia emissions are calculated, for both flight phases, with an emission factor of *0.173 g / kg jet kerosene* (UBA, 2010).

[112] Personal e-mail communication with Dr. Feuerhelm, FAM Hamburg, 9 June 2009

In each case, the *NMVOC* emission factors are obtained from the difference between the emission factor for hydrocarbons and that for methane.

The IPCC emission-factor database does not list any values for particulate emissions from jet kerosene (Total Suspended Particulate matter (TSP; $PM_{2.5}$; PM_{10}). For this reason, the emission factors for particulates (TSP) are taken from *Corinair 2006*. Table 8.2 in that source lists differentiated values for the flight phases of an average fleet: For national flights, 0.7 kg TSP / LTO and 0.2 kg TSP / t jet kerosene; for international flights, 0.15 kg TSP / LTO and 0.2 kg TSP / t kerosene. According to that table, jet-kerosene consumption per LTO cycle of 825 kg for national flights, and 1,617 kg for international flights, is assumed. These values are used to determine the emission factors for the LTO phase.

Avgas

In the *IPCC Guidelines* (2006a, page 3-64), the emission factors for *nitrous oxide* are explicitly defined as equal to the relevant values given for jet-kerosene use. That assumption has been adopted here – along with the forecasts for jet-kerosene use in cruise phases of national air transports (cruise phase in 2010).

As to fuel properties, there are no fundamental differences between avgas and automobile petrol[113]. Consequently, values for specific SO_2 emissions from automobile petrol may be used for avgas. Pursuant to the Fachausschuss für Mineralöl- und Brennstoff-Normung (FAM; technical committee for petroleum and fuels standardisation), the maximum permitted level for total sulphur content in petrol-station fuel is 10 mg/kg, or 0.001 % by weight, which is one-tenth of the figure given for jet kerosene. As a result, the 2008 emission factor for SO_2 from jet kerosene, which is reduced by 90 %, is used in the present context.

Different types of avgas, with different *levels of lead*, are used, and the usage percentages for the different types are not available. In calculation of lead emissions, the value determined for the most common type, AvGas 100 LL (Low Lead), 0.56 g/l, is used. That value is somewhat lower than the value proposed in the Corinair Guidebook 2007, 0.6 g/l. Via a mean fuel density of 0.75 kg/l, that emissions value is converted to an emission factor of about *0.75 g lead / kg avgas*.

The emission factor for *particulates* (Total Suspended Particulate Matter – TSP) is obtained from the lead content of AvGas 100 LL, via multiplication by a factor of 1.6 (for EF, cf. Table 317 below). That value has been taken from the TREMOD model, which is used for calculation of emissions from road transports.

As to emission factors for *NMVOC*, pertinent values are given in the *Revised IPCC Guidelines 1996* (pages I 42 and 40); those values are used here.

The other emission factors are not available as special values for average small aircraft. For this reason, they are assumed to be the same as the relevant jet-kerosene emission factors (national, cruise).

[113] E-mail communications with Mr Winkler of the Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry, 8 June 2009

Table 317: Emission factors for avgas

Gas	EF in [g/kg]	Remarks regarding the source or calculation
CO_2	3,018.00	from IPCC Guidelines 2006, Table 3.6.4
CH_4	0.35	same as EF kerosene, LTO/national
N_2O	0.10	same as EF kerosene, cruise/national
SO_2	0.02	equivalent to 1/10 of EF kerosene, cruise/national/2008
NO_X	13.04	same as EF kerosene, cruise/national (calculated in TREMOD-AV)
NMVOC	13.06	from Revised IPCC Guidelines 1996, p. I.42
CO	642.00	calculated in TREMOD-AV
TSP	1.18	calculated from lead content of AvGas 100 LL
Pb	0.75	calculated from max. lead content of AvGas 100 L

Source: Öko-Institut (2009)

Table 318: Overview of emission factors used in the source category Transport – civil aviation (1.A.3.a)

[g/kg]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1.A.3.a – Overarching																					
CO2	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150
SO2	1.08	1.00	0.91	0.83	0.74	0.66	0.57	0.49	0.40	0.38	0.36	0.35	0.33	0.31	0.29	0.27	0.25	0.24	0.22	0.20	0.20
National, LTO																					
CH4	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
N2O	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
NOX	13.36	13.35	13.32	13.38	13.43	13.47	13.54	13.60	13.66	13.72	13.77	13.82	13.87	13.91	13.95	14.01	14.07	14.11	14.15	14.20	14.22
NMVOC	2.7	2.0	1.6	1.2	1.2	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.5	1.4	1.5	1.5	1.6	1.7	1.8	1.8	
CO	13.82	13.77	13.67	13.46	13.26	12.98	12.83	12.64	12.46	12.26	12.04	11.80	11.57	11.34	11.08	10.87	10.67	10.42	10.17	9.95	9.66
National, cruise																					
CH4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NOX	12.25	12.24	12.21	12.26	12.32	12.35	12.41	12.47	12.52	12.58	12.63	12.67	12.71	12.76	12.79	12.84	12.89	12.93	12.97	13.01	13.04
NMVOC	0.6	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
CO	10.15	10.11	10.04	9.89	9.74	9.53	9.42	9.28	9.15	9.01	8.85	8.67	8.50	8.33	8.14	7.99	7.84	7.65	7.47	7.31	7.10
International, LTO																					
CH4	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
N2O	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
NOX	15.81	15.80	15.77	15.83	15.90	15.94	16.02	16.09	16.17	16.24	16.30	16.35	16.41	16.47	16.51	16.58	16.65	16.69	16.74	16.80	16.83
NMVOC	4.5	4.1	3.6	3.2	3.2	3.2	2.6	2.3	2.7	2.5	2.5	2.4	2.4	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.4
CO	21.41	21.33	21.17	20.86	20.54	20.11	19.88	19.58	19.31	19.00	18.66	18.28	17.93	17.57	17.17	16.84	16.53	16.14	15.76	15.41	14.97
International, cruise																					
CH4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
NOX	15.59	15.58	15.54	15.61	15.67	15.71	15.80	15.87	15.94	16.01	16.07	16.12	16.18	16.23	16.28	16.34	16.41	16.46	16.51	16.56	16.59
NMVOC	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5
CO	18.35	18.28	18.15	17.88	17.61	17.24	17.04	16.78	16.55	16.29	15.99	15.67	15.37	15.06	14.72	14.44	14.17	13.83	13.50	13.21	12.83

19.1.3.1.2 Detailed overview of the uncertainties underlying the pertinent activity data and emission factors (1.A.3.a)

Table 319: Overview of the applicable partial uncertainties for activity rates and emission factors

Individual components		Partial uncertainties		AR (kerosene & avgas)		SF (LTO/ cruise)		AR (kerosene) LTO and cruise		EM (H_2O) LTO and cruise		EM (CH_4) LTO and cruise		EM (N_2O) LTO and cruise		EM (SO_2) LTO and cruise		EM (H_2O) LTO and cruise		Remain-ing EM LTO + cruise		Source / reason for assumptions
		[%]		Total	n / i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	n	i	
AR of AGEB and BAFA		-5	5	x	x																	Öko-Institut / DIW 2007 Here, the higher uncertainties of the Energy Balance are used. The uncertainties for the BAFA data are +3, -1% (conservatively estimated, using the approach for the uncertainties of mineral-oil statistics, which are based on BAFA data.)
Split factor SF n <> i		-10	10		x																	1990-2002: Calculations pursuant to TREMOD-AV; as of 2003, figures from Eurocontrol. The value here is a mixed value for the entire time series.
AR (kerosene)	n & i	-11	11					x	x													Calculated
Data of the Federal Statistical Office relative to aircraft movements	n	-0.1	0.1			x																Aviation statistics are based on the Transport statistics act (Verkehrsstatistikgesetz - VerkStatG). The data specified by Arts. 12, 13 VerkStatG are recorded. Pursuant to that act, all civil aviation craft, including aircraft, helicopters, airships, motorised gliders, sailplanes and manned balloons, are to be included in relevant surveys, as long as airports/airfields in Germany are involved.
	i	-0.1	0.1				x															
Real-distance addition	n & i	-3	3			x	x															The data of the Federal Statistical Office are oriented to great-circle distances. A detour factor for cruise flight has been used, as a means of estimating the distances actually flown (cf. IFEU and Öko-Institut 2010).
Allocation of consumption values for kerosene to aircraft types	n	-5	5			x																Aircraft types pursuant to the Federal Statistical Office are assigned emission factors from the EMEP-EEA database. There are four different quality levels for such assignment: a) direct, b) via similar types, c) via regression functions depending on take-off weight, and d) lump-sum EF.
	i	-5	5				x															
SF (LTO / cruise)	n	-6	6					x														Calculated
	i	-6	6						x													Calculated
AR (kerosene) LTO and cruise	n	-13	13							x		x		x		x		x		x		Calculated
	i	-13	13								x		x		x		x		x		x	Calculated
Emission factors (EF)	CO_2	5	5							x	x											IPCC 2006, p.3.69; low uncertainty, since the EF depends only on the C content of the fuel.
	CH_4	-57	100									x	x									IPCC 2006, p.3.69; depends on technology and is thus subject to large uncertainty in combination via the Tier 1 approach
	N_2O	-70	150											x	x							
	SO_2	-10	10													x	x					The emission factor depends only on fuel characteristics (sulphur content).
	H_2O	-5	5															x	x			The emission factor depends only on fuel characteristics. Low values, ranging from -4.9 to 1.6, given in Eurocontrol 2004, p.49.
Remaining EF	n & i	-10	10																	x		Assumption – for NO_X, HC and CO, a mean EF is calculated via TREMOD, on the basis of the EF for individual aircraft types
																					x	
Total uncertainty, *above*				+5	+11	+6	+6	+13	+13	+14	+14	+58	+58	+71	+71	+16	+16	+14	+14	+16	+16	
Total uncertainty, *below*				-5	-11	+6	-6	-13	-13	-14	-14	-101	-101	-150	-150	-16	-16	-14	-14	-16	-16	

n = national share; i = international share

Source: ÖKO-INSTITUT (2009)

19.1.3.2 Derivation of activity rates for road transport (1.A.3.b)

19.1.3.2.1 Harmonisation with the Energy Balance

The basis for CSE data collection for the road-transport sector consists of energy consumption data provided by the Working Group on Energy Balances (AGEB). For each year, the sum of the activity rates for the various individual structural elements must correspond to the Energy Balance data, in TJ. The relevant basic Energy Balance data are shown in Table Table 320 below.

Table 320: Energy inputs in road transports, 1990-2009

Year	Petrol	Diesel fuel	Biodiesel	Bioethanol	LP gas	Natural gas	Petroleum
Energy inputs pursuant to Energy Balances 1990-2009 (last revision: 10/2011), in TJ							
1990	1,330,479	735,920	0	0	138	0	0
1991	1,332,285	785,174	0	0	137	0	0
1992	1,344,129	853,502	0	0	229	0	0
1993	1,350,617	907,787	0	0	184	0	473
1994	1,276,637	932,060	0	0	184	0	559
1995	1,299,982	964,013	1,504	0	138	0	610
1996	1,299,879	964,580	2,046	0	115	0	638
1997	1,297,487	979,586	3,652	0	106	0	357
1998	1,300,463	1,022,794	4,081	0	106	0	637
1999	1,300,602	1,097,036	5,370	0	100	0	637
2000	1,237,055	1,108,105	12,276	0	94	0	414
2001	1,199,318	1,097,416	16,740	0	569	0	471
2002	1,166,381	1,105,842	20,460	0	607	0	472
2003	1,108,989	1,078,352	29,948	0	694	0	0
2004	1,072,720	1,110,931	38,806	1,144	1,887	0	0
2005	992,377	1,077,173	71,792	6,817	2,357	2,843	0
2006	930,834	1,081,161	130,139	13,418	4,605	5,211	0
2007	892,982	1,078,362	143,431	12,065	8,942	4,089	0
2008	854,002	1,107,062	109,612	16,385	15,652	4,882	0
2009	829,227	1,114,253	89,327	23,697	23,842	5,300	0
Provisional figures pursuant to "Mineralölzahlen 2010" (fossil; "2010 Mineral-Oil Statistics") and Amtliche Mineralöldaten 12/2008 (bio; "Official Mineral-Oil Data 12/2008")							
2010	792,257	1,166,224	90,673	30,403	21,836	9,742	0

Sources: Evaluation tables of the Energy Balances, „Mineralöl-Zahlen 2010“ ("2009 Petroleum Data") of the Association of the German Petroleum Industry (MWV) (MWV, 2011) and „Amtliche Mineralöldaten“ ("Official Petroleum Data").

The Energy Balance is also used to model transport-quantity structures in TREMOD. For example, the German Economic Institute (DIW) carries out a fuel-consumption calculation in order to derive total mileage travelled (DIW, 2002). Some of the results of the calculation, for automobile transports, are entered into TREMOD. The DIW uses a fuel-consumption calculation in order to determine total domestic mileage; TREMOD uses some other sources and assumptions to estimate total domestic mileage – especially for goods transports (cf. the detailed description in IFEU, 2002). This estimate also takes the basic figures of the Energy Balance into account.

On the other hand, due to the many dependencies and uncertainties in the model, and to the basic data that must be taken into account, no feasible means is available for comparing mileage and energy consumption, for each year and each vehicle layer, in such a manner that the results yield the Energy Balance sum and the mileage and mean energy consumption figures in the time series are plausible. For this reason, the TREMOD results for the energy consumption are corrected, at the end of the process, in such a manner that the total for each reference year corresponds to the relevant figure in the Energy Balance.

Since TREMOD calculates energy consumption in tonnes, the results first have to be converted into TJ. For this purpose the net calorific values provided by the Working Group on Energy Balances (AGEB) are used (cf. Table Table 321).

Table 321: Net calorific values for petrol and diesel fuel

Year	Petrol	Diesel fuel
1990-1992	43.543 MJ/kg	42.704 MJ/kg
since 1993	43.543 MJ/kg	42.960 MJ/kg

Source: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)

The correction factors are derived in TREMOD separately for the various vehicle categories, as follows:

- Firstly, a correction factor for petrol is derived from the calculated petrol consumption for all vehicle categories and from petrol sales pursuant to the Energy Balance.
- The correction factor for petrol is then also used to bring fuel consumption of vehicles with diesel engines, among automobiles and other vehicles ≤ 3.5 t (light duty vehicles (LNF), and of motor homes and motorcycles (MZR)), in line with the Energy Balance.
- The difference between the corrected diesel-fuel consumption of automobiles and of other vehicles ≤ 3.5 t and the Energy Balance is then allocated to heavy duty vehicles and busses.
- The correction factor for heavy duty vehicles and busses is then calculated from their energy consumption, as calculated in accordance with the domestic principle, and the pertinent difference, as calculated for this group, from the Energy Balance.

Table 322 below summarises the correction factors used.

Table 322: Correction factors for harmonisation with the Energy Balance

Year	Area of application	Petrol (including bioethanol)	Diesel fuel (including biodiesel)	
		Automobiles, light duty vehicles, motorcycles	Automobiles, light duty vehicles	Heavy duty vehicles, busses
1990	ABL	1.038	1.038	1.115
1990	NBL	1.066	1.066	1.420
1991	ABL	1.035	1.035	1.110
1991	NBL	1.061	1.061	1.015
1992	ABL	1.039	1.039	1.189
1992	NBL	0.997	0.997	1.200
1993	ABL	1.042	1.042	1.191
1993	NBL	0.976	0.976	1.301
1994	ABL	0.988	0.988	1.197
1994	NBL	0.988	0.988	1.197
1995	D	0.999	0.999	1.222
1996	D	1.000	1.000	1.201
1997	D	0.997	0.997	1.202
1998	D	0.989	0.989	1.265
1999	D	0.990	0.990	1.323
2000	D	0.959	0.959	1.353
2001	D	0.945	0.945	1.254
2002	D	0.939	0.939	1.212
2003	D	0.925	0.925	1.149
2004	D	0.931	0.931	1.095
2005	D	0.919	0.919	1.085
2006	D	0.896	0.896	1.119
2007	D	0.886	0.886	1.074
2008	D	0.882	0.882	1.070
2009	D	0.873	0.873	1.110
2010	D	0.870	0.870	1.157

Remark: 1994 correction factors for old German Länder (ABL) and new German Länder (NBL) as for Germany (D) as a whole

19.1.3.2.2 Allocation of biofuels, petroleum, natural gas and LP gas to the structural elements

For the transport sector, the Energy Balance lists data for biofuels, petroleum, natural gas and LP gas. For purposes of importing into the CSE, the results for these fuels are derived as follows:

- Biodiesel is allocated to all structural elements with diesel engines, in keeping with their percentage shares of consumption of conventional diesel fuel.
- Bioethanol is allocated to all structural elements with petrol engines, in keeping with their percentage shares of consumption of conventional petrol.
- Petroleum is allocated to busses on roads outside of municipalities – and, thus, to the structural elements SV BUS KOAO and SV BUS MTAO – in keeping with their percentage shares of consumption of conventional diesel fuel.
- LP gas is allocated to conventional automobiles, with petrol engines, on municipal roads (structural element SV PKWO KOIO).

19.1.3.2.3 Activity rate for evaporation

The activity rate for evaporation emissions is set as total petrol consumption, on municipal roads, pursuant to TREMOD; the corresponding figure for mopeds is the total consumption. The values corrected to the Energy Balance are used.

19.1.3.3 Derivation of emission factors

19.1.3.3.1 Emission factors from TREMOD

In the CSE, emission factors for the "engines" ("Antrieb") category are listed in kg/TJ, while those for the "evaporation" category are given in kg/t. For the subtances "petrol" and "diesel fuel", these values can be derived from TREMOD for all structural elements. To that end, emissions (in tonnes) and energy consumption (in TJ; converted from the results "energy consumption in t", using the net calorific values pursuant to Table 321) are derived from the TREMOD results and allocated to the relevant structural elements. The emission factor for each structural element then results as the quotient produced by dividing emissions, in tonnes per structural element, by the energy consumption, per structural element, in TJ. A similar procedure is used to obtain the emission factors for evaporation (evaporation emissions, in kg / consumption on municipal roads, in t).

For purposes of this derivation, TREMOD results without correction to the Energy Balance are used, since such correction is already contained in the activity rates for the CSE. Use of the corrected values (emissions and energy consumption) leads to the same results, however, since the correction factor cancels out in calculation of mean emission factors (emissions corrected / energy corrected = emissions uncorrected / energy uncorrected).

19.1.3.3.2 Emission factors for biodiesel, bioethanol, petroleum and LP gas

In all cases, the emission factors for biodiesel and petroleum are set to the same values as those for conventional diesel fuel. The emission factors for bioethanol are set to the same values as those for conventional petrol.

Exceptions:

- The CO_2 emission factor for biodiesel is set to 70.8 t/TJ;
- The SO_2 emission factor for petroleum is set to 24 kg/TJ for those years in which diesel fuel has a higher value. In all other years, the lower value for diesel fuel is used.

At present, in TREMOD liquefied petroleum gas is still allocated completely to conventional automobiles without exhaust gas treatment conforming to EURO standards.

TREMOD does not yet take account of use of natural gas. Therefore, use of natural gas is recorded directly in the Central System of Emissions (CSE). In that regard, the EF currently used in TREMOD for liquefied petroleum gas are adopted, with the exception of those for CH_4 (and CO_2).

The following emission factors are currently being used in the CSE for calculation of emissions from mobile combustion of liquefied petroleum gas and natural gas:

Table 323: Emission factors for automobiles running on liquefied petroleum gas and on natural gas, 1990-2010

Greenhouse gas / pollutant	EF in [kg/TJ]	
	Liquefied petroleum gas	Natural gas
CO_2	65,000.00	56,000.00
CH_4	3	50*
N_2O	1.7	1,7**
CO	350	350**
NH_3	0.5	0,5**
NMVOC	157	157**
NO_X	975	975**
SO_2	1.7	1,7**

*) IPCC default

**) taken from the corresponding figure for liquefied petroleum gas

19.1.3.4 Derivation of data for western and eastern Germany, 1994

TREMOD distinguishes between old and new German Länder only until 1993. Since the CSE also requires such differentiation for 1994, a relevant breakdown must be made using simplifying assumptions. The framework conditions include:

- The sum total of activity rates for engines (Antrieb) must correspond to the relevant Energy Balance values (in each case, for old and new German Länder).
- In the overall result, emissions resulting from linking activity rates with emission factors must correspond to the TREMOD results for Germany.
- With these framework conditions, a relevant breakdown is possible only under the following assumptions:
- The emission factors for old and new German Länder are set, for all structural elements, to the relevant values for all of Germany in 1994.
- The structural elements' percentage shares of the activity rates, for each fuel, are considered to be the same in each case for the old and new German Länder, and they are the same as the relevant values for all of Germany in 1994.

With these assumptions, the aforementioned conditions are fulfilled. A third framework condition is not fulfilled: the plausibility of emissions results in the time series, in each case, for the old/new German Länder.

19.2 Other detailed methodological descriptions for the source category "industrial processes" (2)

19.2.1 Mineral products (2.A)

19.2.2 Chemical industry (2.B)

19.2.3 Metal production (2.C)

19.2.4 Other production (2.D)

19.2.4.1 Pulp and paper (2.D.1)

The fibre for paper production is produced, via chemical or mechanical processes, either from fresh fibre or from processed recycled paper. A distinction is made between integrated and non-integrated pulp and paper mills. Non-integrated pulp mills (that produce pulp for the market) solely produce pulp for sale on the open market. On the other hand, integrated mills produce both pulp and paper, at the same sites. A paper mill can either produce paper from fibre material produced at other locations or be integrated within complete pulping processes set up at one site.

Sulphate pulp mills normally operate in both integrated and non-integrated modes, whereas sulphite pulp mills are normally only integrated – i.e. part of paper-production chains. In most cases, mechanical pulping and used-paper processing are a fixed part of the paper-production process; in a few cases, such processes are not so integrated, i.e. are carried out separately.

19.2.4.1.1 Fibre-production processes

Sulphate process

The sulphate process is the world's most common pulping process, since it yields higher pulp strengths and can be used with all types of wood. In the two German plants, carbonate is extracted from the circulating lye via bonding with calcium (causticising) and then, in a separate lime oven, is burned to burnt lime, a process that releases CO_2. The burnt lime is then reused for causticising. Pursuant to the *IPCC Good Practice Guidelines*, CO_2 released from $CaCO_3$ is assigned an emission factor of "0", since all of its carbon comes from pulped wood. Calcium loss from the cycle is compensated for solely via addition of burnt lime and thus, for the present purposes, also does not lead to report-relevant CO_2 emissions (the CO_2 released in production of burnt lime is already included in the figures for the lime industry (CRF 2.A.2)).

This process also produces atmospheric emissions in lye recovery (boilers), in bark combustion, from lime ovens, in wood-chip storage, in pulp digestion, in pulp washing, in bleaching, in bleach-chemical processing, in evaporation, in sorting and washing, in processing of circulating water and in operation of various types of tanks. Such emissions include fugitive emissions that occur at various processing points – primarily in lye-recovery boilers, lime ovens and auxiliary boilers. The main components of emissions include nitrogen oxides, sulphur-containing compounds, such as sulphur dioxide, and foul-smelling reduced sulphur compounds.

The two German sulphate-pulping plants are fitted with a system for post-incineration of foul-smelling sulphur compounds and with systems for NO_X-reduced combustion in lye-recovery boilers (>20 % NO_X reduction, as reported by the German Pulp and Paper Association (VDP), September 2004 (VDP, 2004)).

No other types of emissions-reduction equipment are yet being used in Germany:

- *Scrubbers* downstream from recovery boilers (>85 % SO_2 reduction)
- SNCR equipment for NO_x reduction downstream from the auxiliary boiler (>30 % NO_x reduction)
- SNCR equipment for NO_x reduction downstream from the recovery boiler (>30 % NO_x reduction)
- NO_x-reduction systems for combustion in auxiliary boilers (>20 % NO_x reduction)

Sulphite process

Sulphite pulp is produced in 4 of 6 systems in Germany. In such plants, pulping is carried out with various chemicals. The sulphate process and the sulphite process have numerous similarities, including similarities with regard to possibilities for using various internal and external measures to reduce emissions. From the standpoint of environmental protection, the main differences between the two pulp-production processes have to do with chemical aspects of the boiling process, with aspects of preparation and post-processing of chemicals and with bleaching intensity – bleaching in sulphite plants is less intensive, since sulphite pulp is whiter than sulphate pulp.

Atmospheric emissions occur especially in lye recovery (boilers) and in bark combustion. Waste-gas emissions with less-concentrated SO_2 are released in washing and sorting processes, and they are released by ventilation shafts of evaporators and by various tanks. Such emissions escape – in part, as fugitive emissions – at various points of the process. They consist primarily of sulphur dioxide, nitrogen oxides and dust.

A number of measures are available for reducing consumption of live steam and electrical energy and for increasing plant-internal generation of steam and electricity. Sulphite pulp mills can generate their own heat and electricity by using the thermal energy in concentrated lye, bark and waste wood. Integrated plants require additional amounts of steam and electricity, however; these additional amounts can be generated either in on-site facilities or at off-site locations. Integrated sulphite pulp and paper mills consume 18 - 24 GJ of process heat, and 1.2 - 1.5 MWh of electrical energy, per tonne of pulp.

All four sulphite pulping plants in Germany are operated with SO_2 scrubbers fitted downstream from recovery boilers (>98 % SO_2 reduction). One plant is fitted with equipment for NO_X-reduced combustion in recovery and auxiliary boilers (total of >40 % NO_X reduction).

No other types of emissions-reduction equipment are yet being used in Germany:

- SNCR equipment for NO_x reduction downstream from the auxiliary boiler (>30 % NO_x reduction)
- SNCR equipment for NO_x reduction downstream from the recovery boiler (>30 % NO_x reduction)

Wood pulp

Wood pulp is produced in 9 plants in Germany. In mechanical pulping, wood fibres are separated from each other via mechanical energy applied to the wood matrix. The process is designed to conserve most of the lignin in the wood, in order to maximise yields while ensuring that the pulp has adequate strength and whiteness. Two main processes are differentiated:

- The wood-grinding process, in which pieces of wood are are wettened and pressed against a rotating grinder, and
- The *refiner* process, in which wood chips are broken down into fibres in disk refiners.

Wood-pulp properties can be influenced by increasing the process temperature and, in the case of the *refiner* process, by chemical pre-treatment of the wood chips. The pulping process in which wood is chemically pre-softened and then broken down into fibres, under pressure, is known as *chemi-thermo-mechanical pulping* (CTMP).

In most cases, the waste-gas emissions consist of emissions from heat and energy generation in auxiliary boilers and of emissions of volatile organic carbon (VOC). VOC emissions occur in storage of wood chips, and in removal of air from containers, including containers for washing wood chips. They also occur in connection with condensates that are produced in recovery of steam from *refiners* and contaminated with volatile wood components. Some of these emissions are released as fugitive emissions, from various parts of mills.

The best available technologies for reducing waste-gas emissions include effective recovery of heat from refiners and reduction of VOC emissions from contaminated steam. Along with VOC emissions, mechanical pulping produces waste-gas emissions from on-site energy generation (i.e. non-process-related emissions). Heat and electricity are generated through combustion of various fossil fuels and wood residues (the latter are a renewable resource). The best available technologies for auxiliary boilers are described below.

Recycled fibre

In general, processes that use recycled fibres (processes for processing used paper) can be divided into two main categories:

- Processes that use solely mechanical cleaning, i.e. processes that use no de-inking. Such processes are used for production of test liners, fluting, carton and cardboard;
- Processes that use mechanical and chemical technologies, i.e. that include de-inking. Such processes are used for production of newsprint, tissue, printing and copier paper, magazine papers (SC/LWC) and for some types of carton and commercial DIP (de-inked recycled paper).

The raw materials for paper production from recycled fibre include recycled paper (main component), water, chemical additives and energy in the form of steam and electricity. Waste-gas emissions occur primarily in energy generation through fossil-fuel combustion, in power stations.

Waste-gas emissions from mills that process recycled paper occur primarily in systems for heat production; in some cases, they are also produced by combined heat/power generation (CHP) systems. For this reason, energy efficiency is closely linked to reductions of waste-gas emissions. The energy-generation systems in such mills normally use standard boilers, and thus they may be considered truly similar to all other such power plants. The following measures are considered the best available techniques for reducing energy consumption and emissions into the atmosphere: heat-power cogeneration, modernisation of existing boilers and retrofits (in connection with replacement investments) with more energy-efficient systems.

Energy-efficient mills for processing recycled paper consume process heat and electrical energy on the following scales:

- Integrated mills that process recycled paper, without de-inking (for example, for production of test liners and fluting):
  6 – 6.5 GJ/t process heat and 0.7 – 0.8 MWh/t electrical energy.
- Integrated mills for tissue production, with DIP systems:
  7 -12 GJ/t process heat and 1 – 1.4 MWh/t electrical energy;

- Integrated mills for production of newsprint, and integrated mills for production of printing and writing paper, and including DIP systems:
  4 – 6.5 GJ/t process heat and 1 – 1.5 MWh/t electrical energy.

19.2.4.1.2 Paper and carton production

Paper is made from fibre materials, water and chemical additives. The entire paper-making process consumes large amounts of energy. Electricity is required primarily for operation of various motors and for grinding of fibres. Process heat is used primarily for heating water, other liquids and air, for evaporating water in dry areas of paper machines and for converting steam into electrical energy (with heat/power cogeneration). Large amounts of water are required as process water and for cooling. Various additives are used in paper production, as process aids and to enhance product properties (paper additives).

Most of the waste-gas emissions produced by non-integrated paper mills are produced by steam-production and energy-generation systems. The boilers used in such systems are standard boilers that do not differ from those of other combustion systems. It is assumed that such systems are operated in the same manner as other auxiliary boilers of the same capacity (see below).

Energy-efficient, non-integrated paper mills consume heat and energy on the following scale:

- Non-integrated mills for production of uncoated fine paper consume process heat at a rate of 7 – 7.5 GJ/t and energy at a rate of 0.6 – 0.7 MWh/t;
- Non-integrated mills for production of coated fine paper consume process heat at a rate of 7 – 8 GJ/t and energy at a rate of 0.7 – 0.9 MWh/t;
- Non-integrated mills for production of tissue from fresh fibre consume process heat at a rate of 5.5 – 7.5 GJ/t and electrical energy at a rate of 0.6 – 1.1 MWh/t.

Auxiliary boilers

In considering waste-gas emissions from auxiliary boilers, one must take account of the actual energy balance of the pulp or paper mill concerned, the nature of the fuels that are supplied to the facility and any use of biomass fuels such as bark and waste wood. Pulp and paper mills that produce fibre materials from primary fibres normally use bark-fired boilers. Non-integrated paper mills, and mills that process recycled paper, generate waste-gas emissions primarily via their steam-production and/or energy-generation systems. Such systems normally consist of standard boilers that do not differ from those of other combustion systems. It is assumed that such systems are operated in the same manner in which all other systems of the same capacity are operated. The technologies involved include:

- Heat/power cogeneration, where the prevailing heat/power ratio permits;
- Use of renewable fuels, such as wood and any waste wood that is produced, in order to reduce emissions of fossil CO_2;
- Reduction of NO_X emissions from auxiliary boilers, via control of combustion conditions and installation of burners with low NO_X emissions;
- Reduction of SO_2 emissions through use of bark, gas and low-sulphur fuels, and waste-gas scrubbing to remove sulphur compounds;
- Use of effective electrical filters (or tube filters) to separate dust in auxiliary boilers fired with solid fuels.

Overall, most product-specific waste-gas emissions are site-dependent (for example, they depend on the type of fuel used, the size and type of the relevant facility, whether the plant is integrated or non-integrated, whether it generates electricity). The auxiliary boilers used in Germany cover a wide spectrum of different sizes (from 10 to more than 200 MW). With smaller boilers, the only useful approach is to use low-sulphur fuels and the pertinent combustion technologies, while secondary reduction measures can also be effective with larger boilers.

Further information about activity rates is provided in Chapter 17.

19.3 Other detailed methodological descriptions for the source category "Solvents and other product use" (3)

19.4 Other detailed methodological descriptions for the source category "Agriculture" (4)

19.4.1 Distribution of housing, storage and application procedures, and pasture-access data (CRF 4.A, 4.B, 4.D)

Table 324, Table 325,Table 326 and Table 327 show the distributions of housing, storage and application procedures on which the German inventory is based, and they provide data on pasture access. The tables also include information relative to emission factors (including that for NH_3). For further details, cf. HAENEL et al. (2012).

Table 324: Frequency distributions of animal housing procedures (in %) and NH_3 emission factors

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	bedding material (straw) kg place d^{-1}	NH_3-N EF for housing, kg NH_3-N per kg TAN in excreta
dairy cattle	tied systems, solid storage	31	31	31	31	16	16	16	16	13	13	13	12	12	12	11	11	10	10	10	9	9	5.0	0.066
	tied systems, slurry	37	37	37	37	38	38	38	38	33	33	32	30	29	28	26	25	23	22	21	19	18		0.066
	cubicles, solid storage	2	2	2	2	3	3	3	3	3	3	4	4	5	5	6	6	7	7	8	8	9	5.0	0.197
	cubicles, slurry	29	29	29	29	42	42	42	42	51	51	52	53	55	56	57	58	59	60	62	63	64		0.197
	time spent on pastures (in % of year)	18	19	18	18	14	14	14	14	14	13	13	12	12	12	12	11	11	11	11	10	10		
male beef cattle	tied systems, solid storage	4	4	4	4	3	3	3	3	2	2	2	3	3	4	4	5	5	6	6	7	7	2.0	0.066
	tied systems, slurry	7	7	7	7	4	4	4	4	3	3	4	4	5	6	6	7	7	8	9	9	10		0.066
	loose housing, fully slatted floor, slurry	83	83	83	83	88	88	88	88	91	91	88	84	81	78	75	71	68	65	62	58	55		0.099
	loose housing, sloped floor	6	6	6	6	4	4	4	4	3	3	5	8	10	12	14	17	19	21	23	26	28	2.5	0.213
	deep litter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.197
	time spent on pastures (in % of year)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		
heifers	tied systems, solid storage	8	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	10	10	10	2.0	0.066
	tied systems, slurry	15	15	15	15	17	17	17	17	17	17	16	16	15	14	14	13	13	12	11	11	10		0.066
	loose housing, grooved floor, slurry	48	48	48	48	49	49	49	49	50	50	50	49	49	48	48	47	47	46	46	45	45		0.099
	loose housing, solid storage	28	28	28	28	25	25	25	25	25	25	26	27	27	28	29	30	31	32	32	33	34	3.0	0.197
	time spent on pastures (in % of year)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20		
calves	tied systems, solid storage	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	0	0	0	0	0	0	2.5	0.066
	deep litter	50	50	50	50	50	50	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	2.5	0.197
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	bedding material (straw) kg place d^{-1}	NH_3-N EF for housing, kg NH_3-N per kg TAN in excreta	
suckler cows	tied systems, solid storage	6	6	6	6	6	6	6	6	7	7	8	8	9	10	11	11	12	13	14	14	15	5.0	0.066	
	tied systems, slurry	2	2	2	2	2	2	2	2	2	2	2	3	3	3	4	4	5	5	5	6	6		0.066	
	loose housing, slurry	7	7	7	7	6	6	6	6	5	5	6	7	9	10	11	12	13	14	16	17	18		0.197	
	deep litter	86	86	86	86	86	86	86	86	86	86	84	81	79	77	75	72	70	68	66	63	61	8.0	0.197	
	time spent on pastures (in % of year)	41	42	43	43	43	43	44	44	45	44	44	45	45	45	46	46	47	47	47	48	48			
stud bulls	tied systems, solid storage	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	5.0	0.066	
	tied systems, slurry	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8		0.066	
	loose housing, slurry	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34		0.197	
	loose housing, solid storage	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	5.0	0.197	
	time spent on pastures (in % of year)	35	33	33	34	33	33	33	32	33	33	33	33	33	33	33	34	34	34	34	34	34			
fattening pigs / weaners	fully slatted floor, slurry	49	49	49	49	59	59	59	59	60	60	61	62	63	64	65	66	67	68	69	70	71		0.3	
	partly slatted floor, slurry	40	40	40	40	34	34	34	34	32	32	31	30	29	28	27	27	26	25	24	23	22		0.3	
	litter based, solid storage	8	8	8	8	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0.30 / 0.15	0.4	
	deep litter	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1.0 / 0.2	0.4	
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
sows / boars	solid storage	42	42	42	42	26	26	26	26	24	24	23	22	21	20	19	19	18	17	16	15	14	0.5	0.34	
	slurry	58	58	58	58	74	74	74	74	76	76	77	78	79	80	81	81	82	83	84	85	86		0.34	
	time spent on pastures (in % of year)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
laying hens	cages; ≥2010: small group housing systems	95	95	95	95	95	94	92	90	89	88	87	85	84	81	77	73	70	68	62	38	18		#)	1)
	floor management, aviary	4	4	4	4	4	5	5	7	7	7	7	7	7	9	12	14	15	17	22	45	63	0.5	#)	1)
	free range, organic farming	1	1	1	1	1	2	2	4	4	5	7	8	9	10	11	13	14	15	16	18	19	0.5	#)	1)
		100	100	100	100	100	101	99	101	100	100	101	100	100	100	100	100	99	100	100	101	100			

livestock category	housing type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	bedding material (straw) kg place d^{-1}	NH_3-N EF for housing, kg NH_3-N per kg TAN in excreta	
broilers	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	1.4	0.09	1)
pullets	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.8	0.03	1)
ducks	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	19.5	0.16	1)
geese	floor management and free range	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100		0.57	2)
turkeys, female	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	10.3	0.19	1)
turkeys, male	floor management	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	10.3	0.255	1)
buffalo	straw based system	NO	NO	NO	NO	NO	NO	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	5.0	0.197	
	slurry based system	NO	NO	NO	NO	NO	NO	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50		0.197	
	time spent on pastures (in % of year)	NO	NO	NO	NO	NO	NO	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16			
horses	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	8.0 / 5.0	0.22	
(heavy horses / light horses, ponies)	time spent on pastures (in % of year)	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21			
mules and asses	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	5.0	0.22	
	time spent on pastures (in % of year)	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21			
sheep without lambs	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.4	0.22	
	time spent on pastures (in % of year)	52	53	53	53	53	52	53	52	52	52	52	52	52	52	52	52	52	52	52	52	53			
lambs	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.16	0.22	
	time spent on pastures (in % of year)	42	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	41	40			
goats	straw based system	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.4	0.22	
	time spent on pastures (in % of year)	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34			

#) cf. Table 327: Laying hens, housing-specific partial NH3 emission factors

1) related to N excreted

2) related to TAN (UAN) excreted

Table 325: Frequency distributions of storage procedures (in %) and emission factors

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system (leachate / urine)	N_2O EF for storage kg N_2O-N per kg N in storage system	N_2O EF for storage kg N_2O-N per kg N in storage system (leachate / urine)	CH_4 MCF for storage kg CH_4-C per kg C in storage system < 10 °C
all cattle, slurry	slurry, open tank (% of total slurry)	1	1	1	1	1	1	1	1	1	1	2	2	3	3	4	4	5	5	6	6	7	0.150		0.000		0.17
	slurry, with solid cover (% of total slurry)	22	22	22	22	22	22	22	22	21	21	21	22	22	22	23	23	23	24	24	24	24	0.015		0.005		0.17
	slurry, with natural crust (% of total slurry)	38	38	38	38	41	41	41	41	42	42	41	41	40	40	39	39	38	38	37	37	36	0.045		0.005		0.10
	slurry, with plastic film	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0.023		0.000		0.17
	slurry, with artificial crust (chaff) (% of total slurry)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0.030		0.000		0.17
	slurry, storage below animal confinements > 1 month (% of total slurry)	39	39	39	39	35	35	35	35	35	35	35	34	34	34	34	33	33	33	33	32	32	0.045		0.002		0.17
dairy cattle, solid	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.014	0.005	0.005	0.02
male beef cattle, solid	solid storage (% of total solid manure)	40	40	40	40	43	43	43	43	40	40	32	28	26	24	23	22	22	21	21	20	20	0.600	0.014	0.005	0.005	0.02
	deep bedding / sloped floor (% of total solid manure)	60	60	60	60	57	57	57	57	60	60	68	72	74	76	77	78	78	79	79	80	80	0.600		0.010		0.17
heifers, solid	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.014	0.005	0.005	0.02
calves, solid	solid storage (% of total solid manure)	50	50	50	50	50	50	50	50	50	50	50	50	50	0	0	0	0	0	0	0	0	0.600	0.014	0.005	0.005	0.02
	deep bedding (% of total solid manure)	50	50	50	50	50	50	50	50	50	50	50	50	50	100	100	100	100	100	100	100	100	0.600		0.010		0.17
suckler cows, solid	solid storage (% of total solid manure)	7	7	7	7	7	7	7	7	8	8	8	9	10	11	12	14	15	16	17	18	20	0.600	0.014	0.005	0.005	0.02
	deep bedding (% of total solid manure)	93	93	93	93	93	93	93	93	92	92	92	91	90	89	88	86	85	84	83	82	80	0.600		0.010		0.17
stud bulls, solid	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.014	0.005	0.005	0.02

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system (leachate / urine)	N_2O EF for storage kg N_2O-N per kg N in storage system	N_2O EF for storage kg N_2O-N per kg N in storage system (leachate / urine)	CH_4 MCF for storage kg CH_4-C per kg C in storage system < 10 °C
all pigs, slurry	slurry, open tank (% of total slurry)	47	47	47	47	27	27	27	27	27	27	25	24	22	20	19	17	15	14	12	10	9	0.150		0.000		0.17
	slurry, with solid cover (% of total slurry)	18	18	18	18	22	22	22	22	22	22	22	23	23	23	24	24	24	25	25	25	26	0.015		0.005		0.17
	slurry, with natural crust (% of total slurry)	3	3	3	3	13	13	13	13	13	13	14	16	17	19	20	22	23	25	26	28	29	0.105		0.005		0.10
	slurry, with plastic film	0	0	0	0	7	7	7	7	7	7	6	6	5	4	4	3	3	2	1	1	0	0.023		0.000		0.17
	slurry, with artificial crust (chaff) (% of total slurry)	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	3	3	3	4	4	4	0.030		0.000		0.17
	slurry, storage below animal confinements > 1 month (% of total slurry)	32	32	32	32	30	30	30	30	31	31	31	31	31	31	31	32	32	32	32	32	32	0.105		0.002		0.17
fattening pigs / weaners, solid	solid storage (% of total solid manure)	73	73	73	73	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	71	0.600	0.030	0.005	0.005	0.02
	deep bedding (% of total solid manure)	27	27	27	27	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29	0.600		0.010		0.17
sows / boars, solid	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.030	0.005	0.005	0.02
laying hens	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.140		0.001		0.015
broilers	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.170		0.001		0.015
pullets	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.170		0.001		0.015
ducks	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.240		0.001		0.015
geese	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.160		0.001		no calculation of VS
turkeys, female	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.240		0.001		0.015
turkeys, male	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.240		0.001		0.015
buffalo	slurry, with natural crust (% of total slurry)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.045		0.005		0.10
	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.014	0.005	0.005	0.02
horses (heavy horses / light horses, ponies)	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.014	0.005	0.005	0.02

livestock category	storage type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system	NH_3-N EF for storage, kg NH_3-N per kg TAN in storage system (leachate / urine)	N_2O EF for storage kg N_2O-N per kg N in storage system	N_2O EF for storage kg N_2O-N per kg N in storage system (leachate / urine)	CH_4 MCF for storage kg CH_4-C per kg C in storage system < 10 °C
mules and asses	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.600	0.014	0.005	0.005	0.02
all sheep	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.280		0.005		0.02
goats	solid storage (% of total solid manure)	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.280		0.005		0.02

Table 326: Frequency distributions of application procedures (in %) and of relevant emission factors

livestock category	application type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	NH_3-N EF for application, kg NH_3-N per kg TAN applied
all cattle, slurry	broadcast, without incorporation	9	9	9	9	2	2	2	2	2	2	2	2	1	1	1	1	1	1	0	0	0	0.50
	broadcast, incorporation < 1 h	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	0.10
	broadcast, incorporation < 4h	0	0	0	0	1	1	1	1	1	1	2	3	4	5	6	6	7	8	9	10	11	0.26
	broadcast, incorporation < 6h	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.35
	broadcast, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3	4	4	5	5	6	0.40
	broadcast, incorporation < 12h	0	0	0	0	19	19	19	19	20	20	18	16	15	13	11	10	8	6	5	3	1	0.43
	broadcast, incorporation < 24h	33	33	33	33	11	11	11	11	11	11	10	9	8	7	6	5	4	3	2	1	0	0.46
	broadcast, incorporation < 48h	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50
	broadcast, vegetation	0	0	0	0	0	0	0	0	0	0	2	3	5	6	8	9	11	12	14	15	17	0.50
	broadcast, grassland	45	45	45	45	43	43	43	43	41	41	42	42	42	42	42	43	43	43	43	44	44	0.60
	trailing hose, without incorporation	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0.46
	trailing hose, incorporation < 1 h	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	0.04
	trailing hose, incorporation < 4h	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0.15
	trailing hose, incorporation < 6h	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.20
	trailing hose, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0.24
	trailing hose, incorporation < 12h	0	0	0	0	8	8	8	8	8	8	7	7	6	5	5	4	3	2	2	1	0	0.30
	trailing hose, incorporation < 24h	1	1	1	1	3	3	3	3	3	3	2	2	2	2	1	1	1	1	0	0	0	0.39
	trailing hose, incorporation < 48h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.46
	trailing hose, vegetation	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	3	3	3	4	4	0.35
	trailing hose, short vegetation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.50
	trailing hose, grassland	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	2	0.54
	trailing shoe	0	0	0	0	2	2	2	2	1	1	2	2	2	2	2	2	2	2	2	2	2	0.36
	open slot	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0.24
	grubber	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3	3	0.05
all cattle, solid manure	broadcast, without incorporation	13	13	13	13	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	0.90
	broadcast, incorporation < 1 h	6	6	6	6	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	0.09
	broadcast, incorporation < 4h	0	0	0	0	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5	5	0.45
	broadcast, incorporation < 12h	7	7	7	7	36	36	36	36	37	37	37	37	37	37	37	37	37	37	37	37	37	0.81
	broadcast, incorporation < 24h	47	47	47	47	19	19	19	19	20	20	20	20	20	20	20	20	20	20	20	20	20	0.90
	broadcast, incorporation < 48h	6	6	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.90
	broadcast, vegetation	22	22	22	22	27	27	27	27	25	25	25	25	25	25	25	25	25	25	25	25	25	0.90

livestock category	application type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	NH_3-N EF for application, kg NH_3-N per kg TAN applied
all pigs, slurry	broadcast, without incorporation	8	8	8	8	5	5	5	5	4	4	4	4	3	3	2	2	2	1	1	0	0	0.25
	broadcast, incorporation < 1 h	4	4	4	4	8	8	8	8	8	8	8	8	7	7	7	7	7	6	6	6	6	0.04
	broadcast, incorporation < 4h	0	0	0	0	1	1	1	1	1	1	1	2	3	4	5	5	6	7	8	8	9	0.09
	broadcast, incorporation < 6h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.11
	broadcast, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	3	3	4	4	5	0.13
	broadcast, incorporation < 12h	0	0	0	0	27	27	27	27	27	27	25	22	20	18	15	13	10	8	6	3	1	0.16
	broadcast, incorporation < 24h	47	47	47	47	5	5	5	5	5	5	4	4	3	3	3	2	2	1	1	0	0	0.21
	broadcast, incorporation < 48h	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25
	broadcast, vegetation	32	32	32	32	23	23	23	23	24	24	24	24	24	24	24	23	23	23	23	23	23	0.25
	broadcast, grassland	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	3	3	3	3	0.30
	trailing hose, without incorporation	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	0	0	0	0.18
	trailing hose, incorporation < 1 h	0	0	0	0	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	0.02
	trailing hose, incorporation < 4h	0	0	0	0	1	1	1	1	1	1	2	2	2	3	3	4	4	5	5	6	6	0.06
	trailing hose, incorporation < 6h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.08
	trailing hose, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	3	3	3	0.09
	trailing hose, incorporation < 12h	0	0	0	0	10	10	10	10	9	9	9	8	7	6	5	5	4	3	2	1	1	0.11
	trailing hose, incorporation < 24h	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1	1	0	0	0	0.14
	trailing hose, incorporation < 48h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.17
	trailing hose, vegetation	0	0	0	0	0	0	0	0	0	0	3	5	8	11	13	16	19	22	24	27	30	0.13
	trailing hose, short vegetation	1	1	1	1	8	8	8	8	9	9	8	7	6	5	5	4	3	2	2	1	0	0.25
	trailing hose, grassland	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0.21
	trailing shoe	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	0.12
	open slot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0.06
	grubber	0	0	0	0	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	0.03
all pigs, solid manure	broadcast, without incorporation	20	20	20	20	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	0.90
	broadcast, incorporation < 1 h	5	5	5	5	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	0.09
	broadcast, incorporation < 4h	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0.45
	broadcast, incorporation < 12h	0	0	0	0	51	51	51	51	52	52	52	52	52	52	52	52	52	52	52	52	52	0.81
	broadcast, incorporation < 24h	70	70	70	70	13	13	13	13	12	12	12	12	12	12	12	12	12	12	12	12	12	0.90
	broadcast, incorporation < 48h	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.90
	broadcast, vegetation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.90

livestock category	application type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	NH_3-N EF for application, kg NH_3-N per kg TAN applied
all cattle and pigs, leachate	broadcast, without incorporation	50	50	50	50	50	50	50	50	50	50	45	41	36	32	27	23	18	14	9	5	0	0.20
	broadcast, incorporation < 1 h	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	0.02
	broadcast, incorporation < 4h	0	0	0	0	0	0	0	0	0	0	1	1	2	3	4	4	5	6	7	7	8	0.07
	broadcast, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	1	1	2	3	3	4	5	5	6	7	7	0.12
	broadcast, incorporation < 12h	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	0.14
	broadcast, vegetation	0	0	0	0	0	0	0	0	0	0	1	3	4	6	7	8	10	11	13	14	15	0.20
	broadcast, grassland	50	50	50	50	50	50	50	50	50	50	50	50	49	49	49	49	48	48	48	48	47	0.20
	trailing hose, without incorporation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.18
	trailing hose, incorporation < 1 h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.01
	trailing hose, incorporation < 4h	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0.05
	trailing hose, incorporation < 8h	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0.09
	trailing hose, incorporation < 12h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0.12
	trailing hose, vegetation	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	3	3	4	4	0.15
	trailing hose, grassland	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	2	2	2	2	3	3	0.14
	trailing shoe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.08
	open slot	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0.04
	grubber	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2	2	2	2	3	3	3	0.02
laying hens, solid manure	broadcast, without incorporation	8	8	8	8	5	5	5	5	8	8	8	8	8	8	8	8	8	8	8	8	8	0.90
	broadcast, incorporation < 1 h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	broadcast, incorporation < 4h	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.18
	broadcast, incorporation < 12h	0	0	0	0	11	11	11	11	21	21	21	21	21	21	21	21	21	21	21	21	21	0.40
	broadcast, incorporation < 24h	92	92	92	92	83	83	83	83	70	70	70	70	70	70	70	70	70	70	70	70	70	0.45
poultry, except laying hens, solid manure	broadcast, incorporation < 24 h	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.45
all other animals, solid manure *)	broadcast, without incorporation	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	0.90

*) (horses, mules and asses, sheep, goats, buffalo)

Table 327: Laying hens, housing-specific partial NH_3 emission factors

[in kg NH_3-N per excreted kg N]	≤ 2000	2001 - 2009	≥2010
Cage housing; as of 2010: small-group housing	0.164		0.066
Floor management, aviary	0.351	linear interpolation	0.090
intensive outdoor management, free-range management, organic production	0.099		

Source: HAENEL et al., 2012

19.5 Other detailed methodological descriptions for the source/sink category "Land-use change and forestry" (5)

19.5.1 Land-use matrix

19.5.1.1 Justification of the decision in favour of a sample-based system

Germany has a range of spatially explicit data available for annual determination of land-use changes. Each of the different sets of data involved has specific advantages and disadvantages, in terms of such aspects as:

- Periodic vs. annual surveys
- Regional surveys vs. national, complete surveys
- Surveys with complete area coverage vs. incomplete surveys with gaps (with incompleteness system-based)
- Focus on surveying (actual) states vs. focus on surveying changes
- Detection of only a single land-use category (such as Forest land)

Owing to the aforementioned differences between sets of data, the following questions arise in connection with any further use of data:

- Do the data take adequate account of all types of land use?
- In their definitions of land-use and land-use-change classes, do the different data records agree among themselves – and with national or international definitions?
- Are the data updated?
- Do their underlying survey methods continue to improve?
- Are any new sources of information available, etc.?

In many cases, development and establishment of GIS-based map systems that are both substantially comprehensive and spatially explicit and complete did not begin until the 1990s. Gradually, the available database was built, and its quality was successively improved. As a result, information about land uses in 1990 – or in periods before or after that year – is not available for every area and every sample point. For that reason, a flexible system has been developed that draws information from the greatest possible number of data sources, for the following purposes:

- Obtaining comprehensive and complete land-use-change information,
- Taking account of the qualitative differences between the different data sources,
- Taking account of the spatial and qualitative development of the data,
- Verifying changes shown via comparison of different data sources,
- Ensuring that the definitions of land-use categories in the time series are consistent, and
- Allowing additional (own) research.

In light of the data available in Germany, only a sample-based system can achieve these purposes, since such a system

- Can verify data sources,
- Can quantify different error sources,
- Considers changes on a point-wise basis, rather than on an area-wise basis. For these reasons, a sample-based system

   1. is more robust in handling minor degrees of imprecision, in area-boundary delimitation, that result from differences between different data sources, and
   2. does not need to provide 100% accuracy in georeferencing (which cannot be attained anyway) (FULLER 2003).
- Can verify the plausibility of land-use changes, and
- Can integrate data sources that are available only in sample form, meaning that the database can be expanded.

The National Forest Inventory (Bundeswaldinventur – BWI) is such a sample-based system. In place since 1987, it periodically, and very precisely, surveys land-use changes from and to forest land. The BWI network is now being used systematically for determination of all land-use changes. In addition to providing consistency in area calculations, that system achieves full consistency between reporting under the UN Framework Convention on Climate Change and reporting within the framework of Article 3.3/3.4 of the Kyoto Protocol. In May 2011, Germany's decision in favour of a sample-based system was approved by a national workshop for experts. Subsequently, it was presented and discussed in the context of an international workshop for experts. The international experts who took part in that event found the system to be well-suited for current and future use.

19.5.1.2 Justification of the decision in favour of the BWI grid

Some of the 31 LULUCF classes (main land-use classes with no changes to "Other Land") account for very small total areas in Germany. For that reason, a simulation was carried out to determine whether such areas can be surveyed precisely enough with the current nation-wide basic 4km x 4km grid, and with the current (state-) Land-specific higher-resolution 2km x 2km grid areas, or whether the resolution of the BWI network needs to be further increased. To that end, a systematic, simple sampling network with 100m x 100m grid cells was generated. From that network, up to 25 sub-networks were derived for each of the following grid cell sizes: 200m x 200m, 500m x 500m, 1000m x 1000m and 2000m x 2000m. From a statistical perspective, it is desirable for each of the 31 LULUCF classes to be covered if at all possible. At the same time, no requirement has been imposed to the effect that estimates of the area shares of even the smallest LULUCF classes have to differ significantly from zero. The test results indicate that a 1km x 1km network has the optimal resolution. If one ignores the manner in which the 217603 BWI cluster-sample points used nationwide are arranged into clusters and higher-resolution areas, then each cluster-sample point represents an area of 1.644km^2 which, in a quadratic arrangement, about corresponds to a network density of 1280m x 1280m. From a statistical perspective, the decision in favour of the current BWI 2012 network thus represents a good compromise. The number of sample points actually used is near to the number that one would have with a systematic 1km x 1km network. Since the correlation between the cluster-sample points is smaller than 1, the probability increases that a single cluster will cover several land-use-change classes, and this also applies to clusters covering land-use-change classes with very small area shares. At the same time, the number of extremely small sampling elements is smaller with a cluster sample than it is with a simple sample, if the same number of sample points is used in each case. The sampling error thus has been conservatively estimated.

In light of requirements pertaining to reporting, the BWI 2012 network can be considered optimal, since:

- an internally consistent land-use matrix can be prepared only with the BWI network,

- including a matrix that is is consistent with the BWI forest-area estimates,
- and is consistent with the BWI carbon- stock-change estimates.

The approach thus fulfills the stringent quality criteria required especially in the KP-reporting context.

19.5.1.3 Implementation of transition time

Step 1

The following holds for points that originally belonged to a "remaining" category:

Event	Description	Formula	Variables
1st case: no change			
The area remains completely in the "remaining" category		$A_{year} = A_{point}$	A_{year} is the share of the point in the category of the year currently being treated by the calculation algorithm A_{point} is the area represented by the point
2nd case: Change to another land use			
Year within the change period	Increase phase, i.e. the area disappears from the "remaining" category, in keeping with the relevant annual changes	$A_{year} = A_{point} - \left(\frac{A_{point}}{time\ period} * (year - starting\ year)\right)$	**Time period =** Duration of change period **Year =** The year currently being considered via the calculation algorithm **Starting year =** Beginning of the transition time for this point
Year after the change period	The area has already disappeared from the "remaining" category	$A_{year} = o$	
3rd case: Change from another land use to the land use under consideration			
Year earlier, or the same year, as the starting year + 20 years	The area has not yet completely "arrived" in the new "remaining" category	$A_{year} = o$	
Year later than the starting year + 20 years (but still within the blocked period)	Piece by piece, in keeping with the relevant annual changes, the area is gradually added to the new "remaining" category	$A_{year} = A_{point} * \left(\frac{year - (starting\ year + 20)}{time\ period}\right)$	

Step 2

The following holds for points that belong to a land-use-change category:

Event	Description	Formula	Variables
1st case: Year within the change period (increase phase)			
For each point monitored, total changes throughout the entire change period are broken down into annual-change increments	In other words, in each case the change area increases each year by the relevant annual increment until, at the end of the change period, the change area encompasses the relevant point's entire area.	$A_{year} = A_{point} * \left(\frac{year - starting\ year}{time\ period}\right)$	
2nd case: Time from the end of the change period until 20 years after the beginning of the change period (plateau phase)			
The area remain in the relevant change category		$A_{year} = A_{point}$	
3rd case: Time from a) 20 years after the beginning of the change period until b) 20 years after the end of the change period (decrease phase)			
Area remaining within the change category	decreases each year by an annual change amount	$A_{year} = A_{point} * \left(\frac{end\ year - year}{time\ period}\right)$	**End year** = the year in which the transition time for the relevant point ends

Step 3

Now, all the area values for the sample points are summed, for each land-use category and each land-use-change category, and for each year, throughout the period 1991 to 2010.

Step 4

Then, the area sums have to be corrected to take account of changes from previous years (1970-1990) that are currently within a transition time. The following holds for the "remaining" categories:

$$\sum A_{year,corrected} = \sum A_{year} + \left((2010 - year) * \sum increase\right)$$

where $\sum A_{year}$ = the sum, as calculated in step 3, of all areas within the land-use / land-use-change category considered, and $\sum increase =$ the area sums, as extrapolated into the period 1970-1990, of the annual changes for all land-use-change categories that, following the end of the transition time, bring about area growth within the land-use category under consideration, for the reference period 1990-2000.

The following holds for the land-use-change categories:

$$\sum A_{year,corrected} = \sum A_{year} + \left(\sum A_{reference\ year} * (2010 - year)\right)$$

where $\sum A_{reference\ year}$ = the area sum, extrapolated into the period 1970-1990, of annual land-use changes in the area under consideration, for the reference period 1990-2000.

19.5.2 *Determination of emission factors for mineral soils*

The following data sources provide the basis for determination of the mean carbon stocks in mineral soils, weighted by climate region, and considered from a complete-coverage perspective, as a function of land use:

1. Soil-overview map (Bodenübersichtskarte; BÜK), scaled to 1:1,000,000 (BÜK 1000; BGR 1995, 1997, 2007)
2. Estimator profiles from the BÜK 1000 n 2.3; FISBo BGR (BGR 2011)

3. "Gehalte an organischer Substanz in Oberböden Deutschlands – Bericht über länderübergreifende Auswertung von Punktinformationen im FISBo BGR" ("Concentrations of organic matter in Germany's topsoils – report on Länder-overarching evaluation of point data in the FISBo BGR") (DÜWEL et al. 2007)
4. Results of the Forest Soil Inventory II (BZE II; vTI 2011)
5. Data records of the Basic Digital Landscape Model (Basis-Digitalen Landschaftsmodell; B-DLM) of the ATKIS® official topographic-cartographic information system, for the years 2000, 2005, 2010 (AdV 2000; 2005; 2010)
6. IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 - Agriculture, Forestry and Other Land Use (IPCC 2006)

The emission factors for the various land-use categories were determined with the help of a fallback system. This means that

- where specifically collected soil data are available for a given land-use category (BZE II data; data from the BGR study (DÜWEL et al. 2007)), those data have been used, either by themselves or in combination with data from the BÜK 1000, for determination of the soil carbon stocks in the relevant categories.
- Where such data are not available, determination has been based on estimates from the BÜK 1000.

In keeping with the different data situations for the various land-use categories, the area-weighted, use-specific and soil-specific carbon stocks were determined separately for the various categories.

19.5.2.1 Land use category Forest (Forest Land)

The provisional mean value, as determined in Forest Soil Inventory II (BZE II), for carbon stocks in mineral soils, to a soil depth of 30 cm, was assigned to areas that the National Forest Inventory treats as "forest land", within the meaning of the definition of the Federal Forest Act and of the IPCC definition chosen by Germany.

The BZE II, a systematic sampling survey, was carried out for the purpose of collecting basic information about the condition of forest soils and the changes taking place in them. Its aims included collecting data on key soil characteristics. To that end, the various Länder intensively studied the soil and site characteristics at a total of some 2,000 points distributed throughout a complete-coverage 8 x 8 km grid. The effort was carried out in accordance with standardised work instructions that had been developed and defined via a cooperative effort of the Federal Government and the Länder (cf. Chapters 7.2.2.2 and 7.2.4.4).

For the current mean carbon stocks in mineral soils to a depth of 30 cm, that inventory produced a provisional result of 62.02 Mg ha^{-1} (37.2 – 92.9 Mg ha^{-1})(vTI-WOI, oral communication, cf. Chapter 7.2.2.2).

All calculations in connection with preparation of the present inventory are based on figures of that magnitude.

19.5.2.2 Land-use categories cropland, grassland, wetlands, settlements and other land

19.5.2.2.1 General information relative to 5.B - 5.F

The BÜK 1000 soil overview map divides Germany's soils into 71 different characteristic soil categories / legend units. Those units, known as "dominant soil associations", comprise dominant and secondary soil types. They are characterised on the basis of dominant soil types that are representative for the areas in question and that have been assigned selected soil profiles. Along with descriptive parameters, the profile descriptions include information about key soil characteristics, such as humus and nitrogen content and physical soil parameters (DÜWEL et al. 2007). For example, the data set on which the present calculations are based includes derived specific measurements for carbon (C_t), inorganic carbon (C_i), nitrogen (N_t), rock content and raw density$_{dry}$, as well as ranges for those values, in the form of class information pursuant to KA 4 (AG BODEN 1994).

The mean carbon stocks of a dominant soil association can be calculated from these data by multiplying the carbon content by soil mass and correcting for skeleton and carbonate content. For determination of the mean carbon stocks in mineral soils of the categories cropland, grassland, wetlands, settlements and other land, the BÜK 1000 was merged with the Basis-DLM (Chapter 7.1.3.2.1). The use-specific area data and soil-characteristics data of the BÜK 1000 (bulk density, skeleton content) were combined with the organic-carbon data produced by the BGR study "Gehalte organischer Substanz in Oberböden Deutschlands: Länderübergreifende Auswertung von Punktinformationen im FISBo BGR" ("Concentrations of organic matter in Germany's topsoils – report on Länder-overarching evaluation of point data in the FISBo BGR") (DÜWEL et al. 2007).

DÜWEL et al. 2007 list typical concentrations of organic matter (C_{org}) and humus in Germany's topsoils, for a total of 15 groups of soil parent material and 4 climate zones. Those listings are based on complete-coverage evaluation of data for ca. 14,000 profiles, broken down by use (cropland, grassland and forest) and by climate region.

In addition, that study assigns the 71 legend units of the BÜK, on the basis of their pedo-lithological characteristics, to those 15 groups of soil parent material (DÜWEL et al. 2007), with the result that those groups serve as links to the legend-unit information of the BÜK 1000.

19.5.2.2.2 Cropland

For cropland with annual crops, the BGR study asserts that its values are valid to a soil depth of 30 cm. As a result, it was possible to apply the carbon-content data from the BGR study to all dominant soil associations of the BÜK 1000.

Table 328: Area [ha], mean area-based carbon stocks [Mg C ha^{-1}] and pertinent uncertainties (upper and lower boundary in %) for croplands in Germany with annual crops

Mineral soils	Carbon stocks [Mg C ha^{-1}]	Boundaries	
		upper [%]	lower [%]
$Cropland_{annual}$	59.77	50.07	32.67

Cropland with perennial crops

With regard to croplands with perennial crops (such as fruit trees, grapevines), it was assumed that such areas are not plowed and are covered to a degree of 75 % with grass. For that reason, calculations of mean carbon stocks for such areas were based on the profile characteristics for grassland. The relevant approach is described in Chapter 19.5.2.2.3. Table 329 shows the values obtained for such areas.

Table 329: Area [ha], mean area-based carbon stocks [Mg C ha^{-1}] and pertinent uncertainties (upper and lower boundary in %) for croplands in Germany with perennial crops

Mineral soils	Carbon stocks [Mg C ha-1]	Boundaries	
		upper [%]	lower [%]
Cropland with perennial crops	72.64	68.18	46.40

Carbon stocks for cropland

The mean carbon stocks for mineral soils in cropland are obtained as follows:

$$C_{min\ cropland} = \frac{\left(C_{cropland\ annual} * A_{cropland\ annual} + C_{cropland\ perennial} * A_{cropland\ perennial}\right)}{A_{cropland\ annual} + A_{cropland\ perennial}}$$

$C_{min\_cropland}$: Mean area-related carbon stocks for all of Germany's mineral cropland soils [Mg ha^{-1}]

$C_{cropland\_annual}$: Mean area-related carbon stocks for all of Germany's mineral cropland soils with annual crops [Mg ha^{-1}]

$C_{cropland\_perennial}$: Mean area-related carbon stocks for all of Germany's mineral cropland soils with perennial crops [Mg ha^{-1}]

$A_{cropland\_annual}$: Area of mineral-soil lands in Germany under cropland with annual crops [ha]

$A_{cropland\_perennial}$: Area of mineral-soil lands in Germany under cropland with perennial crops [ha]

Table 330 shows the mean carbon stocks, for mineral soils under cropland, that have been used as a basis for all pertinent calculations within the inventory.

Table 330: Mean area-based carbon stocks [Mg C ha^{-1}] and pertinent uncertainties (upper and lower boundary in %) for croplands in Germany

Mineral soils	Carbon stocks [Mg C ha^{-1}]	Boundaries		Distribution function
		upper [%]	lower [%]	
Cropland	60.03	50.50	32.99	Log-normal

19.5.2.2.3 Grassland

The land-use category grassland comprises the sub-categories "grassland in the narrower sense" and "woody grassland" (cf. Chapter 7.1.4). Calculations for both sub-categories are carried out on the basis of the same data. The differences between the carbon stocks of these sub-categories thus result only from differences in spatial distribution of land uses and, thus, differences in percentage shares of soil-parent-material groups and climate zones.

For grassland areas, the BGR study asserts that its values are valid to a depth of 10 cm (DÜWEL et al. 2007). The soil carbon stocks were correlated with the characteristics of the mineral-soil profiles of the BÜK 1000 via relationships with soil-parent-material groups, as follows: The soil-carbon-stocks data of the BGR study (DÜWEL et al. 2007) were assigned to the uppermost horizon, in keeping with the thickness as listed (maximum thickness of 10 cm). For that horizon, the bulk density and the skeleton content were taken from the BÜK 1000, as were the data for all characteristics and thicknesses of deeper horizons and depth layers, to a depth of 30 cm. The relevant results are shown in Table 331.

Table 331: Mean area-based carbon stocks [Mg C ha^{-1}] and pertinent uncertainties (upper and lower boundary in %) for grasslands in Germany

Mineral soils	Carbon stocks [Mg C ha^{-1}]	Boundaries upper [%]	lower [%]	Distribution function
Grassland in the narrower sense	77.43	77.87	45.93	Log-normal
Woody grassland	73.18	83.27	42.94	Log-normal

19.5.2.2.4 Terrestrial wetlands, settlements and other land

The mean carbon stocks in mineral soils in terrestrial wetlands were determined via a procedure similar to that used for grassland. Consquently, the procedure is described in Chapter 19.5.2.2.3. Differences in carbon stocks, between grassland and terrestrial wetlands, result solely from differences in spatial distribution of category areas.

The grassland carbon-stock values for A horizons were also assigned to soils under settlements and other land. At the same time, it was assumed that such soils have been disturbed and are not as deeply developed as are grassland sites. Therefore, the horizons of middle dominant profiles and of forest soils were assumed to apply. For a total of 44 of the 71 dominant soil profiles, this approach leads to changes in carbon stocks in comparison with grassland.

The mean carbon-stocks values are listed in Table 332.

Table 332: Mean area-based carbon stocks [Mg C ha^{-1}], and pertinent uncertainties (upper and lower boundary in %), in mineral soils under terrestrial wetlands, settlements and other land

Mineral soils	Carbon stocks [Mg C ha^{-1}]	Boundaries upper [%]	lower [%]	Distribution function
Wetlands (terr.)	73.99	52.48	43.85	Log-normal
Settlements	58.67	84.97	45.11	Log-normal
Other land	55.60	92.86	44.56	Log-normal

The emission factors derived from these mean carbon stocks, which are weighted by climate region, land use and areas, are listed in Table 206 and Table 207 in Chapter 7.1.5. The emission factors are listed with statistical indexes, for description of uncertainties, in Table 255 and Table 260 in Chapter 7.5.5 and 7.6.5, respectively.

19.5.2.2.5 Uncertainties

Since individual profiles do not support conclusions relative to the heterogeneity of soil parameters within the legend units (DÜWEL et al 2007), relevant extreme constellations of class values were constructed for purposes of estimating the potential ranges of carbon and nitrogen stocks in dominant soil associations (DSA) – and, thus, for purposes of determining the relevant uncertainties:

DSA carbon stocks$_{maximum}$: C_{org} content$_{maximum}$, bulk density$_{maximum}$, skeleton content$_{minimum}$

DSA carbon stocks$_{minimum}$: C_{org} content$_{minimum}$, bulk density$_{minimum}$, skeleton content$_{maximum}$

The values for bulk density, skeleton content and carbon stocks in horizons for which no corresponding values were available from the topsoil study of the BGR (DÜWEL et al. 2007) were derived, with the help of KA 4, in accordance with pertinent class information from the dominant-profile descriptions in the BÜK 1000 (BGR 1997).

The so-determined minimum and maximum carbon stocks form the relevant upper and lower boundaries and, in combination with the location scale, show the typical steep-left distribution that is typical for such data.

The carbon-stocks data from the BGR study (DÜWEL et al. 2007) are backed by descriptive statistics. The values for the 25th and 75th percentiles, i.e. the upper and lower threshold values, were derived from those statistics.

In magnitude, the so-determined uncertainties are similar to those for forest soils, which are the result of an inventory and are backed by some 2,000 profiles.

19.5.2.3 Planned improvements

The values listed in the above chapters are the best data now available in complete-coverage form. Major inventories for determination of the carbon and nitrogen stocks in mineral soils have been carried out, and are being carried out, in Germany, with a view to improving such data:

- The Forest Soil Inventory II, for all forest soils (currently being evaluated) (cf. chapter 7.2.8.1).
- The Agricultural Soil Inventory (Bodenzustandserhebung Landwirtschaft), for cropland and grassland soils) (cf. chapter 7.3.8).

Those two major inventories cover about 84 % of Germany's total surface area, or about 88 % of its mineral-soil area.

- The results of the inventories are gradually being used for determination of precise emission factors.
- As part of integration of the results of the major inventories, the reporting system for mineral soils (Berichtssystem Mineralboden) is to be converted from a soil depth of 30 cm to a depth of 1 m) (cf. chapter 7.2.8.2).

19.5.3 Derivation of calculation figures (emission factors) for biomass

19.5.3.1 Perennial crops

In the framework of the research project "Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth" ("Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen"), country-specific carbon-stock data are being collected for orchards, vineyards and Christmas-tree plantations in Germany. From that data, carbon stocks are being derived for both above-ground and below-ground biomass.

19.5.3.1.1 Fruit trees

In the framework of the above-mentioned research project, a total of 100 fruit trees (91 apple trees, 6 cherry trees and 3 plum trees) of different ages and varieties, from Germany's two main fruit-cultivation regions ("Altes Land" in northern Germany and the Lake Constance region in southern Germany), were destructively tested. In addition, the following data was collected from 210 living apple trees:

- Diameter at trunk base
- Diameter at breast height
- Height

A regression procedure applied to all collected data yielded a highly significant link between tree age and mean trunk diameter (=(diameter at trunk base + diameter at breast height)/2):

Equation 45: Regression equation for estimating mean trunk diameter [cm] of apple trees, as a function of tree age [a]

$$S_{mean\ apple} = 19.1645 * \left(1 - e^{(-0.0357x)}\right)$$

S_{mean_apple}: Mean trunk diameter, apple tree [cm]
x: Tree age [a]
Statistical indexes:
r^2 =0.5855
n = 300
p < 0.0001
Standard error of estimation = 1.4318 ≙ 19.72 %

Equation 46: Regression equation for estimating mean trunk diameter [cm] of cherry and plum trees, as a function of tree age [a]

$$S_{mean\ cherry/plum} = 53.8165 * \left(1 - e^{(-0.0252x)}\right)$$

$S_{mean\_cherryplum}$: Mean trunk diameter, cherry/plum tree [cm]
x: Tree age [a]
Statistical indexes:
r^2 =0.9486
n = 9
p < 0.0001
Standard error of estimation = 1.2963 ≙ 11.14 %

Via destructive testing, the masses, water content and carbon content of the fruit trees were separately determined for the compartments above-ground biomass (trunk and branches) and below-ground biomass (roots). The ages of the so-tested apple trees were 6 and 9, while the ages of the cherry and plum trees were 4, 12 and 14.

The trees' biomasses were adjusted to take account for the water content measured during drying at 105°C and then, to determine the carbon stocks of the trees' parts / whole trees, were multiplied by the carbon-content percentage of the $biomass_{dry}$.

From the resulting data, highly significant relationships were derived between mean trunk diameter and carbon stocks of the entire plant [Equation 47 (apple); Equation 49 (cherry/plum)] and between mean trunk diameter and carbon stocks of the above-ground biomass [Equation 48 (apple); Equation 50 (cherry/plum)].

Equation 47: Regression equation for estimating carbon stocks of the entire biomass of apple trees, as a function of mean trunk diameter

$$\ln C_{total\ apple} = -2.1774 + 1.7565 * \ln x$$

ln C_{total_apple}: Logarithm for carbon stocks in total apple-tree biomass [kg $plant^{-1}$]

ln x: Logarithm for mean trunk diameter [cm]
Statistical indexes:
r^2 =0.8011
n = 90
$p < 0.0001$
Standard error of estimation = 0.1915

Equation 48: Regression equation for estimating carbon stocks in the above-ground biomass of apple trees, as a function of mean trunk diameter

$$\ln C_{above\ apple} = -2.7521 + 1.9533 * \ln x$$

ln C_{above_apple}: Logarithm for carbon stocks in above-ground plant parts [kg $plant^{-1}$]
ln x: Logarithm for mean trunk diameter [cm]
Statistical indexes:
r^2 =0.9321
n = 90
$p < 0.0001$
Standard error of estimation = 0.1953

Equation 49: Regression equation for estimating carbon stocks of the entire biomass of cherry and plum trees, as a function of mean trunk diameter

$$C_{total\ cherry/plum} = 0.0369\ x^{2.2725}$$

$C_{total\_cherryplum}$: Carbon stocks of entire cherry/plum tree biomass [kg $plant^{-1}$]
x: Mean trunk diameter, cherry/plum tree [cm]
Statistical indexes:
r^2 =0.9608
n = 9
$p < 0.0001$
Standard error of estimation = 1.8582 (15 %)

Equation 50: Regression equation for estimating carbon stocks in the above-ground biomass of cherry and plum trees, as a function of mean trunk diameter

$$C_{above\ cherry/plum} = 0.0238\ x^{2.3586}$$

$C_{above\_cherryplum}$: Carbon stocks of above-ground cherry/plum tree biomass [kg $plant^{-1}$]
x: Mean trunk diameter, cherry/plum tree [cm]
Statistical indexes:
r^2 =0.9321
n = 9
$p < 0.0001$
Standard error of estimation = 2.025 (20.31 %)

For each variety, the difference between the carbon stocks of the entire plant and the stocks of its above-ground parts yields the root C stocks (cf. Equation 51).

Equation 51: Estimation of the carbon stocks in the root mass of fruit trees of the same variety

$$C_{below} = C_{total} - C_{above}$$

C_{below}: Below-ground carbon stocks [kg $plant^{-1}$]
C_{total}: Carbon stocks of entire plant [kg $plant^{-1}$]
C_{above}: Above-ground carbon stocks [kg $plant^{-1}$]

The absolute C-stocks of all of Germany's fruit trees were calculated with the help of the results of the last exhaustive statistical survey of fruit cultivation (STATISTISCHES BUNDESAMT 2007). On the basis of that survey's results, the Federal Statistical Office determined total numbers of apple, pear, sweet cherry / sour cherry, plum / prune, mirabelle and greengage trees, in different age classes, as well as the areas under cultivation with trees in the various age classes (cf. Table 333).

Table 333: Results of the last exhaustive statistical survey of fruit trees (2007) carried out by the Federal Statistical Office (STATISTISCHES BUNDESAMT 2007)

Age class		Fruit trees, total	Apple	Pear	Sweet cherry	Sour cherry	Plum, prune	Mirabelle, greengage
1	**Area [ha]**	6,337	2,610	558	1,669	569	561	89
	Number [n]	77,908,784	1,959,650	374,357	349,898	309,888	174,950	25,268
1 Apr	**Area [ha]**	1,314	1,283	30	125	9	142	8
	Number [n]	3,493,397	3,460,242	51,926	92,723	6,720	98,538	4,372
5 Sep	**Area [ha]**	7,403	5,159	252	859	330	713	90
	Number [n]	15,410,632	13,645,705	466,895	563,239	234,410	452,011	48,372
14 Oct	**Area [ha]**	10,606	7,275	350	783	866	1,186	146
	Number [n]	19,740,123	17,334,084	581,720	458,483	579,748	722,909	63,179
15-19	**Area [ha]**	10,321	7,603	454	763	372	1,057	71
	Number [n]	19,602,081	17,527,552	831,342	322,364	260,231	632,286	28,306
20-24	**Area [ha]**	8,599	5,995	338	764	791	621	91
	Number [n]	12,899,071	11,365,689	443,150	219,989	543,127	290,899	36,217
25	**Area [ha]**	3,333	1,837	119	519	507	284	66
	Number [n]	3,348,345	2,569,271	126,438	143,442	351,826	130,916	26,452

To determine the total carbon stocks in fruit trees, the carbon stocks – either measured or determined via regression – in the above-ground and below-ground biomass of individual trees of each age class were multiplied by the relevant total numbers of trees. In the process, the values obtained for apple trees were also assigned to pear trees, while those obtained for cherry and plum trees were also assigned to prune, mirabelle and greengage trees.

The area-related emission factors for the various tree varieties were calculated, in each case, via division by the relevant area under cultivation.

Table 334: Area-related carbon stocks [Mg ha^{-1}] (range, or ± half of the 95 % confidence interval) in the biomass of Germany's fruit trees

Fruit tree	**Carbon stocks [Mg C ha^{-1}]**			**Area [ha]**
	Bio_{above}	**Bio_{below}**	**Bio_{total}**	
Apple	7.50 (2.2 – 18.6)	1.21 (0.5 – 2.5)	8.70 (2.5 – 21.5)	31,762
Pear	4.70 (1.4 – 11.7)	0.73 (0.3 – 1.5)	5.43 (1.6 – 13.4)	2,101
Sweet cherry	8.44 ± 3.87	1.47 ± 0.42	9.91 ± 3.70	5,482
Sour cherry	25.66 ± 11.77	4.10 ± 1.20	29.76 ± 11.12	3,444
Plum/prune	13.01 ± 5.97	2.36 ± 0.69	15.37 ± 5.74	4,564
Mirabelle/greengage	12.46 ± 5.72	2.06 ± 0.60	14.53 ± 5.43	561

19.5.3.1.2 Christmas-tree plantations

In Germany today, Christmas trees are cultivated on a total of about 14,000 – 15,000 ha of agricultural land outside of forests (STATISTISCHES BUNDESAMT 2007). With an average planting density of 6,000 plants per ha, about 50 t of biomass (dry) are produced per ha (PÖPKEN 2011). Of that quantity, 45.6 % is root mass. That value was obtained from an overview study of MOKANY et al. (2006), who derived root / shoot ratios, for numerous different types of vegetation, as a function of biomass, climate parameters and site parameters. Their root / shoot ratios were adopted as default values in the 2006 IPCC Guidelines (IPCC 2006).

Table 335: Area-related carbon stocks [Mg ha^{-1}] (± half of the 95 % confidence interval) of biomass of Germany's Christmas trees (in plantations)

Tree	**Carbon stocks [Mg C ha^{-1}]**			**Area [ha]**
	Bio_{above}	**Bio_{below}**	**Bio_{total}**	
Christmas trees	17.3 ± 8.6	5.2 ± 2.6	22.5 ± 11.3	14,666

19.5.3.1.3 Grapevines

In the project "Development of methods for determining the biomass of plants, outside of forests, with multiple years of wood growth" ("Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen") (PÖPKEN 2011), a total of 74 grapevines were destructively tested for the purpose of deriving a country-specific mean value for carbon stocks of grapevines. The ages of the vines tested were 15 and 25 (years). In the testing, the vines' weights, and the water and carbon content of the above-ground and below-ground plant parts, were determined (PÖPKEN 2011). The carbon stocks of grapevines and of parts of vines are calculated via Equation 52.

Equation 52: Calculation of the carbon stocks in grapevines

$$C_{vine} = C_{cont\ above} * M_{105\ bio\ above} + C_{cont\ below} * M_{105\ bio\ below} + M_{cut\ fresh} * WC_{\emptyset} * C_{\emptyset}$$

C_{vine}: Carbon stocks of one grapevine [kg]
$C_{cont\ above}$: Carbon content of the above-ground vine [by weight]
$M_{105\ bio\ above}$: Dry biomass of the vine [kg]
$C_{cont\ below}$: Carbon content of below-ground biomass [by weight]
$M_{105\ bio\ below}$: Dry biomass of below-ground biomass [kg]
$M_{cut\ fresh}$: Fresh weight of cut wood, per plant [kg]
$WC_{\emptyset}$: Average water content in grapevines [by weight / 100]
$C_{\emptyset}$: Average carbon content in grapevines [by weight / 100]

The grapevines were tested without parts removed during annual pruning; those parts had previously been removed and unfortunately were not available for testing. For that reason, the weights of such pruned parts had to be estimated. Pursuant to WALG (2006), some 0.7 – 1.4 kg of wood are pruned from each grapevine per year; on the basis of that figure, the German inventory calculates with a mean value of 1 kg fresh wood. In all further calculations, that figure was added to the above-ground biomass of all 74 grapevines (cf. Equation 52).

Since vineyards in Germany contain an average of 4,000 grapevines per ha (PÖPKEN 2011), the carbon stocks per area unit (ha) were calculated by multiplying the C stocks of individual plant compartments / total plants by 4,000. The absolute carbon stocks are calculated by multiplying the pertinent emission factors by the total vineyard area. The resulting values are shown in Table 336.

Table 336: Area-related carbon stocks [Mg ha^{-1}] (± half of the 95 % confidence interval) in grapevine biomass in Germany

Woody plant	**Carbon stocks [Mg C ha^{-1}]**			**Area [ha]**
	Bio_{above}	**Bio_{below}**	**Bio_{total}**	
Grapevine	1.93 ± 0.07	0.54 ± 0.04	2.47 ± 0.10	102,026

19.5.3.1.4 Mean carbon stocks in the biomass of woody plants cultivated on cropland

For calculation of the mean area-related carbon stocks in woody plants cultivated on cropland, the absolute carbon stocks of the various crop types were calculated, by compartments, summed and then divided by the relevant area. The results are shown in Table 337.

Table 337: Determination of area-weighted carbon stocks, in absolute [Mg] and area-related [Mg ha^{-1}] formats, for woody plants cultivated on cropland in Germany (carbon stocks 2 ± half of the 95 % confidence interval)

Fruit trees	Carbon stocks in Mg			Carbon stocks in Mg ha^{-1}			ha
	Bio_{above}	Bio_{below}	Bio_{total}	Bio_{above}	Bio_{below}	Bio_{total}	Area
Apple	238,132	38,300	276,432	7.50	1.21	8.70	31,762
Pear	9,880	1,531	11,411	4.70	0.73	5.43	2,101
Sweet cherry	46,261	8,068	54,328	8.44	1.47	9.91	5,482
Sour cherry	88,374	14,135	102,508	25.66	4.10	29.76	3,444
Plum / prune	59,385	10,763	70,148	13.01	2.36	15.37	4,564
Mirabelle / greengage	6,992	1,158	8,150	12.46	2.06	14.53	561
Christmas trees	253,224	76,761	329,985	17.27	5.23	22.50	14,666
Grapevine	197,086	54,600	251,686	1.93	0.54	2.47	102,026
Total	**899,333 ± 367,845**	**205,315 ± 67,349**	**1,104,648 ± 432,111**				**164,606**
Area-weighted carbon-stocking rates for cultivated trees (carbon stocks 2)				**5.46 ± 2.23**	**1.25 ± 0.41**	**6.71 ± 2.63**	

Since in Germany woody plants cultivated on cropland are always mixed with grass, the total biomass carbon stocks per area unit for such areas is calculated via Equation 53:

Equation 53:

$$C\ stocks_{cro2} = C\ stocks_{fruit\ trees} + biomass_{grassland} * 0.75$$

The factor for grassland biomass arises in that only the areas directly under the woody plants concerned are kept free of vegetative cover. In orchards and vineyards, grass grows only between rows of the cultivated woody plants. The value for grassland ("in the narrower sense") is used as a basis for determining such biomass. Table 338 shows the carbon stocks for areas with woody plants cultivated on cropland.

Table 338: Area-weighted mixed value for carbon stocks [Mg ha^{-1}] of woody plants cultivated on cropland (± half of the 95 % confidence interval)

Woody plant	Carbon stocks [Mg C ha^{-1}]		
	Bio_{above}	Bio_{below}	Bio_{total}
Areas with woody plants cultivated on cropland	11.73 ± 2.90	8.73 ± 2.24	2.99 ± 1.30

19.5.4 Uncertainties

The uncertainties for the German LULUCF inventory were determined in accordance with the provisions of the IPCC (2000; IPCC – Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories). The uncertainty statistics commonly given for a normal distribution include the 95 % confidence interval, ± half of the 95 % confidence interval and 1.96 x the standard error, in % of the mean.

For asymmetric distributions – in the present context, usually consisting of data sets with a logarithmic normal distribution – the relevant deviations are described as upper and lower bounds, expressed as % values of the pertinent position scale. Pursuant to the IPCC (2000), in such cases propagation of uncertainties is to be calculated via a conservative estimation in which the distance between the extreme value of the sloping axis section and the position scale is defined as half of the 95 % confidence interval.

Table 339 shows the results of uncertainties calculation for all pools and sub-categories of the German LULUCF inventory. The pertinent calculation shows that the total uncertainty for the German LULUCF inventory is 21.78 %. It is clear that two pools contribute especially significantly to the total emissions and total uncertainty of the LULUCF inventory. These are, firstly, biomass in connection with forests, especially in the Forest Land remaining Forest Land category, and functioning as a sink; and secondly, and to an even greater extent, organic soils in cropland and grassland pools, functioning as an emissions source. Only emissions/removals from/in biomass in the Woody Grassland sub-category are perceptible. All other pools and categories have only a marginal influence.

Table 339: Uncertainty Calculation for the German GHG Emissions from Sector 5.A - 5.F (LULUCF)

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category		Gas	Base year emissions [CO_2- eq.]	Year 2010 emissions [CO_2- eq.]	Activity data uncertainty (half the 95% confidence interval)	Emission factor uncertainty (half the 95% confidence interval)	Combined uncertainty (half the 95% confidence interval)	Combined uncertainty as % of total national emissions in year 2010	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Gg CO_2-Eq. a^{-1}	Gg CO_2-Eq. a^{-1}	%	%	%	%	%	%	%	%	%
5.A.1 Forest Land remaining Forest Land	Mineral soil	CO2	0.00	0.00	1.34	40.03	40.05	0.000	0.000	0.000	0.000	0.000	0.000
5.A.1 Forest Land remaining Forest Land	Organic soil	CO2	497.30	558.93	1.34	180.88	180.89	1.315	0.002	0.004	0.368	0.008	0.368
5.A.1 Forest Land remaining Forest Land	EF Biomass	CO2	-63110.69	-16507.06	1.34	59.38	59.40	12.756	0.168	0.129	9.956	0.244	9.959
5.A.1 Forest Land remaining Forest Land	EF litter	CO2	0.00	0.00	1.34	59.38	59.40	0.000	0.000	0.000	0.000	0.000	0.000
5.A.1 Forest Land remaining Forest Land	EF dead wood	CO2	-3507.86	-3638.50	1.34	64.22	64.23	3.041	0.012	0.028	0.769	0.054	0.771
5.A.2.1 Cropland converted to Forest Land	Mineral soil	CO2	-63.61	-43.18	8.02	35.45	36.34	0.020	0.000	0.000	0.001	0.004	0.004
5.A.2.1 Cropland converted to Forest Land	Organic soil	CO2	14.25	9.67	8.02	48.25	48.91	0.006	0.000	0.000	0.000	0.001	0.001
5.A.2.1 Cropland converted to Forest Land	EF Biomass	CO2	-3112.88	-1833.60	8.02	19.39	20.99	0.501	0.000	0.014	0.005	0.162	0.162
5.A.2.1 Cropland converted to Forest Land	EF litter	CO2	-318.38	-206.40	8.02	59.38	59.92	0.161	0.000	0.002	0.007	0.018	0.020
5.A.2.1 Cropland converted to Forest Land	EF dead wood	CO2	0.00	0.00	8.02	0.00	8.02	0.000	0.000	0.000	0.000	0.000	0.000
5.A.2.2 Grassland 1 converted to Forest Land	Mineral soil	CO2	667.08	391.78	9.66	48.57	49.52	0.252	0.000	0.003	0.003	0.042	0.042
5.A.2.2 Grassland 1 converted to Forest Land	Organic soil	CO2	32.75	19.28	9.66	49.05	49.99	0.013	0.000	0.000	0.000	0.002	0.002
5.A.2.2 Grassland 1 converted to Forest Land	EF Biomass	CO2	-3112.88	-2440.26	9.66	20.21	22.40	0.711	0.004	0.019	0.090	0.260	0.276
5.A.2.2 Grassland 1 converted to Forest Land	EF litter	CO2	-492.88	-274.49	9.66	59.38	60.16	0.215	0.000	0.002	0.010	0.029	0.031
5.A.2.2 Grassland 1 converted to Forest Land	EF dead wood	CO2	0.00	0.00	9.66	0.00	9.66	0.000	0.000	0.000	0.000	0.000	0.000
5.A.2.2 Grassland 2 converted to Forest Land	Mineral soil	CO2	204.51	111.52	12.37	50.52	52.02	0.075	0.000	0.001	0.004	0.015	0.016
5.A.2.2 Grassland 2 converted to Forest Land	Organic soil	CO2	9.20	5.02	12.37	180.88	181.31	0.012	0.000	0.000	0.001	0.001	0.001
5.A.2.2 Grassland 2 converted to Forest Land	EF Biomass	CO2	-689.64	-851.89	12.37	189.91	190.31	2.109	0.003	0.007	0.650	0.116	0.660
5.A.2.2 Grassland 2 converted to Forest Land	EF litter	CO2	-184.57	-96.11	12.37	59.38	60.66	0.076	0.000	0.001	0.007	0.013	0.015
5.A.2.2 Grassland 2 converted to Forest Land	EF dead wood	CO2	0.00	0.00	12.37	0.00	12.37	0.000	0.000	0.000	0.000	0.000	0.000
5.A.2.3 Wetlands 1 converted to Forest Land	Mineral soil	CO2	31.03	16.40	31.88	36.47	48.44	0.010	0.000	0.000	0.001	0.006	0.006
5.A.2.3 Wetlands 1 converted to Forest Land	Organic soil	CO2	34.37	18.17	31.88	180.88	183.67	0.043	0.000	0.000	0.003	0.006	0.007
5.A.2.3 Wetlands 1 converted to Forest Land	EF Biomass	CO2	-322.22	-224.56	31.88	132.87	136.64	0.399	0.000	0.002	0.032	0.079	0.085
5.A.2.3 Wetlands 1 converted to Forest Land	EF litter	CO2	-49.68	-25.08	31.88	59.38	67.40	0.022	0.000	0.000	0.002	0.009	0.009
5.A.2.3 Wetlands 1 converted to Forest Land	EF dead wood	CO2	0.00	0.00	31.88	0.00	31.88	0.000	0.000	0.000	0.000	0.000	0.000
5.A.2.3 Wetlands 2 converted to Forest Land	Mineral soil	CO2	0.00	0.00	62.75	49.77	80.09	0.000	0.000	0.000	0.000	0.000	0.000
5.A.2.3 Wetlands 2 converted to Forest Land	Organic soil	CO2	0.30	0.18	62.75	180.88	191.46	0.000	0.000	0.000	0.000	0.000	0.000
5.A.2.3 Wetlands 2 converted to Forest Land	EF Biomass	CO2	-27.36	-16.72	62.75	56.36	84.34	0.018	0.000	0.000	0.000	0.012	0.012
5.A.2.3 Wetlands 2 converted to Forest Land	EF litter	CO2	-3.20	-1.87	62.75	59.38	86.39	0.002	0.000	0.000	0.000	0.001	0.001
5.A.2.3 Wetlands 2 converted to Forest Land	EF dead wood	CO2	0.00	0.00	62.75	0.00	62.75	0.000	0.000	0.000	0.000	0.000	0.000

A Source category		B Gas	C Base year emissions [CO_2- eq.] Gg CO_2-Eq. a^{-1}	D Year 2010 emissions [CO_2- eq.] Gg CO_2-Eq. a^{-1}	E Activity data uncertainty (half the 95% confidence interval) %	F Emission factor uncertainty (half the 95% confidence interval) %	G Combined uncertainty (half the 95% confidence interval) %	H Combined uncertainty as % of total national emissions in year 2010 %	I Type A sensitivity %	J Type B sensitivity %	K Uncertainty in trend in national emissions introduced by emission factor uncertainty %	L Uncertainty in trend in national emissions introduced by activity data uncertainty %	M Uncertainty introduced into the trend in total national emissions %
5.A.2.4 Settlements converted to Forest Land	Mineral soil	CO2	-43.68	-27.79	17.79	48.58	51.73	0.019	0.000	0.000	0.001	0.005	0.005
5.A.2.4 Settlements converted to Forest Land	Organic soil	CO2	5.20	3.30	17.79	49.05	52.18	0.002	0.000	0.000	0.000	0.001	0.001
5.A.2.4 Settlements converted to Forest Land	EF Biomass	CO2	-932.57	-697.20	17.79	137.25	138.40	1.255	0.001	0.005	0.147	0.137	0.201
5.A.2.4 Settlements converted to Forest Land	EF litter	CO2	-130.00	-78.97	17.79	59.38	61.99	0.064	0.000	0.001	0.000	0.016	0.016
5.A.2.4 Settlements converted to Forest Land	EF dead wood	CO2	0.00	0.00	17.79	0.00	17.79	0.000	0.000	0.000	0.000	0.000	0.000
5.A.2.5 Other Land converted to Forest Land	Mineral soil	CO2	-3.43	-4.01	53.65	51.14	74.12	0.004	0.000	0.000	0.001	0.002	0.002
5.A.2.5 Other Land converted to Forest Land	Organic soil	CO2	0.18	0.20	53.65	180.88	188.67	0.001	0.000	0.000	0.000	0.000	0.000
5.A.2.5 Other Land converted to Forest Land	EF Biomass	CO2	-45.40	-52.96	53.65	50.00	73.34	0.051	0.000	0.000	0.010	0.031	0.033
5.A.2.5 Other Land converted to Forest Land	EF litter	CO2	-5.31	-5.92	53.65	59.38	80.03	0.006	0.000	0.000	0.001	0.004	0.004
5.A.2.5 Other Land converted to Forest Land	EF dead wood	CO2	0.00	0.00	53.65	0.00	53.65	0.000	0.000	0.000	0.000	0.000	0.000
5.B.1 Cropland remaining Cropland	Mineral soil	CO2	0.00	0.00	0.54	32.99	33.00	0.000	0.000	0.000	0.000	0.000	0.000
5.B.1 Cropland remaining Cropland	Organic soil	CO2	22255.68	23381.36	0.54	50.00	50.00	15.211	0.078	0.183	3.907	0.140	3.909
5.B.1 Cropland remaining Cropland	EF Biomass	CO2	0.00	0.00	0.54	7.86	7.88	0.000	0.000	0.000	0.000	0.000	0.000
5.B.2.1 Forest Land converted to Cropland	Mineral soil	CO2	30.46	16.10	8.02	24.85	26.11	0.005	0.000	0.000	0.000	0.001	0.001
5.B.2.1 Forest Land converted to Cropland	Organic soil	CO2	176.03	93.03	8.02	47.38	48.06	0.058	0.000	0.001	0.005	0.008	0.009
5.B.2.1 Forest Land converted to Cropland	EF Biomass	CO2	460.26	9.33	8.02	28.39	29.50	0.004	0.002	0.000	0.059	0.001	0.059
5.B.2.1 Forest Land converted to Cropland	EF DOM	CO2	335.69	8.02	8.02	55.65	56.23	0.006	0.002	0.000	0.084	0.001	0.084
5.B.2.1 Forest Land converted to Cropland	N2O	CO_2-Eq.	0.03	0.01	8.02	87.50	87.87	0.000	0.000	0.000	0.000	0.000	0.000
5.B.2.2 Grassland 1 converted to Cropland	Mineral soil	CO2	1245.45	1257.99	5.59	49.10	49.41	0.809	0.004	0.010	0.196	0.078	0.211
5.B.2.2 Grassland 1 converted to Cropland	Organic soil	CO2	1122.86	1134.17	5.59	37.76	38.17	0.563	0.004	0.009	0.136	0.070	0.153
5.B.2.2 Grassland 1 converted to Cropland	EF Biomass	CO2	44.15	-12.38	5.59	12.66	13.84	0.002	0.000	0.000	0.004	0.001	0.004
5.B.2.2 Grassland 1 converted to Cropland	N2O	CO_2-Eq.	1.23	1.24	5.59	93.86	94.03	0.002	0.000	0.000	0.000	0.000	0.000
5.B.2.2 Grassland 2 converted to Cropland	Mineral soil	CO2	237.62	134.48	14.63	51.10	53.15	0.093	0.000	0.001	0.003	0.022	0.022
5.B.2.2 Grassland 2 converted to Cropland	Organic soil	CO2	120.99	68.48	14.63	47.38	49.59	0.044	0.000	0.001	0.002	0.011	0.011
5.B.2.2 Grassland 2 converted to Cropland	EF Biomass	CO2	760.34	102.34	14.63	171.34	171.96	0.229	0.003	0.001	0.474	0.017	0.474
5.B.2.2 Grassland 2 converted to Cropland	N2O	CO_2-Eq.	0.24	0.14	14.63	94.93	96.05	0.000	0.000	0.000	0.000	0.000	0.000

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category		Gas	Base year emissions [CO_2- eq.]	Year 2010 emissions [CO_2- eq.]	Activity data uncertainty (half the 95% confidence interval)	Emission factor uncertainty (half the 95% confidence interval)	Combined uncertainty (half the 95% confidence interval)	Combined uncertainty as % of total national emissions in year 2010	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Gg CO_2-Eq. a^{-1}	Gg CO_2-Eq. a^{-1}	%	%	%	%	%	%	%	%	%
5.B.2.3 Wetlands 1 converted to Cropland	Mineral soil	CO2	6.74	3.66	69.05	36.76	78.23	0.004	0.000	0.000	0.000	0.003	0.003
5.B.2.3 Wetlands 1 converted to Cropland	Organic soil	CO2	79.12	42.99	69.05	50.00	85.25	0.048	0.000	0.000	0.002	0.033	0.033
5.B.2.3 Wetlands 1 converted to Cropland	EF Biomass	CO2	11.72	-0.00	69.05	113.43	132.80	0.000	0.000	0.000	0.006	0.000	0.006
5.B.2.3 Wetlands 1 converted to Cropland	N2O	CO_2-Eq.	0.01	0.00	69.00	88.04	111.86	0.000	0.000	0.000	0.000	0.000	0.000
5.B.2.3 Wetlands 2 converted to Cropland	Mineral soil	CO2	0.00	0.00	69.00	50.50	85.51	0.000	0.000	0.000	0.000	0.000	0.000
5.B.2.3 Wetlands 2 converted to Cropland	Organic soil	CO2	3.43	3.00	69.00	50.00	85.21	0.003	0.000	0.000	0.000	0.002	0.002
5.B.2.3 Wetlands 2 converted to Cropland	EF Biomass	CO2	-1.79	0.00	69.00	7.86	69.45	0.000	0.000	0.000	0.000	0.000	0.000
5.B.2.3 Wetlands 2 converted to Cropland	N2O	CO_2-Eq.	0.00	0.00	69.00	0.00	69.00	0.000	0.000	0.000	0.000	0.000	0.000
5.B.2.4 Settlements converted to Cropland	Mineral soil	CO2	-34.37	-23.66	11.39	49.15	50.46	0.016	0.000	0.000	0.001	0.003	0.003
5.B.2.4 Settlements converted to Cropland	Organic soil	CO2	548.00	377.26	11.39	37.76	39.44	0.194	0.000	0.003	0.014	0.047	0.050
5.B.2.4 Settlements converted to Cropland	EF Biomass	CO2	201.75	36.70	11.39	112.86	113.43	0.054	0.001	0.000	0.074	0.005	0.074
5.B.2.4 Settlements converted to Cropland	N2O	CO_2-Eq.	0.00	0.00	11.39	0.00	11.39	0.000	0.000	0.000	0.000	0.000	0.000
5.B.2.5 Other Land converted to Cropland	Mineral soil	CO2	-1.49	-0.75	73.58	51.78	89.97	0.001	0.000	0.000	0.000	0.001	0.001
5.B.2.5 Other Land converted to Cropland	Organic soil	CO2	6.49	3.25	73.58	50.00	88.96	0.004	0.000	0.000	0.000	0.003	0.003
5.B.2.5 Other Land converted to Cropland	EF Biomass	CO2	-2.24	0.00	73.58	7.86	74.00	0.000	0.000	0.000	0.000	0.000	0.000
5.B.2.5 Other Land converted to Cropland	N2O	CO_2-Eq.	0.00	0.00	73.58	0.00	73.58	0.000	0.000	0.000	0.000	0.000	0.000
Liming		CO2	1158.93	1638.09	3.54	0.00	3.54	0.075	0.007	0.013	0.000	0.064	0.064
5.C.1 Grassland remaining Grassland	Mineral soil	CO2	0.00	0.00	1.76	45.93	45.97	0.000	0.000	0.000	0.000	0.000	0.000
5.C.1 Grassland remaining Grassland	Organic soil	CO2	11169.08	10764.63	1.76	50.00	50.03	7.007	0.032	0.084	1.584	0.210	1.598
5.C.1 Grassland remaining Grassland	EF Biomass	CO2	0.00	0.00	1.76	24.69	24.75	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.1 Forest Land converted to Grassland	Mineral soil	CO2	-204.94	-134.09	13.58	51.78	53.53	0.093	0.000	0.001	0.004	0.020	0.021
5.C.2.1 Forest Land converted to Grassland	Organic soil	CO2	88.76	58.07	13.58	45.33	47.32	0.036	0.000	0.000	0.002	0.009	0.009
5.C.2.1 Forest Land converted to Grassland	EF Biomass	CO2	399.92	13.99	13.58	28.94	31.96	0.006	0.002	0.000	0.051	0.002	0.051
5.C.2.1 Forest Land converted to Grassland	EF DOM	CO2	297.65	11.84	13.58	55.65	57.28	0.009	0.001	0.000	0.072	0.002	0.072
5.C.2.2 Cropland converted to Grassland	Mineral soil	CO2	0.00	0.00	0.00	47.36	47.36	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.2 Cropland converted to Grassland	Organic soil	CO2	0.00	0.00	0.00	37.76	37.76	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.2 Cropland converted to Grassland	EF Biomass	CO2	0.00	0.00	0.00	12.66	12.66	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.25 Grassland 2 converted to Grassland	Mineral soil	CO2	-62.52	-50.85	13.23	92.86	93.80	0.062	0.000	0.000	0.010	0.007	0.012
5.C.2.25 Grassland 2 converted to Grassland	Organic soil	CO2	66.55	54.13	13.23	45.33	47.22	0.033	0.000	0.000	0.005	0.008	0.009
5.C.2.25 Grassland 2 converted to Grassland	EF Biomass	CO2	619.12	155.33	13.23	172.60	173.11	0.350	0.002	0.001	0.291	0.023	0.292
5.C.2.3 Wetlands 1 converted to Grassland	Mineral soil	CO2	-4.67	-2.96	42.04	62.80	75.58	0.003	0.000	0.000	0.000	0.001	0.001
5.C.2.3 Wetlands 1 converted to Grassland	Organic soil	CO2	109.53	69.46	42.04	50.00	65.33	0.059	0.000	0.001	0.001	0.032	0.032
5.C.2.3 Wetlands 1 converted to Grassland	EF Biomass	CO2	32.77	-0.00	42.04	115.22	122.65	0.000	0.000	0.000	0.018	0.000	0.018

A Source category		B Gas	C Base year emissions [CO_2- eq.] Gg CO_2-Eq. a^{-1}	D Year 2010 emissions [CO_2- eq.] Gg CO_2-Eq. a^{-1}	E Activity data uncertainty (half the 95% confidence interval) %	F Emission factor uncertainty (half the 95% confidence interval) %	G Combined uncertainty (half the 95% confidence interval) %	H Combined uncertainty as % of total national emissions in year 2010 %	I Type A sensitivity %	J Type B sensitivity %	K Uncertainty in trend in national emissions introduced by emission factor uncertainty %	L Uncertainty in trend in national emissions introduced by activity data uncertainty %	M Uncertainty introduced into the trend in total national emissions %
5.C.2.3 Wetlands 2 converted to Grassland	Mineral soil	CO2	0.00	0.00	32.04	43.90	54.35	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.3 Wetlands 2 converted to Grassland	Organic soil	CO2	12.97	20.54	32.04	50.00	59.38	0.016	0.000	0.000	0.005	0.007	0.009
5.C.2.3 Wetlands 2 converted to Grassland	EF Biomass	CO2	-7.35	-7.35	32.04	24.69	40.45	0.004	0.000	0.000	0.001	0.003	0.003
5.C.2.4 Settlements converted to Grassland	Mineral soil	CO2	-372.04	-437.32	9.76	59.67	60.46	0.344	0.002	0.003	0.100	0.047	0.110
5.C.2.4 Settlements converted to Grassland	Organic soil	CO2	138.92	163.30	9.76	37.76	39.00	0.083	0.001	0.001	0.024	0.018	0.029
5.C.2.4 Settlements converted to Grassland	EF Biomass	CO2	141.38	139.00	9.76	115.29	115.70	0.209	0.000	0.001	0.049	0.015	0.051
5.C.2.5 Other Land converted to Grassland	Mineral soil	CO2	-64.19	-53.87	31.55	83.27	89.05	0.062	0.000	0.000	0.010	0.019	0.021
5.C.2.5 Other Land converted to Grassland	Organic soil	CO2	12.72	10.67	31.55	50.00	59.12	0.008	0.000	0.000	0.001	0.004	0.004
5.C.2.5 Other Land converted to Grassland	EF Biomass	CO2	-20.51	-7.35	31.55	24.69	40.06	0.004	0.000	0.000	0.001	0.003	0.003
5.C.1 Grassland 2 remaining Grassland 2	Mineral soil	CO2	0.00	0.00	5.81	42.94	43.33	0.000	0.000	0.000	0.000	0.000	0.000
5.C.1 Grassland 2 remaining Grassland 2	Organic soil	CO2	33.08	35.91	5.81	50.00	50.34	0.024	0.000	0.000	0.006	0.002	0.007
5.C.1 Grassland 2 remaining Grassland 2	EF Biomass	CO2	0.00	0.00	5.81	197.28	197.37	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.1 Forest Land converted to Grassland 2	Mineral soil	CO2	-149.48	-83.23	15.27	49.10	51.41	0.056	0.000	0.001	0.002	0.014	0.014
5.C.2.1 Forest Land converted to Grassland 2	Organic soil	CO2	13.96	7.77	15.27	63.95	65.75	0.007	0.000	0.000	0.000	0.001	0.001
5.C.2.1 Forest Land converted to Grassland 2	EF Biomass	CO2	-174.58	-20.71	15.27	117.00	117.99	0.032	0.001	0.000	0.077	0.003	0.077
5.C.2.1 Forest Land converted to Grassland 2	EF DOM	CO2	302.63	31.77	15.27	55.65	57.71	0.024	0.001	0.000	0.065	0.005	0.065
5.C.2.2 Cropland converted to Grassland 2	Mineral soil	CO2	-114.24	-264.49	9.47	51.10	51.97	0.179	0.002	0.002	0.078	0.028	0.083
5.C.2.2 Cropland converted to Grassland 2	Organic soil	CO2	3.74	8.67	9.47	47.38	48.32	0.005	0.000	0.000	0.002	0.001	0.003
5.C.2.2 Cropland converted to Grassland 2	EF Biomass	CO2	-365.99	-979.53	9.47	171.34	171.60	2.187	0.006	0.008	1.017	0.102	1.022
5.C.2.25 Grassland converted to Grassland 2	Mineral soil	CO2	13.45	33.25	14.76	77.87	79.26	0.034	0.000	0.000	0.015	0.005	0.016
5.C.2.25 Grassland converted to Grassland 2	Organic soil	CO2	1.74	4.30	14.76	45.33	47.67	0.003	0.000	0.000	0.001	0.001	0.001
5.C.2.25 Grassland converted to Grassland 2	EF Biomass	CO2	-132.59	-287.57	14.76	172.60	173.23	0.648	0.002	0.002	0.280	0.047	0.284
5.C.2.3 Wetlands 1 converted to Grassland 2	Mineral soil	CO2	0.08	0.04	146.88	62.80	159.75	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.3 Wetlands 1 converted to Grassland 2	Organic soil	CO2	0.24	0.12	146.88	90.44	172.49	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.3 Wetlands 1 converted to Grassland 2	EF Biomass	CO2	-2.94	0.00	146.88	122.65	191.35	0.000	0.000	0.000	0.002	0.000	0.002
5.C.2.3 Wetlands 2 converted to Grassland 2	Mineral soil	CO2	0.00	0.00	80.46	43.24	91.34	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.3 Wetlands 2 converted to Grassland 2	Organic soil	CO2	0.15	0.13	80.46	90.44	121.05	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.3 Wetlands 2 converted to Grassland 2	EF Biomass	CO2	-6.86	-17.18	80.46	197.28	213.06	0.048	0.000	0.000	0.020	0.015	0.025
5.C.2.4 Settlements converted to Grassland 2	Mineral soil	CO2	-55.65	-73.67	20.94	59.67	63.24	0.061	0.000	0.001	0.019	0.017	0.025
5.C.2.4 Settlements converted to Grassland 2	Organic soil	CO2	2.13	2.82	20.94	45.33	49.93	0.002	0.000	0.000	0.001	0.001	0.001
5.C.2.4 Settlements converted to Grassland 2	EF Biomass	CO2	-133.20	-115.87	20.94	158.15	159.53	0.240	0.000	0.001	0.044	0.027	0.052

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category		Gas	Base year emissions [CO_2- eq.]	Year 2010 emissions [CO_2- eq.]	Activity data uncertainty (half the 95% confidence interval)	Emission factor uncertainty (half the 95% confidence interval)	Combined uncertainty (half the 95% confidence interval)	Combined uncertainty as % of total national emissions in year 2010	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Gg CO_2-Eq. a^{-1}	Gg CO_2-Eq. a^{-1}	%	%	%	%	%	%	%	%	%
5.C.2.5 Other Land converted to Grassland 2	Mineral soil	CO2	-7.90	-7.59	65.46	56.92	86.74	0.009	0.000	0.000	0.001	0.005	0.006
5.C.2.5 Other Land converted to Grassland 2	Organic soil	CO2	0.35	0.34	65.46	90.44	111.64	0.000	0.000	0.000	0.000	0.000	0.000
5.C.2.5 Other Land converted to Grassland 2	EF Biomass	CO2	-22.33	-0.00	65.46	197.28	207.86	0.000	0.000	0.000	0.021	0.000	0.021
5.D.1 Wetlands 1 remaining Wetlands 1	Mineral soil	CO2	0.00	0.00	20.89	43.85	48.57	0.000	0.000	0.000	0.000	0.000	0.000
5.D.1 Wetlands 1 remaining Wetlands 1	Organic soil	CO2	2055.19	2005.60	20.89	39.87	45.01	1.174	0.006	0.016	0.240	0.463	0.521
5.D.1 Wetlands 1 remaining Wetlands 1	EF Biomass	CO2	0.00	0.00	20.89	153.47	154.88	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.1 Forest Land converted to Wetlands 1	Mineral soil	CO2	-4.56	-3.09	72.48	0.00	72.48	0.003	0.000	0.000	0.000	0.002	0.002
5.D.2.1 Forest Land converted to Wetlands 1	Organic soil	CO2	0.00	0.00	72.48	90.44	115.90	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.1 Forest Land converted to Wetlands 1	EF Biomass	CO2	7.60	0.00	72.48	62.15	95.48	0.000	0.000	0.000	0.002	0.000	0.002
5.D.2.1 Forest Land converted to Wetlands 1	EF DOM	CO2	10.75	0.00	72.48	55.65	91.38	0.000	0.000	0.000	0.003	0.000	0.003
5.D.2.2 Cropland converted to Wetlands 1	Mineral soil	CO2	-3.54	-3.01	60.22	47.63	76.78	0.003	0.000	0.000	0.000	0.002	0.002
5.D.2.2 Cropland converted to Wetlands 1	Organic soil	CO2	0.00	0.00	60.22	50.00	78.28	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.2 Cropland converted to Wetlands 1	EF Biomass	CO2	-5.10	0.00	60.22	113.43	128.43	0.000	0.000	0.000	0.003	0.000	0.003
5.D.2.3 Grassland 1 converted to Wetlands 1	Mineral soil	CO2	0.95	2.79	33.95	0.00	33.95	0.001	0.000	0.000	0.000	0.001	0.001
5.D.2.3 Grassland 1 converted to Wetlands 1	Organic soil	CO2	0.00	0.00	33.95	50.00	60.44	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.3 Grassland 1 converted to Wetlands 1	EF Biomass	CO2	-6.84	-19.59	33.95	115.22	120.12	0.031	0.000	0.000	0.014	0.007	0.016
5.D.2.3 Grassland 2 converted to Wetlands 1	Mineral soil	CO2	-0.08	-0.06	109.99	0.00	109.99	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.3 Grassland 2 converted to Wetlands 1	Organic soil	CO2	0.00	0.00	109.99	90.44	142.40	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.3 Grassland 2 converted to Wetlands 1	EF Biomass	CO2	4.88	-0.00	109.99	122.65	164.74	0.000	0.000	0.000	0.003	0.000	0.003
5.D.2.35 Wetlands 2 converted to Wetlands 1	Mineral soil	CO2	0.00	0.00	146.69	0.00	146.69	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.35 Wetlands 2 converted to Wetlands 1	Organic soil	CO2	0.00	0.00	146.69	0.00	146.69	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.35 Wetlands 2 converted to Wetlands 1	EF Biomass	CO2	-2.20	-0.00	146.69	153.47	212.29	0.000	0.000	0.000	0.002	0.000	0.002
5.D.2.4 Settlements converted to Wetlands 1	Mineral soil	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.4 Settlements converted to Wetlands 1	Organic soil	CO2	0.00	0.00	0.00	50.00	50.00	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.4 Settlements converted to Wetlands 1	EF Biomass	CO2	0.00	0.00	0.00	115.09	115.09	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.5 Other Land converted to Wetlands 1	Mineral soil	CO2	-0.86	-0.43	110.49	0.00	110.49	0.001	0.000	0.000	0.000	0.001	0.001
5.D.2.5 Other Land converted to Wetlands 1	Organic soil	CO2	0.00	0.00	110.49	0.00	110.49	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.5 Other Land converted to Wetlands 1	EF Biomass	CO2	-2.93	-0.00	110.49	153.47	189.10	0.000	0.000	0.000	0.002	0.000	0.002
5.D.1 Wetlands 2 remaining Wetlands 2	Mineral soil	CO2	0.00	0.00	6.19	0.00	6.19	0.000	0.000	0.000	0.000	0.000	0.000
5.D.1 Wetlands 2 remaining Wetlands 2	Organic soil	CO2	0.00	0.00	6.19	0.00	6.19	0.000	0.000	0.000	0.000	0.000	0.000
5.D.1 Wetlands 2 remaining Wetlands 2	EF Biomass	CO2	0.00	0.00	6.19	0.00	6.19	0.000	0.000	0.000	0.000	0.000	0.000

A Source category		B Gas	C Base year emissions [CO_2- eq.] Gg CO_2-Eq. a^{-1}	D Year 2010 emissions [CO_2- eq.] Gg CO_2-Eq. a^{-1}	E Activity data uncertainty (half the 95% confidence interval) %	F Emission factor uncertainty (half the 95% confidence interval) %	G Combined uncertainty (half the 95% confidence interval) %	H Combined uncertainty as % of total national emissions in year 2010 %	I Type A sensitivity %	J Type B sensitivity %	K Uncertainty in trend in national emissions introduced by emission factor uncertainty %	L Uncertainty in trend in national emissions introduced by activity data uncertainty %	M Uncertainty introduced into the trend in total national emissions %
5.D.2.1 Forest Land converted to Wetlands 2	Mineral soil	CO2	0.00	0.00	44.31	1.52	44.34	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.1 Forest Land converted to Wetlands 2	Organic soil	CO2	0.00	0.00	44.31	90.44	100.71	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.1 Forest Land converted to Wetlands 2	EF Biomass	CO2	45.95	0.00	44.31	34.50	56.16	0.000	0.000	0.000	0.007	0.000	0.007
5.D.2.1 Forest Land converted to Wetlands 2	EF DOM	CO2	27.64	0.00	44.31	55.65	71.14	0.000	0.000	0.000	0.007	0.000	0.007
5.D.2.2 Cropland converted to Wetlands 2	Mineral soil	CO2	0.00	0.00	21.09	50.50	54.73	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.2 Cropland converted to Wetlands 2	Organic soil	CO2	0.00	0.00	21.09	50.00	54.27	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.2 Cropland converted to Wetlands 2	EF Biomass	CO2	28.43	29.81	21.09	7.86	22.51	0.009	0.000	0.000	0.001	0.007	0.007
5.D.2.3 Grassland 1 converted to Wetlands 2	Mineral soil	CO2	0.00	0.00	27.45	77.87	82.56	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.3 Grassland 1 converted to Wetlands 2	Organic soil	CO2	0.00	0.00	27.45	50.00	57.04	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.3 Grassland 1 converted to Wetlands 2	EF Biomass	CO2	13.44	35.51	27.45	24.69	36.92	0.017	0.000	0.000	0.005	0.011	0.012
5.D.2.3 Grassland 2 converted to Wetlands 2	Mineral soil	CO2	0.00	0.00	55.85	83.27	100.27	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.3 Grassland 2 converted to Wetlands 2	Organic soil	CO2	0.00	0.00	55.85	90.44	106.30	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.3 Grassland 2 converted to Wetlands 2	EF Biomass	CO2	30.80	42.88	55.85	197.28	205.03	0.114	0.000	0.000	0.038	0.026	0.046
5.D.2.35 Wetlands 1 converted to Wetlands 2	Mineral soil	CO2	0.00	0.00	76.95	52.48	93.14	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.35 Wetlands 1 converted to Wetlands 2	Organic soil	CO2	0.00	0.00	76.95	0.00	76.95	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.35 Wetlands 1 converted to Wetlands 2	EF Biomass	CO2	8.77	-0.00	76.95	153.47	171.68	0.000	0.000	0.000	0.006	0.000	0.006
5.D.2.4 Settlements converted to Wetlands 2	Mineral soil	CO2	0.00	0.00	29.98	84.97	90.10	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.4 Settlements converted to Wetlands 2	Organic soil	CO2	0.00	0.00	29.98	50.00	58.30	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.4 Settlements converted to Wetlands 2	EF Biomass	CO2	40.11	66.07	29.98	172.60	175.19	0.151	0.000	0.001	0.057	0.022	0.061
5.D.2.5 Other Land converted to Wetlands 2	Mineral soil	CO2	0.00	0.00	139.34	92.86	167.45	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.5 Other Land converted to Wetlands 2	Organic soil	CO2	0.00	0.00	139.34	0.00	139.34	0.000	0.000	0.000	0.000	0.000	0.000
5.D.2.5 Other Land converted to Wetlands 2	EF Biomass	CO2	0.00	0.00	139.34	0.00	139.34	0.000	0.000	0.000	0.000	0.000	0.000
5.E.1 Settlements remaining Settlements	Mineral soil	CO2	0.00	0.00	2.82	45.11	45.20	0.000	0.000	0.000	0.000	0.000	0.000
5.E.1 Settlements remaining Settlements	Organic soil	CO2	1964.47	2016.45	2.82	50.00	50.08	1.314	0.007	0.016	0.327	0.063	0.333
5.E.1 Settlements remaining Settlements	EF Biomass	CO2	0.00	0.00	2.82	172.60	172.62	0.000	0.000	0.000	0.000	0.000	0.000
5.E.2.1 Forest Land converted to Settlements	Mineral soil	CO2	29.66	20.03	18.75	36.76	41.26	0.011	0.000	0.000	0.001	0.004	0.004
5.E.2.1 Forest Land converted to Settlements	Organic soil	CO2	21.52	14.53	18.75	45.33	49.05	0.009	0.000	0.000	0.001	0.003	0.003
5.E.2.1 Forest Land converted to Settlements	EF Biomass	CO2	194.71	28.16	18.75	55.76	58.83	0.022	0.001	0.000	0.039	0.006	0.039
5.E.2.1 Forest Land converted to Settlements	EF DOM	CO2	189.80	32.07	18.75	55.65	58.72	0.025	0.001	0.000	0.036	0.007	0.036
5.E.2.2 Cropland converted to Settlements	Mineral soil	CO2	83.66	136.66	5.49	47.63	47.95	0.085	0.001	0.001	0.032	0.008	0.033
5.E.2.2 Cropland converted to Settlements	Organic soil	CO2	155.07	253.30	5.49	37.76	38.16	0.126	0.001	0.002	0.047	0.015	0.050
5.E.2.2 Cropland converted to Settlements	EF Biomass	CO2	-458.41	-635.84	5.49	113.43	113.56	0.939	0.003	0.005	0.319	0.039	0.322

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category		Gas	Base year emissions [CO_2- eq.]	Year 2010 emissions [CO_2- eq.]	Activity data uncertainty (half the 95% confidence interval)	Emission factor uncertainty (half the 95% confidence interval)	Combined uncertainty (half the 95% confidence interval)	Combined uncertainty as % of total national emissions in year 2010	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Gg CO_2-Eq. a^{-1}	Gg CO_2-Eq. a^{-1}	%	%	%	%	%	%	%	%	%
5.E.2.3 Grassland 1 converted to Settlements	Mineral soil	CO2	259.08	372.95	11.10	49.10	50.34	0.244	0.002	0.003	0.083	0.046	0.095
5.E.2.3 Grassland 1 converted to Settlements	Organic soil	CO2	55.57	80.00	11.10	37.76	39.36	0.041	0.000	0.001	0.014	0.010	0.017
5.E.2.3 Grassland 1 converted to Settlements	EF Biomass	CO2	-95.71	-91.17	11.10	115.29	115.82	0.137	0.000	0.001	0.030	0.011	0.032
5.E.2.3 Grassland 2 converted to Settlements	Mineral soil	CO2	37.89	50.99	28.08	52.48	59.52	0.039	0.000	0.000	0.012	0.016	0.020
5.E.2.3 Grassland 2 converted to Settlements	Organic soil	CO2	5.87	7.90	28.08	45.33	53.32	0.005	0.000	0.000	0.002	0.002	0.003
5.E.2.3 Grassland 2 converted to Settlements	EF Biomass	CO2	89.08	134.33	28.08	158.15	160.63	0.281	0.001	0.001	0.100	0.042	0.108
5.E.2.4 Wetlands 1 converted to Settlements	Mineral soil	CO2	9.23	5.47	49.19	49.85	70.03	0.005	0.000	0.000	0.000	0.003	0.003
5.E.2.4 Wetlands 1 converted to Settlements	Organic soil	CO2	213.97	126.97	49.19	50.00	70.14	0.116	0.000	0.001	0.001	0.069	0.069
5.E.2.4 Wetlands 1 converted to Settlements	EF Biomass	CO2	18.31	0.00	49.19	115.09	125.16	0.000	0.000	0.000	0.010	0.000	0.010
5.E.2.4 Wetlands 2 converted to Settlements	Mineral soil	CO2	0.00	0.00	83.66	28.56	88.40	0.000	0.000	0.000	0.000	0.000	0.000
5.E.2.4 Wetlands 2 converted to Settlements	Organic soil	CO2	3.20	2.05	83.66	50.00	97.46	0.003	0.000	0.000	0.000	0.002	0.002
5.E.2.4 Wetlands 2 converted to Settlements	EF Biomass	CO2	-10.45	0.00	83.66	172.60	191.81	0.000	0.000	0.000	0.008	0.000	0.008
5.E.2.5 Other Land converted to Settlements	Mineral soil	CO2	-3.00	-1.83	110.49	47.36	120.21	0.003	0.000	0.000	0.000	0.002	0.002
5.E.2.5 Other Land converted to Settlements	Organic soil	CO2	1.30	0.79	110.49	50.00	121.28	0.001	0.000	0.000	0.000	0.001	0.001
5.E.2.5 Other Land converted to Settlements	EF Biomass	CO2	-13.20	-2.45	110.49	172.60	204.94	0.007	0.000	0.000	0.007	0.003	0.008
5.F.1 Other Land remaining Other Land	Mineral soil	CO2	0.00	0.00	23.93	44.56	50.58	0.000	0.000	0.000	0.000	0.000	0.000
5.F.1 Other Land remaining Other Land	Organic soil	CO2	0.00	0.00	23.93	0.00	23.93	0.000	0.000	0.000	0.000	0.000	0.000
5.F.1 Other Land remaining Other Land	EF Biomass	CO2	0.00	0.00	23.93	0.00	23.93	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.1 Forest Land converted to Other Land	Mineral soil	CO2	0.00	0.00	0.00	49.15	49.15	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.1 Forest Land converted to Other Land	Organic soil	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.1 Forest Land converted to Other Land	EF Biomass	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.1 Forest Land converted to Other Land	EF DOM	CO2	0.00	0.00	0.00	55.65	55.65	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.2 Cropland converted to Other Land	Mineral soil	CO2	0.00	0.00	0.00	49.85	49.85	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.2 Cropland converted to Other Land	Organic soil	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.2 Cropland converted to Other Land	EF Biomass	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.3 Grassland 1 converted to Other Land	Mineral soil	CO2	0.00	0.00	0.00	59.71	59.71	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.3 Grassland 1 converted to Other Land	Organic soil	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.3 Grassland 1 converted to Other Land	EF Biomass	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.3 Grassland 2 converted to Other Land	Mineral soil	CO2	0.00	0.00	0.00	84.97	84.97	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.3 Grassland 2 converted to Other Land	Organic soil	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.3 Grassland 2 converted to Other Land	EF Biomass	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000

A		B	C	D	E	F	G	H	I	J	K	L	M
Source category		Gas	Base year emissions [CO_2- eq.]	Year 2010 emissions [CO_2- eq.]	Activity data uncertainty (half the 95% confidence interval)	Emission factor uncertainty (half the 95% confidence interval)	Combined uncertainty (half the 95% confidence interval)	Combined uncertainty as % of total national emissions in year 2010	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Gg CO_2-Eq. a^{-1}	Gg CO_2-Eq. a^{-1}	%	%	%	%	%	%	%	%	%
5.F.2.4 Wetlands 1 converted to Other Land	Mineral soil	CO2	0.00	0.00	0.00	62.80	62.80	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.4 Wetlands 1 converted to Other Land	Organic soil	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.4 Wetlands 1 converted to Other Land	EF Biomass	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.4 Wetlands 2 converted to Other Land	Mineral soil	CO2	0.00	0.00	0.00	41.31	41.31	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.4 Wetlands 2 converted to Other Land	Organic soil	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.4 Wetlands 2 converted to Other Land	EF Biomass	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.5 Settlements converted to Other Land	Mineral soil	CO2	0.00	0.00	0.00	57.48	57.48	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.5 Settlements converted to Other Land	Organic soil	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
5.F.2.5 Settlements converted to Other Land	EF Biomass	CO2	0.00	0.00	0.00	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000
Total			**128,076.15**	**76,861.93**				**21.730**					**10.974**
			Sum Σ 1990	**Sum Σ 2010**									

19.5.5 Results of the international review workshop on LULUCF methodologies

The following section presents important original quotations from the minutes, as approved by all participants, of the international review workshop on the new German LULUCF methodologies that was held on 24 and 25 May 2011 in Brunswick (Braunschweig).

Experts' workshop: The German LULUCF Reporting System – key statements of the workshop report, as approved by the participants, on LULUCF methodologies

> ***Venue:*** *Johann Heinrich von Thünen Institute, Braunschweig, 24-25 May, 2011*
> ***Workshop organizer:*** *Federal Environment Agency (Single National Entity)*
> ***Local organizer:*** *Johann Heinrich von Thünen Institute*
> ***Participants:*** *Scientists and leaders of national inventories for LULUCF in Austria, Czech Republic and Switzerland.*
> ***Aim of the workshop:*** *The aim of the workshop was to discuss and evaluate the adaptations and changes proposed by Germany, in response to the ICR process 2011, with international LULUCF and QA/QC experts; to share experience with neighbouring countries regarding LULUCF and KP-LULUCF reporting; to obtain additional advice relative to further improvement of the German approach; and to determine, on the basis of the expert review, the scientific soundness and adequacy of the methodologies and data sources used.*
>
> ***Main results:***
>
> *The proposed new methodologies of Germany for the land-use matrix and for determination of organic carbon stock changes in mineral soils were evaluated as follows:*
>
> - *The new methodologies are generally suitable for UNFCCC and KP reporting.*
> - *A 20-year transition time should be implemented for all types of land-use changes. This includes assumptions about land-use change rates in the pre-1990 period.*
> - *It is vitally important for descriptions of methodologies and data sources, and of decisions' impacts on results, to be transparent.*
> - *It is important to strive for consistency, relative to the degree and resolution of stratification, across all pools.*
> - *The international experts recommended that pragmatic decisions be taken with a view to keeping the reporting robust and transparent.*
>
> ***Consistent representation of land areas; Documentation of methodological choice***
>
> *Germany should provide clarification, rationale and documentation:*
>
> - *About the number and type of land-use categories and sub-categories used for CRFs*
> - *Which criteria were followed for aggregation of ATKIS object types to land-use categories and sub-categories*
> - *Intervals in time series used for the reporting: we report annual data, based on a range of available data sources with different intervals.*
> - *Clarify the hierarchy of quality, relative to data sets and land-use category/point*
>
> *Reasons for moving to point-sampling approach:*

- *One of the advantages of the point-sampling approach is that it permits combination of different various data sources. In addition, it supports transparency relative to the hierarchy of the quality of data sets and decisions*
- *The consistency achieved via use of a point-based system for all land categories was seen as progress.*
- *Consistency and transparency criteria provide important support for the choice taken with regard to grid size. At the same time, that choice needs to be assessed in terms of uncertainties and accuracy.*

Accuracy, robustness and uncertainty

- *It was not possible to assess robustness / accuracy completely. Therefore, no final conclusion about the grid size was reached.*
- *The accuracy level of land areas for UNFCCC should be as good as is reasonably possible.*
- *For KP, all ARD and FM categories need to be detectable.*

Calculation of C stocks and C-stock changes in land-use categories and sub-categories

- *Describe the way calculations are carried out, and describe how fractional carbon stocks are allocated to the reported sub-categories*

Transition time:

- *The experts clearly stated that a 20-year transition period is useful with regard to the inventory's simplicity, consistency and transparency.*
- *One can argue that the 20-year transition time applies mainly to soil, and not necessarily to all wood categories (e.g with regard to perennial crops).*
- *Use of a 20-year transition period would require tracing land uses back to 20 years before 1990.*
- *Trends prior to 1990 should be determined via expert assumptions, with substantiated arguments relative to any missing data.*

Reporting for mineral soils outside forest:

- *Many countries have successfully applied a "switch" approach with switching between average C stocks per land-use category, after LUC.*
- *A 20-year default transition time is necessary for soils.*

Conclusions:

- *The "switch" approach is robust and would be accepted by CZ, Austria, and Switzerland if they were reviewers.*
- *Be transparent and explain why you do what you do, and what the consequences of your actions are.*

19.6 Other detailed methodological descriptions for the source category "Waste and wastewater" (6)

19.6.1 Solid waste disposal on land (6.A)

19.6.1.1 Uncertainties for the source category "solid waste disposal on land"

The following uncertainties were estimated by the responsible Federal Environment Agency expert on 23 February 2004. The uncertainties must be considered provisional for the time being, since no national experience has yet been gained with the FOD method. In addition, an effort is being made to hold an experts' hearing that will adjust the estimated uncertainties as necessary, thereby placing them on a broader, more reliable basis.

	Definition of time series						Uncertainties data					
		Source description					Base year 1990 [4]		2002			
No.	CRF	For example, CSE module name or suitable aggregate within the listed CRF code [1]	If applicable, further source differentiation [2]	If applicable, CSE time series ID	Value type (EF / EM / AR)	If EF / EM: Gas	Uncertainty [+/-%] [3]	Distribution type[5]	Uncertainty [+/-%] [3]	Distribution type[5]	Remarks on considerations, literature sources, etc.	Estimated by
1	6A1	Waste landfilling			MSW_T (x)							
2	6A1	Waste landfilling			MSW_F(x)		+/-5%	N	+/-2%	N	for 1990: Low reliability in ABL, no data for NBL	
3	6A1	Waste landfilling			DOC(x)	CH_4	+/-20%	N	+/-20%	N	Reliable results from projects for study of raw waste in waste-incineration facilities are available	
4	6A1	Waste landfilling			DOC_F	CH_4	+/-30%	N	+/-30%	N		
5	6A1	Waste landfilling			MCF(x) (for MCF=1)	CH_4	+ 0% (-10%)	L	(+0%) (-10%)	L	Pursuant to IPCC-GPG	
6	6A1	Waste landfilling			F	CH_4	(+10%) (-0%)	L	(+10%) (-0%)	L		
7	6A1	Waste landfilling			k	CH_4	(+50%) (-35%)	L	(+50%) (-35%)	L		
8	6A1	Waste landfilling			R(t)	CH_4	+/-10%	N	+/-10%	N	Pursuant to IPCC-GPG, small by comparison to other uncertainties	
9	6A1	Waste landfilling			OX	CH_4	(+50%) (-35%)	L	(+50%) (-35%)	L	Corresponds to a half-life of 3.5 years (k=0.23) to 8 years (k=0.09)	

[1] If the CSE module name and CSE time-series ID are not available for estimation, or are too detailed, the sources may also be defined via CRF, and another unambiguous description, in the field "further source differentiation".
[2] Pursuant to CSE dimensions, if required for differentiation: e.g. fuel, operational mode, material, technology, measure
[3] With log-normal distribution: [+x%; -y%]
[4] For F gases, the base year is 1995.
[5] Distribution types: N (normal distribution); L (log-normal distribution); T (triangular); U (uniform)

19.6.2 Wastewater (6.B) – Data for determination of emission factors for wastewater and sewage-sludge treatment (6.B.2)

The remarks made in Chapter 14.6.2 of the NIR 2008 apply.

19.6.3 Determination of nitrous oxide emissions from wastewater treatment (6.B.2)

The remarks made in Chapter 14.6.3 of the NIR 2008 apply.

20 ANNEX 4: CO_2 REFERENCE APPROACH, A COMPARISON OF THAT APPROACH WITH THE SECTORAL APPROACH, AND RELEVANT INFORMATION ON THE NATIONAL ENERGY BALANCE

Information on the CO_2 Reference Approach, a comparison of that approach with the sectoral approach and relevant information on the national Energy Balance are provided in Chapter 3.2.1.1.

21 ANNEX 5: ASSESSMENT OF COMPLETENESS, AND ASSESSMENT OF POTENTIALLY EXCLUDED SOURCES AND SINKS OF GREENHOUSE GAS EMISSIONS

The following two tables show the sources for greenhouse gases that have not been included in Germany's greenhouse-gas inventories to date. The tables also include explanations of the reasons for such omission. Thie table is a summary of CRF Table 9(a), which contains a more detailed overview of non-included sources and sinks. Additional information is presented in Chapter 1.8.

Table 340: Overview, for completeness, of sources and sinks whose emissions are not estimated (NE)

Source Category	Substance	Explanation
5.A.1 Forest Land remaining Forest Land	CH_4	According to IPCC GPG (2003, p.1.11) countries are not required "to prepare estimates for categories contained in appendices,..." -
5 Forest Land converted to Other Land-Use Categories	CH_4	No reliable data is available for reporting on CH_4, NO_X, CO, NMVOC emissions.
5 Grassland converted to Other Land-Use Categories	CH_4	No reliable data is available for reporting on NMVOC, CH_4, NO_X and CO.
5.D.2 Land converted to Wetlands	CH_4, N_2O	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
5.E 5.E Settlements	CO_2, CH_4, N_2O	No data available
5.E.1 Settlements remaining Settlements	CH_4, N_2O	No data available
5.E.2 Land converted to Settlements	CH_4, N_2O	No data available
5.F 5.F Other Land	CO_2, CH_4, N_2O	No data available
5.F.2 Land converted to Other Land	CH_4, N_2O	No data available
5.G 5.A.1 C from lime to forest	CH_4, N_2O	CH_4 and N_2O emissions from drainage of soils and wetlands do not have to be reported according to GPG IPCC (2003), p. 1.11.
5.G Harvested Wood Products	CO_2, CH_4, N_2O	According to IPCC GPG 2003 HWP do not have to be reported (p.1.11 chp.1.7).

Table 341: Overview, for completeness, of sources and sinks that are reported elsewhere (included elswhere, IE)

Source Category	Substance	Explanation

Source Category	Substance	Explanation
1.A.2.A Iron and Steel	CO_2	Emissions are part of the carbon balance and were reported under blast furnace gas incineration (solid fuels).
1.A.2.B Non-Ferrous Metals	CH_4, CO_2, N_2O	reported under source catagory 1.A.2.f other because of confidential data
1.A.2.C Chemicals	CH_4, CO_2, N_2O	reported under source catagory 1.A.2.f other
1.A.2.D Pulp, Paper and Print	CH_4, CO_2, N_2O	reported under source catagory 1.A.2.f other
1.A.3.B Road Transportation	CH_4, N_2O	CH_4 emissions from lubricants supposed to be included in corresponding emissions from liquid fuels consumed!
1.A.3.C Railways	CH_4, N_2O	CH_4 emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
1.A.3.C Railways	CO_2	CO_2 emissions from biodiesel used in 1.A.3.c seem not to be included to CRF 1.C.3 "CO_2 Emissions from Biomass" automatically. Therefore, they are set to IE to prevent inclusion in National Totals and are included in CRF 1.A3.E Other Transportation - Other non-specified - Biomass. - actual value: 12,42 Gg.
1.A.3.D Navigation	CH_4, N_2O	CH_4 emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
1.A.3.D Navigation	CO_2	CO_2 emissions from biodiesel used in 1.A.3.d seem not to be included to CRF 1.C.3 "CO_2 Emissions from Biomass" automatically. Therefore, they are set to IE to prevent inclusion in National Totals and are included in CRF 1.A3.E Other Transportation - Other non-specified - Biomass. - actual value: 48,08 Gg.
1.B.1.A.2.2 Post-Mining Activities	CH_4	considered in 1.B.1.A.2.1
1.B.1.B Solid Fuel Transformation	CO_2	considered in 1.A.1.C
1.B.2.A.4 Refining / Storage	CO_2	CO_2 from flares are reported under 1.B.2.c, other CO_2 emissions do not occur
1.B.2.B.1 Exploration	CH_4, CO_2	considered in 1.B.2.a.i
1.B.2.C.1.1 Oil	CH_4, CO_2	included in 1.B.2.A.ii
1.B.2.C.1.2 Gas	CH_4, CO_2	included in 1.B.2.B.iv
1.B.2.C.1.3 Combined	CH_4, CO_2	included in 1.B.2.A.ii and in 1.B.2.B.iv
1.B.2.C.2.3 Combined	CH_4, CO_2, N_2O	considered in 1.B.2.C.2.1. and 1.B.2.C.2.2.
1.C1.B Marine	CH_4, N_2O	CH_4 emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
2.A.3 Limestone and Dolomite Use	CO_2	allocation: 1.A.1.a, 2.A.1 and 2.A.2, 2.A.7, 2.C.1
2.A.7.2a - Ceramic production	CO_2	see 2.A.7.2b bricks an tiles
2.C.1.2 Pig Iron	CH_4, CO_2	is considered in CRF 1A2
2.C.1.3 Sinter	CH_4, CO_2	is considered in CRF 1A2
2.C.1.4 Coke	CH_4, CO_2	is considered in CRF 1A1c
2.F.1 Refrigeration and Air Conditioning Equipment	HFCs, PFCs	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
2.F.2 Foam Blowing	HFCs	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
2.F.3 Fire Extinguishers	HFCs	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
2.F.4 Aerosols/ Metered Dose Inhalers	HFCs	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
2.F.7 Semiconductor Manufacture	HFCs, PFCs, SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
2.F.8 Electrical Equipment	SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
2.F.P2.1 In bulk	SF_6	Included in export
2.F.P2.2 In products	SF_6	Included in export
3.D.3 N2O from Aerosol Cans	N_2O	Emissions of N_2O used in Aerosol cans of cream are aggregated in technical use of N_2O in 3.D.4 Other Use of N_2O.
5.A.1 C from lime to forest	CO_2	Included in limestone.
5.A.1 Forest Land remaining Forest Land	Carbon	Included in Gains
5.A.1 Forest Land remaining Forest Land	CO2	Due to the stock change method used for the estimation of carbon stock changes in biomass, CO2-emissions

Source Category	Substance	Explanation
		are included in category 5.A. carbon stock change in biomass.
5.A.2 Land converted to Forest Land	CH_4, CO_2, N2O	Area burned under Land converted to Forest Land cannot be differentiated from Area burned reported under Forest Land remaining Forest Land, therfore it is included in the latter category.
5.B.2.1 Forest Land converted to Cropland	N_2O	NIR 7.2.4.6.4 Included in 4.D.1.5
5.B.2.2 Grassland converted to Cropland	N_2O	NIR 7.3.4.4 Included in 4.D.1.5
5.B.2.3 Wetlands converted to Cropland	N_2O	NIR 7.3.4.4 Included in 4.D.1.5
5.B.2.5 Other Land converted to Cropland	N_2O	NIR 7.3.4.4 Included in 4.D.1.5
5.C.1 Grassland remaining Grassland	CO_2	Reported under 5.B.1 (NIR 7.3.1)
5.C.1 Grassland remaining Grassland	CO_2	Included in limestone.
AWACS maintenance	SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
Car Tyres	SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
Ceramics	CH_4, CO_2, N_2O	reported under source catagory 1.A.2.f other because of confidential data
Double glaze windows	SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
Glass Wares	CH_4, CO_2, N_2O	reported under source catagory 1.A.2.f other because of confidential data
lime	CH_4, CO_2, N_2O	reported under source catagory 1.A.2.f other because of confidential data
Magnesium production	SF_6	The confidential emissions are reported in 2G.
Military use	CH_4, N_2O	CH_4 emissions from lubricants assumed to be included in corresponding emissions from liquid fuels consumed!
N_2O for Medical Using	N_2O	The emissions from the production of N2O for the use as Anasthetikum are included in the emissions from the use of Anasthetica in 3.D
Optical Glass Fibre	SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
Other non-specified	CH_4	is considered in steel
Other non-specified	CH_4, N_2O	!!!emissions from co-incineration of lubricants in domestic civil aviation!!!
Other non-specified	SF_6	Confidential SF_6-emissions of the use in AWACs, Sport shoes and for Welding are reported in "Unspecified mix of HFCs" to keep confidentiality of these data.
Shoes	SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
Solar Technology	PFC, SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
Trace gas	SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.
Welding	SF_6	The potential emissions are not disaggregated into the subcategorys. Such detailled informations are because of confidential and technical reasons not possible.

22 ANNEX 6: ADDITIONAL INFORMATION TO BE CONSIDERED AS PART OF THE NIR SUBMISSION (WHERE RELEVANT) OR OTHER USEFUL REFERENCE INFORMATION

22.1 Additional information relative to inventory preparation and to the National System

22.1.1 Definitions in the "National System" principles paper on emissions reporting

In the "National System" principles paper on emissions reporting, state secretaries of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU); Federal Ministry of the Interior (BMI); Federal Ministry of Defence (BMVg); Federal Ministry of Finance (BMF); Federal Ministry of Economics and Technology (BMWi); Federal Ministry of Transport, Building and Urban Affairs (BMVBS) and Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) defined responsibilities pertaining to the various relevant source and sink groups and to the necessary financing for 2008. The agreement reads as follows:

BMU, BMI, BMVg, BMF, BMWi, BMVBS, BMELV Berlin, 5 June 2007

"National System" principles paper on emissions reporting

The state secretaries of the ministries concerned have determined as follows, by common consent, with regard to the issue of the "National System" for emissions reporting pursuant to Art. 5(1) Kyoto Protocol:

1. *The Federal Environmental Agency, Section I 4.6[114] "Emissions Situation", is the responsible "Single national entity" (national co-ordinating agency) for reporting pursuant to the UN Framework Convention on Climate Change and the Kyoto Protocol. A country's Single National Entity is responsible for preparing the country's national inventory, working for continual improvement of the inventory, supporting those persons involved in the national system and preparing decisions of the Co-ordinating Committee.*

2. *A Co-ordinating Committee, representing all affected departments, has been established to deal with all questions arising in the framework of the National System, and to be responsible for official discussion and approval of the inventories and the reports required pursuant to Articles 5, 7 and 8 of the Kyoto Protocol. The Committee shall support all pertinent processes in this framework and, in particular, it shall clarify any pertinent uncertainties – for example, in connection with definition of individual emission factors.*

   In particular, the Committee shall define key source and sink categories, and the minimum requirements pertaining to quality control and quality assurance for data collection and processing and to the annual quality control and quality assurance plan.

   As necessary, the Committee may specify the methods to be used for calculating emissions in the various source categories and for calculating storage in sink categories. The Committee is chaired by the BMU. The Committee shall meet whenever at least one department sees a need for such a meeting. Subordinate authorities and other institutions involved in inventory preparation may be included in meetings as necessary.

[114] Author's remark: currently, I 2.6.

3. *For preparation of the national inventory, such data shall be used, for calculations of emissions and reductions, as are required pursuant to the provisions of Art. 3 (1) of decision 280/2004/EC and of Art. 2 (1) of the Ground rules for calculating emissions in source categories and storage in sink categories. Inventories shall be prepared on an annual basis. In addition, quality assurance in keeping with the requirements of Art. 12 of the rules shall be carried out. Furthermore, reliable documentation and archiving shall be required.*

   Existing data-transfer arrangements, such as those made on the basis of voluntary agreements or legal provisions, should not be fundamentally changed; they should only be completed and improved as necessary in order to provide a reliable database. For this reason, the aforementioned responsibilities do not necessarily include data collection and forwarding. With regard to division of responsibilities between BMU/UBA, BMVBS and BMWI, attention is called especially to Annex 1.

   The responsibilities for ensuring proper data delivery to the Single National Entity, and for quality control, documentation and data archiving, shall be distributed as follows among the various relevant departments:

   a) For source category 1 (Energy) – with the exception of source categories 1.A.3 (Transport) und 1.A.5a (Energy: other), where emissions sources of the German Federal Armed Forces (Bundeswehr) are concerned – the Federal Ministry of Economics and Technology (BMWi) has responsibility.

   b) For source categories 2 (Production processes) and 3 (Use of solvents and other products), the Federal Ministry of Economics and Technology (BMWi) has responsibility.

   c) For source category 1.A.3 (Transport), the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) has responsibility.

   d) For source category 1.A.5a (Energy: other), where emissions sources of the German Federal Armed Forces (Bundeswehr) are concerned – the Federal Ministry of Defence (BMVg) has responsibility. Where data are subject to secrecy provisions, the Federal Environment Agency shall take the relevant secrecy requirements into account.

   e) For source and sink categories 4 (Agriculture) and 5 (Land use, land-use changes and forestry), the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) has responsibility.

   f) For source category 6 (Waste) and source category 7, and well as for issues related to greenhouse-gas emissions from biomass combustion, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has responsibility.

   g) The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) is also responsible for preparing tables in the standardised reporting format pursuant to Art. 2 (2) letter a of Decision 2005/166/EC (implementation rules) in source and sink categories 4 and 5.

   In addition, the relevant authorities, as determined by the pertinent statistics regulations, are responsible for tasks relative to official statistics, including data delivery, quality assurance and data documentation and archiving. Co-operation between a) the statistical offices of the Federal Government and the Länder and b) the agencies concerned with reporting is co-ordinated via the Federal Statistical Office. In the process, secrecy requirements pertaining to statistics are to be observed.

4. The responsible departments shall clarify, in the short term, how proper data provision is to be permanently assured, to the extent such clarification has not already been completed. In particular, this requirement shall apply to agreements, ordinances or laws needed for institutionalisation of the National System. In general, for purposes of emissions reporting, voluntary agreements with associations and/or individual companies shall have the same status as pertinent legal provisions. In addition, as agreed in the co-ordination discussion on 12 September 2006, the Federal Environment Agency and the Federal Statistical Office shall determine what data can be provided, for reporting purposes, from the official statistical system, as well as what additional data should be collected via the official statistical system. The various relevant departments, the Federal Environment Agency and the Federal Statistical Office shall send their pertinent proposals to the BMU by 15 July 2007.

5. By 31 July 2007, the BMU shall invite participating departments to co-ordinate pertinent proposals and to establish a schedule for implementing the required instruments. The responsible departments, and the Federal Government, shall arrange for the establishment of the required instruments as quickly as possible.

6. Where additional funding is required for execution of the responsibilities mentioned under 3., such funding shall be provided from proceeds from sale of AAUs, via an expansion of the state secretaries' agreement of 22 December 2006 relative to Article 3.4 of the Kyoto Protocol.

To this end, a budget item for relevant income shall be established within Individual Plan 16 (Einzelplan 16) as of the 2008 fiscal year. Following review by the Federal Ministry of Finance (BMF), the additional requirements requiring financing shall be listed as expenditures within the departments' individual budgets. The departments' additional requirements in this regard must be submitted to the BMF by 6 June 2007.

Should additional budget funding be required in coming years, in addition to the additional requirements determined in connection with the 2008 budget, then suitable relevant amounts of additional AAUs shall be sold in subsequent years.

[…]

Annex: Division of responsibilities between BMU/UBA, BMVBS and BMWI

The BMU, BMVBS and BMWi have agreed that the existing emissions-reporting structures are to be retained and that the Federal Environment Agency (UBA) shall continue to perform its existing tasks with regard to the source categories 1, 1.A.3, 2 and 3. The BMVBS and the BMWi shall ensure that any gaps in the data for those source categories for which they are responsible are closed.

Specifically:

BMWi:

With regard to source category 1: The inventories in this area shall be prepared by the Federal Environment Agency, on a basis that shall include energy data provided by the agency contracted by the BMWi for preparation of energy balances, as well as on the basis of additional relevant statistics and association information.

With regard to source category 2: The inventories in this area shall be produced by the Federal Environment Agency on the basis of data that shall include data from statistics of the manufacturing sector (Produzierendes Gewerbe – ProdGewStatG) and from communications of relevant associations / individual companies.

With regard to source category 3: The inventories in this area shall be produced by the Federal Environment Agency on the basis of data that shall include data from statistics of the manufacturing sector (Produzierendes Gewerbe – ProdGewStatG), from foreign trade statistics and from communications of relevant associations / individual companies.

Existing requirements for further optimisation shall be clarified, in the short term, by BMWi, BMU and UBA, working in co-ordination. Where data optimisation is required via changes in existing surveys based on the Environmental Statistics Act (UStatG) or on the 13th Ordinance on the Execution of the Federal Immission Control Act (13. BimSchV), the BMU shall be responsible. The Federal Environment Agency shall assume responsibility for recording and archiving data received by the Federal Environment Agency.

BMVBS:

Emissions relative to source category 1.A.3 (Transport) shall be calculated by the Federal Environment Agency, using the TREMOD model. The BMVBS shall provide data/calculations as needed to close data gaps and determine emissions relative to international air transports or shall ensure that such data/calculations are provided by third parties. At present, emissions from ship transports may be calculated from Energy Balance data, using default emission factors. The Federal Environment Agency shall assume responsibility for recording and archiving data received by the Federal Environment Agency.

22.1.2 Additional information about the Quality System of Emissions Inventories

22.1.2.1 Minimum requirements pertaining to a system for quality control and assurance

As described above in the main section, the requirements pertaining to the system for quality control and quality assurance (QC/QA system) and to measures for quality control and quality assurance are defined primarily by Chapter 8 of the *IPCC Good Practice Guidance*.

From those provisions, the Federal Environment Agency has derived its own "General minimum requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting" ("Allgemeine Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasemissionsberichterstattung"; last revision: November 2007). These are described below.

22.1.2.1.1 Introduction

Representatives of the departments participating in the co-ordinating committee for the National System of Emissions Inventories define the general minimum requirements, which are described in the present document, for quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions. Such minimum requirements serve as the basis for collection, processing and forwarding of, and reporting on, all data that support the process of reporting on greenhouse-gas emissions.

These minimum QC/QA requirements must be adhered to on all levels of inventory preparation. In many cases, relevant efforts can draw on existing processes and systems, such as the quality standards for public statistics. Annex 1 of the present document describes, by way of example, implementation of the minimum QC/QA requirements and the

QC/QA system within the Federal Environment Agency. All participating institutions are required to submit suitable descriptions of their implementation of these minimum requirements; such descriptions are to be published with the inventory report in the framework of reporting in 2009. On request, the Federal Environment Agency supports participating ministries in preparing QC/QA systems in their relevant areas of responsibility.

22.1.2.1.2 System for quality control and quality assurance

The *rules (Commission Decision 2005/166/EC) implementing Decision 280/2004/EC* require national greenhouse-gas inventories to conform to the QC/QA requirements of the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC Good Practice Guidance) and the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (IPCC Good Practice Guidance for LULUCF).

The *IPCC Good Practice Guidance* specifies that QC/QA systems must be introduced, with the aim of enhancing transparency, consistency, comparability, completeness and precision of national emissions inventories and, especially, that such inventories must fulfill requirements pertaining to "good inventory practice". A QC/QA system comprises the following:

- An agency responsible for co-ordinating QC/QA activities
- Development and implementation of a QC/QA plan
- General QC procedures
- Source-category-specific QC procedures
- QA procedures and
- Reporting procedures
- Documentation and archiving procedures

QC/QA measures can conflict with requirements for punctuality and cost-effectiveness. Available time, and available staffing and financial resources, should thus be taken into account in any QC/QA-system development. In good practice, more stringent data-quality requirements are applied to key categories. For other source categories, not all source-category-specific QC procedures have to be implemented. In addition, not all measures have to be carried out on an annual basis; for example, data-collection methods have to be reviewed only once in detail. Thereafter, it suffices to carry out periodic controls to determine whether the prerequisites for application of relevant methods are still being fulfilled. Data uncertainty is another factor that enters into requirements pertaining to QC/QA measures. In order to reduce an inventory's overall uncertainty, those source categories that have high levels of uncertainty should be reviewed in detail.

22.1.2.1.3 Agency responsible for co-ordinating QC/QA activities

As the Single National Entity (national co-ordinating agency), the Federal Environment Agency is responsible for the QC/QA system for the national greenhouse-gas inventory. In this function, it has established the position of co-ordinator for the Quality System for Emissions Inventories (QSE). In good practice, each company and organisation involved in inventory preparation appoints a QC/QA co-ordinator and notifies the QSE co-ordinator of such appointment.

A QC/QA co-ordinator has responsibility for ensuring that a relevant QC/QA system is developed and implemented. Such implementation should be suitably institutionalised – for example, by means of an in-house directive or association agreement.

In order to ensure that the Single National Entity can efficiently carry out its supporting tasks, the persons responsible for the following additional functions should be announced (by name) to the QSE co-ordinator:

Responsible expert (Fachverantwortlicher) – Person responsible for data collection, data entry and pertinent calculation, in keeping with the prescribed methods, as well as for carrying out QC measures and preparing a relevant textual contribution for the National Inventory Report.

Quality control manager (Qualitätskontrollverantwortlicher) – Person responsible for checking and approving data and report sections (the QC/QA co-ordinator may also perform this function).

22.1.2.1.4 QC/QA plan

The purpose of the QC/QA plan is to ensure that QC/QA measures are properly organised and executed. It includes a description of all required QC/QA measures and a schedule for implementation of such measures. The QC/QA plan also defines the primary emphases of such measures. The criteria for selection of source categories for detailed review include the following:

- The source category's relevance (key category yes/no, uncertainties high/low)
- The time of the last detailed QC/QA measure for the source category, and the results of such measure
- Changes in methods or the pertinent database
- Results of annual inventory review in keeping with the UN Framework Convention on Climate Change and the Kyoto Protocol
- Available resources for execution of QC/QA measures

Good practice calls for establishing a QC/QA plan and then reviewing and updating it each year after the latest inventory has been prepared.

On the basis of the results of annual inventory review, and of the results of QC/QA measures of which it is aware, the Single National Entity prepares an improvement plan for the entire inventory. On this basis, in turn, it derives proposals for a binding inventory plan for the next report year. Such proposals are then submitted to the co-ordinating committee for approval. The QC/QA co-ordinator, working in co-operation with the QSE co-ordinator in the Single National Entity, defines the procedures, scheduling and scope for inclusion of his institution's QC/QA measures in the inventory plan for the overall inventory.

22.1.2.1.5 General quality control

Pursuant to the definition used by the IPCC (Chapter 8.1 *Good Practice Guidance*), quality control (QC) comprises a system of routine specialised measures for measuring and checking the quality of inventories in preparation.

Consequently, a QC system should achieve the following:

- Facilitate routine, standardised checks in the interest of data integrity, correctness and completeness;

- Identify and eliminate errors and omissions;
- List and archive inventory material and record all QC activities.

Table 8.1 of the *IPCC Good Practice Guidance* includes a complete list of general QC measures. Requirements pertaining to general, Tier-1 QC procedures can be derived from the requirements mentioned in Chapter 8.6 of the *IPCC Good Practice Guidance*. Typical general quality control measures in activity-rate determination include checking data for transfer errors, checking data for completeness, checking formulae for combining data and carrying out plausibility checks with the help of external data sources and earlier calculations. Suppliers of emissions calculations have to carry out additional QC measures – for example, checking formulae for emissions calculation.

Required quality controls should be recorded in checklists. Such lists should include at least the checking measures carried out, the results of checking, any pertinent corrections made and the name of the person(s) responsible for the measures. Annex 2 of the present document includes a sample checklist of the Federal Environment Agency.

Not all quality controls have to be carried out on an annual basis; some may be implemented at longer regular intervals. This applies especially to aspects of data collection that do not change from year to year. Requirements pertaining to the frequency and completeness of QC measures are more stringent for key categories than for other source categories. It should be ensured that all source categories undergo detailed quality control at least periodically.

22.1.2.1.6 Source-category-specific quality control

Available resources permitting, particularly relevant source categories (such as key categories), in addition to undergoing Tier 1 procedures, should undergo Tier 2 quality control with regard to determination of activity rates, emissions and uncertainties (cf. Chapter 8.7 *Good Practice Guidance*). The chapters of the IPCC Good Practice Guidance that pertain to the various individual source categories (Chapter 5) include additional information relative to source-category-specific QC measures. Such guidelines must be observed in preparation of any QC/QA plan: :

Where combined **activity data** from secondary sources are used, good practice calls for evaluating pertinent QC measures in connection with preparation of such secondary sources. If the level of such measures is adequate, it suffices to call attention to this fact in the documentation. Where secondary sources do not fulfill minimum requirements pertaining to quality control, suitable QC/QA checks should be carried out by the institution that uses the data. Results of subsequent QC/QA checks should enter into determination of uncertainties for activity rates. In addition, wherever possible, a range of different sources should be compared for purposes of determining data quality.

In use of facility-specific activity data, it is good practice to review the methods and QC/QA standards applied to data collection. Where such methods and standards do not meet minimum requirements, the advisability of using the data should be reconsidered and the uncertainties should be adjusted as necessary.

With regard to **emissions data**, it is good practice to review the emission factors that have been used. Such efforts include using national emission factors for key categories and reviewing the validity of IPCC standard factors under the applicable national circumstances.

Where emissions data are obtained via direct measurements, it is good practice to review the relevant measurement methods and the quality standards applied. Emissions data and emission factors should be reviewed in light of data from previous years, and from independent sources, and any resulting discrepancies should be explained.

Quality control for uncertainties includes checking to determine whether calculations are free of errors and whether documentation for reproduction of results is adequate. In use of experts' assessments, the pertinent experts' qualifications and estimation methods should be reviewed and documented.

22.1.2.1.7 Quality assurance procedures

While the primary aim of quality control is to ensure that methods are correctly applied, the primary purpose of quality assurance is to examine methods as such and improve them as necessary.

Pursuant to the relevant IPCC definition (Chapter 8.1 Good Practice Guidance), measures for **quality assurance** (QA) are based *"on a planned system of reviews by persons who are not directly involved in preparing the inventory. Such reviews – which are best carried out by independent third parties – should be applied to completed inventories, after QC procedures have been carried out. Such measures accomplish the following:*

- Verify that data-quality criteria are fulfilled,
- Ensure that the inventory takes account of the best available estimates of emissions and sinks, in keeping with the latest scientific findings and available data, and
- Promote the efficiency of the QC system".

The required instrument for quality assurance is the peer review. While use of audits is encouraged, audits are not required.

22.1.2.1.8 Reporting procedures

The Single National Entity is responsible for initiating and co-ordinating reporting and carrying out relevant overall organisation. Provision of data and reports by third parties must conform to applicable requirements pertaining to the scope, form and scheduling of/for such provision.

22.1.2.1.9 Documentation and archiving

As a general requirement, all data and information used for inventory calculation must be documented (i.e. recorded) and archived, for each report year. The purpose of such documentation (i.e. recording) is to make it possible to completely reconstruct all emissions calculations after the fact. The general requirements pertaining to documentation and archiving for the entire process of preparation of greenhouse-gas inventories are described in Chapter 8.10.1 of the *IPCC Good Practice Guidance*.

Consequently, data providers have the obligation to keep records of the following information relative to data they supply to the Federal Environment Agency, for purposes of inventory calculations:

Data providers:

- Publication / source of activity data, with detailed referencing of the relevant Table numbers and names, and of the relevant pages in the original sources;
- Survey contents (definitions of the surveyed characteristics, delimitations used, survey units used) and survey methods;
- The legal foundations and ordinances on which surveys are based;
- Chronological and spatial comparability with previous-year data, and any changes with regard to definitions, scopes of validity, cut-off points, sources of activity rates or data-collection methods;
- Any revision of previously published data;
- The accuracy or quantitative error of activity data, methods used to estimate errors and the names of experts who have carried out error estimation.
- Secrecy and data protection: suitable notification with regard to any individual data items that are considered secret.

Such materials should be provided to the Federal Environment Agency on an annual basis, together with pertinent data, and they are centrally archived by the Federal Environment Agency.

Quality control (QC)

The records kept in the framework of quality control should include the names of the persons responsible for managing and carrying out relevant actions, the types of quality control carried out, the dates on which quality control measures were carried out, the pertinent results, and the corrections and modifications triggered by quality control measures. In each case, record-keeping and archiving for quality control measures are carried out internally, by the institution supplying the pertinent data. A general description of regularly executed quality control measures is provided to the Federal Environment Agency for purposes of the national inventory report and inventory review.

Providers of emissions calculations

For providers of emissions calculations, the minimum requirements pertaining to record-keeping also include the following:

- Description of the pertinent calculation methods and reasons why the methods were selected;
- Assumptions and criteria pertaining to selection of activity data and emission factors;
- Documentation pertaining to emission factors and their sources, with detailed references to the relevant numbers and pages in original sources;
- Calculation models;
- Calculation files, calculation software.

Points 1-4 are recorded and archieved along with descriptions provided for the national inventory report. Separate documentation pertaining to calculation models must be provided, in keeping with general scientific practice, and along with internal documentation in the form of manuals or guides. Data suppliers archive calculation files and calculation software, and keep pertinent records, on an internal basis. Such materials should be provided to the Federal Environment Agency as necessary in the framework of inventory review.

Quality assurance

In addition to carrying out quality control measures, providers of emissions calculations are obligated to carry out quality assurance. The records kept in the framework of quality assurance should include the names of the persons responsible for managing and carrying out relevant actions, the types of quality assurance carried out, the dates on which quality assurance measures were carried out, the pertinent results, and the corrections and modifications triggered by quality assurance measures. In addition, records should be kept of source-category-specific quality controls.

In each case, record-keeping and archiving relative to pertinent quality assurance are carried out internally, by the relevant data-supplying institution. In addition, pertinent quality assurance measures are summarised in the national inventory report.

Confidential data / secrecy

In general, confidential data must be designated as such when they are provided, to ensure that the proper precautions are taken when they are used.

In inventory review, general obligations apply whereby confidential data must be disclosed in cases in which inventory reviewers consider such disclosure to be necessary to ensure that emissions calculations are transparent and clear. The extent to which such disclosure actually must involve disclosure of individual data items should be clarified on a case-by-case basis with the institution providing the data.

22.1.2.1.10 Annex 1: Minimum requirements pertaining to quality control and quality assurance in emissions reporting in the Federal Environment Agency

22.1.2.1.10.1 Introduction

The general minimum requirements, as approved by the co-ordinating committee for the National System of Emissions Inventories, pertaining to quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions apply to all participants. These requirements are the basis for collecting, processing, forwarding and reporting of/on all data that support reporting on greenhouse-gas emissions. They are thus binding for all working groups involved, in the Federal Environment Agency, in fulfillment of this reporting task.

22.1.2.1.10.2 System for quality control and quality assurance

In addition to the general minimum requirements, approved by the co-ordinating committee for the National System of Emissions Inventories, pertaining to quality control and quality assurance (QC/QA) in reporting on greenhouse-gas emissions, the specific provisions of in-house directive (Hausanordnung) No. 11/2005 also apply at the Federal Environment Agency. Pursuant to that directive, the pertinent procedure defined in the QSE manual is binding for all Federal Environment Agency personnel involved in emissions reporting (Rules of procedure of the Federal Environment Agency (Geschäftsordnung des Umweltbundesamtes), Volume II, Numeral XV).

The in-house directive fully implements the requirements of Chapter 8 of the *IPCC Good Practice Guidance*. Suitable UBA-specific instruments have been established to ensure effective identification and execution of measures for continual inventory improvement (improvement plan and inventory plan; cf. 22.1.2.1.10.3). That work has led to the development of the Quality System for Emissions Inventories (QSE), via which the points mentioned in Chapter 22.1.2.1.2 have been implemented.

22.1.2.1.10.2.1 Agency responsible for co-ordinating QC/QA activities in the Federal Environment Agency

Pursuant to in-house directive No. 11/2005, section FG I 2.6, "Emissions Situation", is the "Single National Entity" (SNE) within the Federal Environment Agency. In the Federal Environment Agency's organisational diagramme, the so-defined SNE is thus included in the Federal Environment Agency’s group of “focal points” and liaison offices for international organisations. In addition, this assignment of responsibility was confirmed by the relevant ministries via a state secretaries' resolution of 5 June 2007.

The roles and responsibilities of the Single National Entity, and of the specialised departments participating in emissions reporting, are described in Chapter 3.2, "Roles and responsibilities", of the QSE manual. The Single National Entity is responsible for updating and managing the QSE manual and its appendices and annexes. In carrying out this responsibility, the SNE is assisted by the contact persons named to it by the relevant specialised departments. The version of the QSE manual and its co-applicable documents published on the Single National Entity's intranet is the binding version of these materials.

22.1.2.1.10.2.2 Reporting procedures

In many cases, complex activities comprise numerous different, but related and cumulative, activities (processes) that lead to the production of a single product. To manage such processes effectively, one must strive to understand the manner in which the processes function (or should function), to describe such functioning in logical, realistic ways (activities, dependencies, responsibilities, and many more) and to interrelate the processes in a useful way.

In practice, workflows of complex processes cannot always be fit smoothly into the hierarchical, traditional structures of companies and institutions. The required processes are often diametrally opposed to such structures, since they have to cut across different organisational units. To organise interrelated work processes in a manner oriented to production of the desired product, one must look outside of rigid hierarchies and redefine the processes with a view to improvement.

For this reason, emissions reporting was first described as a process that, via a number of interrelated activities, leads to a product (NIR and inventories) (cf. Figure 81). Additional relevant information is provided in the QSE manual, Chapter 4.3.

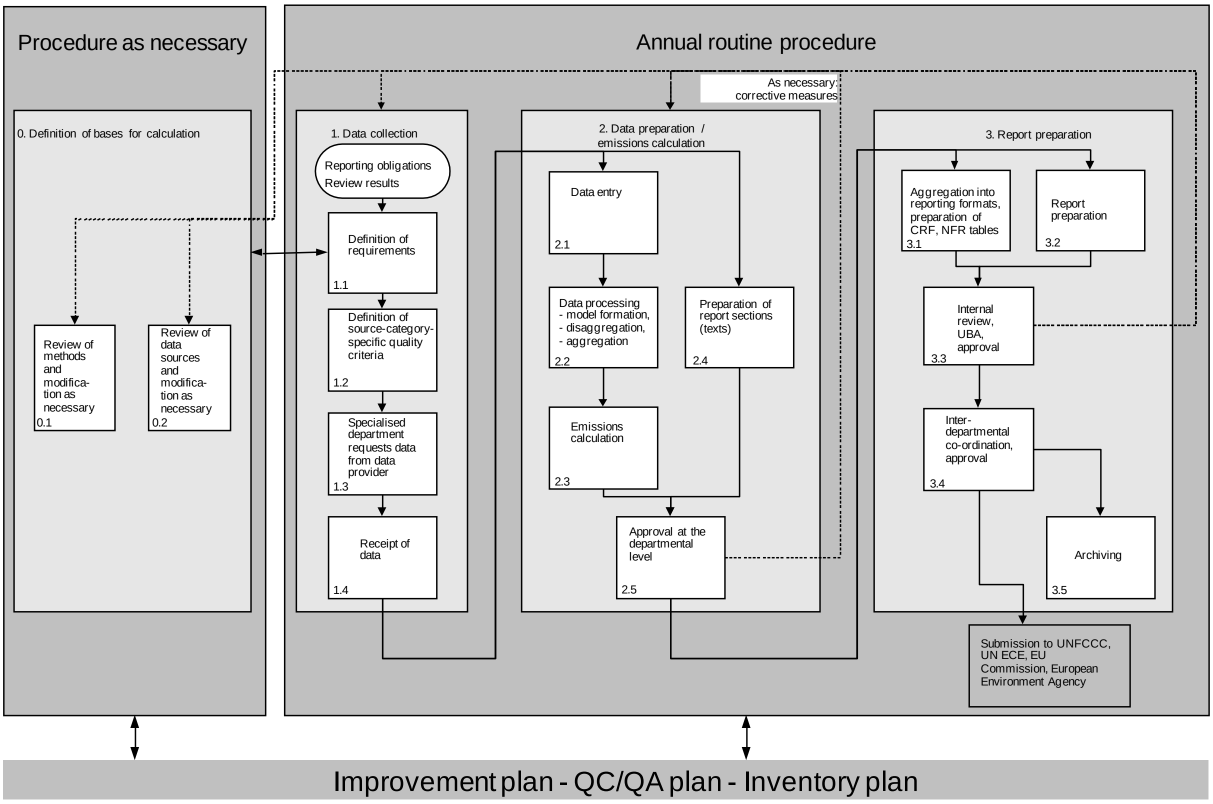


Figure 81: Overview of the overall emissions-reporting process

Via a role concept, suitable responsibilities have been assigned to cover the activities within the main processes and sub-processes shown. Each responsibility thus involves execution of pertinent processes. To understand this approach, it is useful to consider the situation in which many different people carry out the same basic activities even though they work in different work units and source categories. In the present case, this situation was approached by defining a certain group of persons (persons with a specific role – for example, responsible experts). That group was then seen to be subordinate to another group of persons (with a different role – for example, specialised contact persons) that ensures that the first group observes and fulfills the requirements pertaining to its work. In addition, a QSE co-ordinator was appointed, in keeping with relevant requirements of the IPCC (cf. Chapter 22.1.2.1.2), to ensure that the system is refined and improved as necessary.

Overall, a comprehensive role concept was developed that addresses the many different requirements applying to the Federal Environment Agency in its task as Single National Entity. The roles involved include the following:

1. Responsible expert at the operational level (FV)

- Main responsibilities: data collection, data entry, calculations with prescribed methods, execution of QC measures, preparation of the NIR text

2. Quality control manager (QKV)

- Is the superior for the FV
- Main responsibilities: checking and approving data and report sections

3. Specialised contact person (FAP)

- Member of the Single National Entity's staff

- Main responsibilities: providing source-category-specific support for involved experts (inventory work and report preparation) and quality control / quality assurance relative to pertinent source categories in the NIR and CSE.

4. Co-ordinator for the national inventory report (NIRK)

- Member of the Single National Entity's staff
- Main responsibilities: co-ordination of supporting textual work, preparation of the NIR from the various relevant contributions, overarching QC and QA for the NIR

5. CSE co-ordinator (ZSEK)

- Member of the Single National Entity's staff
- Main responsibilities: maintenance of databases, emissions calculation and aggregation, overarching QC and QA in connection with data entries and calculations for the inventory

6. QSE co-ordinator (QSEK)

- Member of the Single National Entity's staff
- Main responsibilities: maintenance and refinement of the QSE (system, checklists, improvement plan, inventory plan, QC/QA plan and QSE manual)

7. NaSE co-ordinator (NaSEK)

- Member of the Single National Entity's staff
- Main responsibilities: schedule-conformal, requirements-conformal reporting, providing for involvement of national institutions, establishing/recording legal agreements

As a rule, each of the above-described roles will have tasks in several different main and sub-processes of emissions reporting.

22.1.2.1.10.3 QC plan, QA plan and inventory plan

To ensure that all potential improvements identified during the course of inventory work are systematically implemented, identified improvements must be listed in a co-ordinated way. In the process, identified potential improvements should be listed together with all relevant information (origin of the potential improvement, source category, pertinent responsibility, priority, etc.) needed for efficient further processing. Planning and arrangements for implementing identified potential improvements (required actions / corrective measures, deadlines, etc.) should then be made on the basis of such information.

In the interest of proper control and record-keeping in the framework of the NaSE and the QSE (cf. Figure 82), procedures have been defined for processing identified potential improvements for their systematic management and further use. The overall aim is to answer the central question of WHO should do WHAT, HOW, WHEN and WHY:

WHO: This provides the reference to the role concept: A certain person xy is responsible – for example, in the role of responsible expert (FV)

WHAT: This provides the reference to the object that is to be improved – for example, the CO_2 calculation in source category xy needs to be improved

HOW: This provides the reference to the aim that is to be achieved – for example, a certain improvement, pursuant to an inventory plan or checklist.

WHEN: This provides the reference to the time by which the improvement must be completed, pursuant to the inventory plan

WHY: This provides the reference to the origin of the necessary action – for example, the improvement must be carried out as a result of a recommendation via the UNFCCC review process

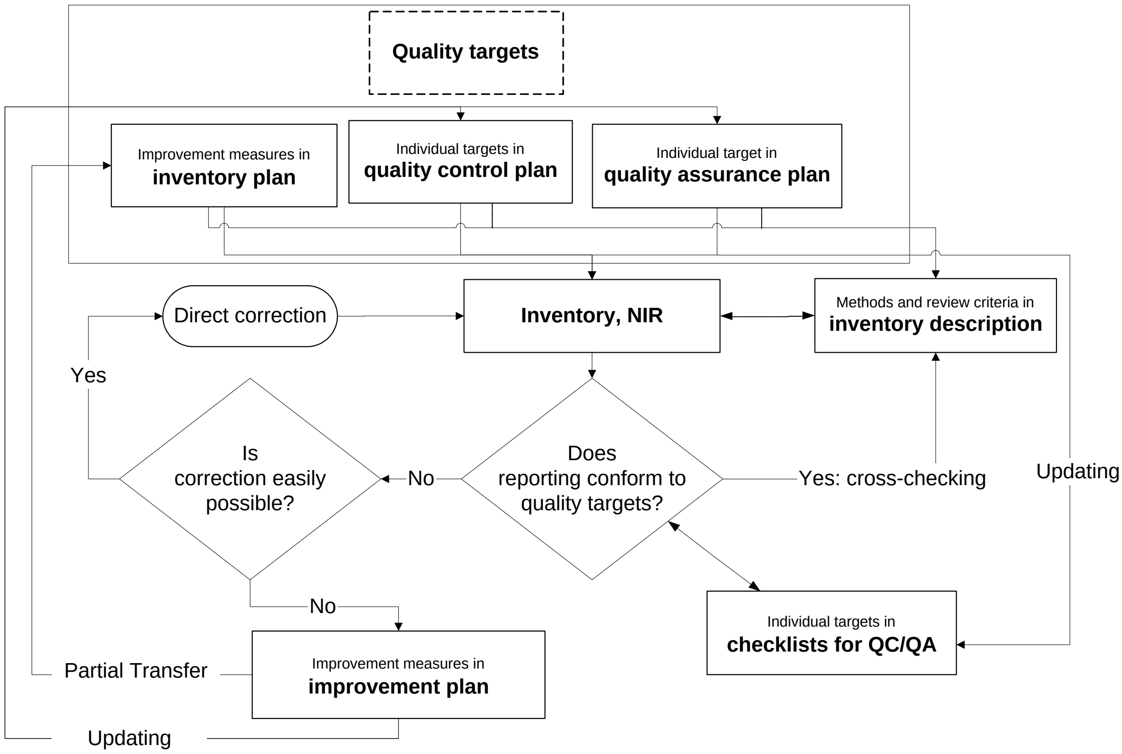


Figure 82: Control and documentation in the framework of the NaSE and the QSE

The **quality targets** have been derived from the general quality aims of the IPCC Good Practice Guidance (transparency, consistency, accuracy, comparability, completeness). In addition, operational individual objectives, relative to quality control and quality assurance, for the various source categories, have to be derived from comparison of the requirements from the *IPCC Good Practice Guidance*, the results of independent inventory review (UNFCCC and EU) and assessment of inventory realities.

In an **improvement plan**, all potential improvements and criticisms resulting from independent inventory review are collected and assigned potential corrective measures. The Single National Entity categorises the corrective measures, prioritises them and then, via consultations with the relevant responsible experts, integrates them as necessary within the **inventory plan**. There, they are linked with deadlines and responsibilities. As an annex to the NIR, the inventory plan undergoes a co-ordination and release process in the Federal Environment Agency and in the co-ordinating committee. It is thus a binding set of specifications for improvements to be carried out in future.

In the interest of transparent, effective control and execution of inventory-improvement measures, such measures, in keeping with the *IPCC Good Practice Guidance* (Chapter 8.5) are defined role-specifically, as well as source-category-specifically as necessary, in the

quality control plan / quality assurance plan (QC/QA plan). The QC plan is oriented solely to quality control aims for the inventory. In the QA plan, quality assurance objectives may be focused on the inventory, the reporting process or the QSE itself. Furthermore, the quality assurance plan includes scheduling of quality assurance measures to be performed by external third parties.

The **checklists for quality control and quality assurance** list all individual objectives in the emissions-reporting process, in keeping with the pertinent quality control and quality assurance plans. The checklists, which are designed to facilitate review of achievement of individual objectives, are made available to all persons responsible for quality control and quality assurance. The checklists are used to record execution of measures for quality control and quality assurance. Where individual objectives are not achieved and direct correction is not possible, a pertinent entry must be made in the improvement plan (see above).

22.1.2.1.10.4 Procedures for general and source-category-specific quality control

From the requirements set forth in the IPCC Good Practice Guidance, the Federal Environment Agency has developed a checklist concept via which quality requirements are formulated as specific targets. Every effort should be made to achieve such targets. When a target is achieved, such achievement is noted and described in the checklists. The possible entries for such records include "yes" (the target was achieved), "not relevant" (the target as formulated does not correspond to the special situation for the source category in question; this answer is seldom a viable option) and "no" (it was not possible to achieve the target).

Each checklist includes a general section that reflects all Tier 1 QC requirements from IPCC Good Practice Guidance and that is used in connection with every instance of reporting. In addition, each checklist contains a source-category-specific section (Tier 2) that provides concrete objectives for the relevant key category area.

Checklists are provided only for the first five roles within the role concept. Where different roles are responsible for different main and sub- processes of emissions reporting (cf. Chapter 22.1.2.1.10.2.2), pertinent checklists will also be oriented to several different main and sub- processes of emissions reporting. They thus represent a cross-section of emissions reporting. The checklists of the FV and the FAP include a basic common set of goals. The FAP are responsible for checking the work of the FV, and such checking is most effective when both roles are oriented to the same goals.

22.1.2.1.10.5 Quality assurance procedures

In the role concept, procedures are designed to ensure that quality assurance is always supported by a "four-eyes" principle. The specialised contact persons (FAP) have the task of ensuring that the emissions calculations and textual work of the responsible experts (FV) are of the proper quality.

In its section on "Expert Peer Review", the IPCC notes that the (above-described) formal procedure selected by the Federal Environment Agency can complement, but not replace, expert peer review (Good Practice Guidance; Chapter 8.8). In one solution found for addressing the justified call for inclusion of external experts, within the framework of available resources, detailed review of specific issues is carried out by external third parties via research projects and studies. In general, the two sides involved (i.e. FV and FAP) jointly manage the process of commissioning third parties. In another means found for addressing the need for third-party inclusion, workshops on the National System are held at irregular intervals. For such workshops, national experts are invited to come to the Federal Environment Agency for discussion with Federal Environment Agency experts (FV) on current inventory issues relative to selected source categories.

No audits have been carried out in the Federal Environment Agency to date, and none are planned at present. According to the Good Practice Guidance, audits are not absolutely required.

22.1.2.1.10.6 Documentation and archiving

Standardised record-keeping and archiving procedures are to be used in preparation of German greenhouse-gas inventories. At the same time, it is important to differentiate between the central record-keeping and archiving carried out by the Single National Entity and the non-central record-keeping and archiving carried out by the specialised departments of the Federal Environment Agency and of other institutions.

Record-keeping procedures for data and context information vary in accordance with specific requirements. In their information storage, they overlap to some degree, with such overlapping consisting partly of redundancies and partly of storage of similar items at differing levels of detail. On a regular basis, consistency must be ensured for both types of overlapping.

To ensure that all of the Federal Environment Agency's working units use basically consistent procedures, the specifications applying to the instruments used in such procedures – including both general specifications and specifications developed especially for emissions reporting – must be complied with. For purposes of "documentation" (i.e. record-keeping), the Federal Environment Agency has access to the instruments described in Table 342. The specifications pertaining to each type of document / record must be observed. Where no special specifications apply, the provisions from the "General minimum requirements for quality control and quality assurance in reporting on greenhouse-gas emissions" ("Allgemeine Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasemissionsberichterstattung") apply.

Table 342: Documentation / record-keeping instruments at the Federal Environment Agency

Instrument	Specifications
Publicly available	
National inventory (CRF tables, CRF-Reporter)	Annex 2, QSE manual: instructions for carrying out recalculations in the CRF tables
National inventory report	Annex 3, QSE manual: specifications for preparing report sections in the context of the National System
Publication	Rules of procedure of the Federal Environment Agency: Point 6.2 Publications
Published manuals, guides	For IT descriptions: procedural model of the Federal Environment Agency; otherwise: no special specifications
Centralised, and internally available, at the Single National Entity	
CSE database	Annex 5, QSE manual: specifications for data recording within the CSE
Inventory description	Annex 4, QSE manual: requirements pertaining to documentation (record-keeping) and archiving
De-centralised, and internally available	
Files of the central registry	Rules of procedure of the Federal Environment Agency: Point 4.2.10 Handling of files
Reference files	no special specifications
Internal manuals, guides	For IT descriptions: procedural model of the Federal Environment Agency; otherwise: no special specifications

An integrated documentation / record-keeping concept defines what key content should be stored in the aforementioned documentation instruments. It also defines how a suitable referencing system is to be used to ensure consistency and transparency throughout all such instruments (cf. Annex 4, QSE manual).

22.1.2.1.11 Annex 2: Example of a general checklist for the responsible-expert role

The example presented below (last revision: CHKL 2010) includes only the relevant requirements. Detailed information has been removed in the interest of clarity.

Table 343: General checklist for responsible experts

Process No.	Sub-process name	Individual goal	Optional goal
Main process: 0. Definition of bases for calculation			
0.1	Review of methods, and modification as necessary	The calculation method is in conformance with current key-source analysis.	
0.1	Review of methods, and modification as necessary	The calculation method has been selected in accordance with, or accords with, the pertinent decision tree of the IPCC Good Practice Guidance.	Departures from the decision tree of the IPCC Good Practice Guidance have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.
0.1	Review of methods, and modification as necessary	The calculation method has been selected in keeping with requirements from the inventory plan.	Departures from the inventory plan have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.
0.1	Review of methods, and modification as necessary	The selected calculation method can be applied to the entire time series as of 1990, or is already being consistently applied.	In cases of changes of methods in the time series, recalculation pursuant to the QSE manual (Annex 2), and proper pertinent documentation, are assured.

Process No.	Sub-process name	Individual goal	Optional goal
0.1	Review of methods, and modification as necessary	Departures from the objectives required via 0.1.01-0.1.04 have been properly explained, in keeping with logical and pertinent specialised criteria, and have been duly documented.	
0.2	Review of data sources, and modification as necessary	Have new data sources been used?	
0.2	Review of data sources, and modification as necessary	The data source(s) is / are / will be available throughout the long term (for example, on the basis of legal provisions, long-term agreements [> 3 years], etc.).	
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	Gaps in the data available for time series as of 1990 have been properly and logically explained, and have been duly documented.
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	A suitable procedure (interpolation/ extrapolation) has been chosen for dealing with data gaps, in conformance with IPCC Good Practice Guidance (Chap. 7.3.2.2), and the procedure has been logically documented. Note: Continued use of the same value is not extrapolation !
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	Following closure of data gaps, time-series recalculation has been carried out as necessary, pursuant to QSE manual (Annex 2), and such recalculation has been documented and substantiated in the NIR and CRF.
0.2	Review of data sources, and modification as necessary	The data source(s) completely cover the source category.	The incomplete coverage has been addressed in an extrapolation and has been taken into account in the uncertainties calculation. All steps have been documented and justified clearly and logically.
0.2	Review of data sources, and modification as necessary	Uncertainties information (amount and distribution) is available for the data source(s).	
0.2	Review of data sources, and modification as necessary	The EF and the AR agree in terms of the manner in which they are tailored to the source category.	In the case of discrepancies between the EF and AR, other data sources can establish agreement between the two values. Alternatively, the lack of agreement has been taken into account in an extrapolation, and in the uncertainties calculation, and the entire process has been properly and logically documented.
0.2	Review of data sources, and modification as necessary	The procedures for calculating outset data are clearly described.	
0.2	Review of data sources, and modification as necessary	The data source(s) have been selected in keeping with requirements from the inventory plan.	Any discrepancies have been clearly and logically justified and documented.
0.2	Review of data sources, and modification as necessary	The assumptions and criteria upon which the relevant data source(s) have been selected have been clearly and logically documented.	
0.2	Review of data sources, and modification as necessary	The data provider has carried out routine quality controls of the data source(s). For one-time projects, one-time quality controls have been carried out. Execution of the controls has been duly documented.	
0.2	Review of data sources, and modification as necessary	In use of one/more new data sources, a recalculation pursuant to the QSE manual (Annex 2) was carried out on the basis of	

Process No.	Sub-process name	Individual goal	Optional goal
		this/these other data source(s).	
0.2	Review of data sources, and modification as necessary	In use of IPCC default EF, the manner in which the EF were generated has been reviewed in light of national circumstances, and the EF may be used for Germany. The result of such review has been duly documented.	For IPCC default values that do not fit with national circumstances, the discrepances have been taken into account in the uncertainties and documented.
0.2	Review of data sources, and modification as necessary	In use of EF other than the IPCC default EF, use of such EF has been clearly and logically justified and substantiated. Note: Use of other EF is permissible only when such EF permit more precise calculation of country-specific emissions.	
0.2	Review of data sources, and modification as necessary	The AR used have been compared with other data sources (for example, EU-ETS, IEA, EPER, etc.), and the result has been duly documented.	
Main process: 1. Data collection			
1.1	Definition of requirements	The requirements pertaining to data reflect the information and indications from the inventory plan and the inventory reviews (for example, S&A Report, Centralized Review).	
1.3	The relevant specialised department requests the data from the pertinent data provider(s)	The requirements pertaining to QC and data formats have been forwarded to the data suppliers and/or contracting entities, and such forwarding has been duly documented. Note: Where data suppliers are involved via NaSE agreements, this objective has been achieved.	The data supplier (for example, an association) carries out its own routine quality controls, and the results have been duly documented.
1.4	Receipt of data	The data provider or contracting entity has carried out the required quality controls and made proper records of such action.	The data supplier (for example, an association) carries out its own routine quality controls, and the results have been duly documented.
1.4	Receipt of data	The received data are complete, without any gaps.	All data gaps in the time series as of 1990 have been closed, in accordance with the IPCC Good Practice Guidance, via extrapolation/interpolation (Chapter 7.3.2.2) and duly documented and justified. Note: Continued use of the same value is not extrapolation
1.4	Receipt of data	The data received are consistent with the previous year's data, and they have been properly described.	Any marked discrepancies with the previous year's data have been duly documented and justified.
1.4	Receipt of data	The order of magnitude of the received data is in line with that of comparable data from other sources (such as ETS data, IEA, EPER, etc.). The result of the review has been duly documented.	The reasons for any discrepancies have been clearly and logically explained and duly documented.
1.4	Receipt of data	The methods/assumptions on which the uncertainties determinations are based have been clearly and logically documented.	Where it was not possible to derive assumptions, expert assessment was carried out, and the relevant expert's quantification was clearly and logically documented.
1.4	Receipt of data	The uncertainties determinations are complete and plausible.	
Main process: 2. Data preparation / emissions calculation			
2.1	Data entry (preferably into	All of the EF have been entered into the	

Process No.	Sub-process name	Individual goal	Optional goal
	the CSE)	CSE.	
2.1	Data entry (preferably into the CSE)	The documentation for the EF data source(s) is complete and conforms to the requirements of the QSE manual (Annexes 3, 4 and 5).	
2.1	Data entry (preferably into the CSE)	Development of the EF within the time series has been plausibly explained and, in the case of unusual effects (such as changes in order of magnitude), has been clearly and logically explained and documented.	Implausible EF have been corrected.
2.1	Data entry (preferably into the CSE)	All of the AR have been entered into the CSE.	
2.1	Data entry (preferably into the CSE)	The documentation for the AR data source(s) is complete and conforms to the requirements of the QSE manual (Annexes 3, 4 and 5).	
2.1	Data entry (preferably into the CSE)	Development of the AR within the time series has been plausibly explained and, in the case of unusual effects (such as changes in order of magnitude), has been clearly and logically explained and documented.	Implausible discrepancies have been corrected.
2.1	Data entry (preferably into the CSE)	Following entry of all data into the CSE, all entered figures, units and conversion factors have been checked for correctness and confirmed.	
2.1	Data entry (preferably into the CSE)	All of the uncertainties have been entered into the CSE and have been documented in keeping with the requirements of the QSE manual (Annexes 3, 4 and 5).	
2.2	Data preparation (model formation, disaggregation, aggregation)	The inventory description includes an adequate description of pertinent models, with regard to organisation, structure, calculation procedures, assumptions, etc..	
2.3	Emissions calculation	The current inventory calculations have been checked against calculations from previous reports.	Where any significant changes or obvious deviations from an expected trend have occurred, the pertinent calculation, and the data used in calculation, have been reviewed, and any persisting discrepancies have been properly, clearly and logically explained and duly documented.
2.3	Emissions calculation	The results of emissions calculation for current / previous reports have been checked against other data sources for Germany, especially ETS data, and found to be comparable. The result has been duly documented.	Where comparability has not been found, or no comparison was carried out, the pertinent reasons have been properly, clearly and logically explained.
2.3	Emissions calculation	The national Implied EF (cf. S&A Report I) from the previous report is comparable with the Implied EF of other countries (same order of magnitude).	Extreme Implied EF have been properly, clearly and logically explained, and duly documented, in the NIR, or reference to an existing explanation has been made.
2.4	Preparation of report sections (texts)	The source category has been completely and logically described, for the NIR, in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	
2.5	Approval by the relevant experts	The values of AR, EF and ED, of their uncertainties, are up to date in the NIR and congruent with the pertinent values in the CSE.	
2.5	Approval by the relevant experts	Documentation of the origins for AR, EF and ED data, and for their uncertainties, are up to date in the NIR and congruent with the pertinent values in the CSE.	Lacking or incomplete documentation of data origin has been properly, clearly and logically explained and duly documented.

22.1.3 The database system for emissions – Central System of Emissions

Since 1998, the Federal Environment Agency has maintained and managed an IT tool for inventory preparation: the *Central System of Emissions (CSE)*, an integrated national database. The CSE implements the diverse requirements pertaining to emissions calculation and reporting, and it automates key steps in such work. It supports the processes of inventory planning and reporting (for example, by carrying out emissions calculations and recalculations, and relevant error analysis); inventory management (for example, by carrying out archiving and annual data evaluation); and quality management at the data level (cf. UBA 2003a, Projekthandbuch Decor (Decor project handbook)). The CSE makes it possible to fulfill the key requirements of transparency, consistency, completeness, comparability and accuracy at the data level.

Data documentation plays a central role in the CSE. The CSE stores such information as who is responsible for handling specific tasks; data sources and calculation procedures; uncertainties in time-series values; and records of changes, including the relevant times and persons responsible. With its history-management functionality, the system archives deleted values and can restore them as necessary. Such functionality thus makes it possible to trace and reconstruct data as necessary, and it provides a basis for independent, third-party reviews. The system also provides mechanisms that support quality assurance at the data level (e.g. components for detecting uncertainties and checking plausibility). Above all, transparency is accommodated by ensuring that data are recorded within the same structure in which they are provided, and that all processing and transformations into a reporting format take place first in the CSE itself, and thus remain open to examination. In addition, the CSE manages detailed technology-specific activity data and emission factors that can be processed, via calculation rules (calculation methods), into aggregated, source-category-specific values for the various reporting formats. Aggregation of individual CSE time series for the CRF report lines, for example, is described in Annex 3 and Chapter 3ff – in each case, with regard to individual source categories. In addition to aggregation and model formation for calculations, the CSE also supports scenario and forecast calculations.

Data exchange within the framework of the National System – i.e. within the Federal Environment Agency and with third parties – is also organised via the Central System of Emissions. Such processes involve both direct data entry and imports of aggregated values, from existing databases and via a standard interface (for example, transport data from the TREMOD database and agricultural data from the GAS-EM database). Ideally, inventory data should be entered into the CSE directly by the relevant responsible experts or should be imported, by the CSE administrator, via the import interface. This applies to in-house UBA employees as well as to external parties involved in the National System. To this end, a range of measures have been implemented:

- Provision of a *standardised import format for the CSE* in 2002 has facilitated the direct import of data from other emissions-relevant databases.

- In September 2002, participating technical experts from the Federal Environment Agency were given direct access to the CSE via the Federal Environment Agency intranet. The relevant parties are identified via an annual survey of specialisations; as a result, virtually all of the responsible experts at the Federal Environment Agency now have such access. However, write-access rights for these experts are normally confined to the database content for which they are technically responsible.
- Since November 2002, training courses on CSE procedures have been held on an annual basis for involved Federal Environment Agency staff.
- Since 2005, qualitative and quantitative information about data uncertainties has also been included in the CSE.
- Since 2006, reporting obligations under the Geneva Convention on Long-Range Transboundary Air Pollution and EU legislation (such as the NEC directive) have been fulfilled via the CSE.
- Since 2008, data providers and experts outside of the Federal Environment Agency, and project partners, can work interactively with the CSE via remote access.

Launch of the fully operational version of the CSE, in 2002, fulfilled the principal technical requirements for compliance with the Kyoto requirements for inventories; the next stage now is to make all emissions-calculation and data-collection procedures completely interoperable with the CSE. Numerous efforts in this regard have already been undertaken in the past, including integration of Reference Approach calculations and implementation of extensive data-secrecy requirements. Planned future efforts in this regard include improving the CSE's forecasting and scenario-calculation functionalities. All in all, the system – including both its technological functionalities and its database – is continually being adjusted and improved.

22.2 Supplementary information as required pursuant to Article 7 (1) of the Kyoto Protocol

22.2.1 KP-LULUCF

The CRF tables are reported separately.

22.2.2 Standard Electronic Format (SEF) Tables

22.2.2.1 Standard Electronic Format for the reported year 2011

UNFCCC SEF application
Version 1.2

Settings

Party:	Germany
ISO:	DE
Submission year:	2012
Reported year:	2011
Commitment period:	1
Completeness check:	YES
Consistency check:	YES
File locked:	YES
Lock timestamp:	05.01.2012 15:28
Submission version number:	2
Submission type:	Official

Party	Germany
Submission year	2012
Reported year	2011
Commitment period	1

Table 1. Total quantities of Kyoto Protocol units by account type at beginning of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	3560634088	405458	NO	1763593	NO	NO
Entity holding accounts	510041389	2930093	NO	34305426	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	2194	5663	NO	554726	NO	NO
Retirement account	854569558	670990	NO	49721049	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	4925247229	4012204	NO	86344794	NO	NO

Party	Germany
Submission year	2012
Reported year	2011
Commitment period	1

Table 2 (a). Annual internal transactions

	Additions						Subtractions					
	Unit type						Unit type					
Transaction type	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Article 6 issuance and conversion												
Party-verified projects		3697267					3697267		NO			
Independently verifed projects		NO					NO		NO			
Article 3.3 and 3.4 issuance or cancellation												
3.3 Afforestation and reforestation			NO				NO	NO	NO	NO		
3.3 Deforestation			NO				NO	NO	NO	NO		
3.4 Forest management			NO				NO	NO	NO	NO		
3.4 Cropland management			NO				NO	NO	NO	NO		
3.4 Grazing land management			NO				NO	NO	NO	NO		
3.4 Revegetation			NO				NO	NO	NO	NO		
Article 12 afforestation and reforestation												
Replacement of expired tCERs							NO	NO	NO	NO	NO	
Replacement of expired lCERs							NO	NO	NO	NO		
Replacement for reversal of storage							NO	NO	NO	NO		NO
Replacement for non-submission of certification report							NO	NO	NO	NO		NO
Other cancellation							634	7495	NO	202878	NO	NO
Sub-total		3697267	NO				3697901	7495	NO	202878	NO	NO

	Retirement					
	Unit type					
Transaction type	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**lCERs**
Retirement	418523027	4194506	NO	33374387	NO	NO

Party	Germany
Submission year	2012
Reported year	2011
Commitment period	1

Table 2 (b). Annual external transactions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Transfers and acquisitions												
CDM	NO	NO	NO	13146479	NO	NO	NO	NO	NO	NO	NO	NO
AT	4106502	133961	NO	364676	NO	NO	4835130	420769	NO	1134102	NO	NO
BE	7976537	5191500	NO	1281109	NO	NO	8847005	1120146	NO	841846	NO	NO
BG	52914	32940	NO	NO	NO	NO	NO	NO	NO	3000	NO	NO
CH	NO	1590470	NO	5870040	NO	NO	NO	53378	NO	296264	NO	NO
CZ	5316341	NO	NO	185050	NO	NO	3341546	131284	NO	846393	NO	NO
DK	415767	NO	NO	9752	NO	NO	1329000	NO	NO	NO	NO	NO
EE	704830	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
ES	3472405	NO	NO	9648	NO	NO	125387	139200	NO	3484775	NO	NO
FI	1333541	NO	NO	504410	NO	NO	1123846	NO	NO	884310	NO	NO
FR	16145088	659902	NO	5379828	NO	NO	26900716	251809	NO	964474	NO	NO
GB	119438269	22874613	NO	64969820	NO	NO	112919155	4959784	NO	34770278	NO	NO
GR	1553089	NO	NO	NO	NO	NO	NO	NO	NO	43096	NO	NO
HU	334981	50070	NO	NO	NO	NO	1390373	NO	NO	178156	NO	NO
IE	1223215	NO	NO	313000	NO	NO	93500	NO	NO	110550	NO	NO
IT	4914268	4000	NO	1048265	NO	NO	1464738	5866	NO	1391743	NO	NO
JP	NO	294990	NO	1767065	NO	NO	NO	NO	NO	NO	NO	NO
LI	450000	NO	NO	NO	NO	NO	175030	NO	NO	NO	NO	NO
LT	2550000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
LU	510000	NO	NO	27618	NO	NO	73904	NO	NO	172249	NO	NO
NL	24134402	2758286	NO	12153241	NO	NO	25531922	157245	NO	5729069	NO	NO
NO	1276168	NO	NO	345442	NO	NO	1757258	71365	NO	442963	NO	NO
PL	7545678	167291	NO	21701	NO	NO	259138	843186	NO	4147945	NO	NO
PT	616577	NO	NO	665177	NO	NO	695177	NO	NO	2548241	NO	NO
RO	1425573	80114	NO	NO	NO	NO	8000	NO	NO	369586	NO	NO
RU	NO	56904	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
SE	909050	91789	NO	517838	NO	NO	947604	NO	NO	1301873	NO	NO
SI	20881	116136	NO	474423	NO	NO	554423	100000	NO	122049	NO	NO
SK	1516988	50000	NO	80000	NO	NO	4280424	102000	NO	1639092	NO	NO
UA	NO	362219	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	207943064	34515185	NO	109134582	NO	NO	196653276	8356032	NO	61422054	NO	NO
cont.	**Additional information**											
Independently verified ERUs								NO				
	Table 2 (c). Total annual transactions											
Total (Sum of tables 2a and 2b)	207943064	38212452	NO	109134582	NO	NO	200351177	8363527	NO	61624932	NO	NO

Party Germany

Submission year 2012
Reported year 2011
Commitment period 1

Table 3. Expiry, cancellation and replacement

Transaction or event type	Expiry, cancellation and requirement to replace – Unit type: tCERs	lCERs	Replacement – Unit type: AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Temporary CERs (tCERS)								
Expired in retirement and replacement accounts	NO							
Replacement of expired tCERs			NO	NO	NO	NO	NO	
Expired in holding accounts	NO							
Cancellation of tCERs expired in holding accounts	NO							
Long-term CERs (lCERs)								
Expired in retirement and replacement accounts		NO						
Replacement of expired lCERs			NO	NO	NO	NO		
Expired in holding accounts		NO						
Cancellation of lCERs expired in holding accounts		NO						
Subject to replacement for reversal of storage		NO						
Replacement for reversal of storage			NO	NO	NO	NO		NO
Subject to replacement for non-submission of certification report		NO						
Replacement for non-submission of certification report			NO	NO	NO	NO		NO
Total			NO	NO	NO	NO	NO	NO

Party	Germany
Submission year	2012
Reported year	2011
Commitment period	1

Table 4. Total quantities of Kyoto Protocol units by account type at end of reported year

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	3112267083	4931830	NO	1941653	NO	NO
Entity holding accounts	547477254	24058140	NO	48262629	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO		
Non-compliance cancellation accounts	NO	NO	NO	NO		
Other cancellation accounts	2828	13158	NO	757604	NO	NO
Retirement account	1273092585	4865496	NO	83095436	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	4932839750	33868624	NO	134057322	NO	NO

Party	Germa ny
Submission year	2012
Reported year	2011
Commitment period	1

Table 5 (a). Summary information on additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
Starting values	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Issuance pursuant to Article 3.7 and 3.8	4868096694											
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over	NO	NO		NO								
Sub-total	4868096694	NO		NO			NO	NO	NO	NO		
Annual transactions												
Year 0 (2007)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 1 (2008)	111031173	NO	NO	48712902	NO	NO	103572319	NO	NO	8671720	NO	NO
Year 2 (2009)	372071597	863729	NO	52171623	NO	NO	352967489	541351	NO	26795677	NO	NO
Year 3 (2010)	297102669	8289950	NO	64167793	NO	NO	266517290	4605787	NO	43794853	NO	NO
Year 4 (2011)	207943064	38212452	NO	109134582	NO	NO	200351177	8363527	NO	61624932	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sub-total	988148503	47366131	NO	274186900	NO	NO	923408275	13510665	NO	140887182	NO	NO
Total	5856245197	47366131	NO	274186900	NO	NO	923408275	13510665	NO	140887182	NO	NO

Table 5 (b). Summary information on replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Previous CPs			NO	NO	NO	NO	NO	NO
Year 1 (2008)		NO	NO	NO	NO	NO	NO	NO
Year 2 (2009)		NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)		NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)		NO	NO	NO	NO	NO	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO	NO	NO
Total	NO	NO	NO	NO	NO	NO	NO	NO

Table 5 (c). Summary information on retirement

	Retirement					
	Unit type					
Year	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO
Year 3 (2010)	854569558	670990	NO	49721049	NO	NO
Year 4 (2011)	418523027	4194506	NO	33374387	NO	NO
Year 5 (2012)	NO	NO	NO	NO	NO	NO
Year 6 (2013)	NO	NO	NO	NO	NO	NO
Year 7 (2014)	NO	NO	NO	NO	NO	NO
Year 8 (2015)	NO	NO	NO	NO	NO	NO
Total	1273092585	4865496	NO	83095436	NO	NO

Party Germany

Submission year 2012
Reported year 2011
Commitment period 1

Table 6 (a). Memo item: Corrective transactions relating to additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6 (b). Memo item: Corrective transactions relating to replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	lCERs	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

Table 6 (c). Memo item: Corrective transactions relating to retirement

	Retirement					
	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs

22.2.3 More detailed information about the national system, and about changes in the national system

All information has been provided in the preceding chapters.

22.2.4 More detailed information on the national registry and the accounting of Kyoto Units

22.2.4.1 Registry Initialization Recommendation

Customer	UNFCCC	
Service Name	International Transaction Log	
Project Document Reference	ITL/OM/24	
Customer Service Issue	3.0	
Base Document reference		
Issue date	30/03/2011	
Registry	Germany	
Status	Issue	
Distribution	Service Operations Manual	
Prepared by	Peter Broadbent	
Approved by (Logica)	Steve Ruby	Logica SDD

Amendment history

Date	Issue	Status	Author
21/11/2007	1.0	Issue	Alwyn Rowlands
28/08/2008	2.0	Issue	Simon Gaskin
30/03/2011	3.0	Issue	Peter Broadbent

Distribution

Date	Issue	Recipient	Organisation
21/11/2007	1.0	Andrew Howard	UNFCCC
21/11/2007	1.0	Anthony Mak	UNFCCC
21/11/2007	1.0	Thomas Schuetz	Umeltbundesamt, Deutsche Emissionshandelsstelle
28/08/2008	2.0	Heidi McKenna	UNFCCC
30/03/2011	3.0	Jean-Francois Halleux	UNFCCC

22.2.4.1.1 Introduction

Following successful interoperability testing of the registry configuration following the changes made, this document recommends that the national registry of DE – Germany is ready to be connected to the ITL. The outcome of the testing is detailed below.

22.2.4.1.2 Documentation

The following documents represent the data pack for the Registry.

22.2.4.1.2.1 Readiness

The following documents support the completion of the Readiness review process:

Document Reference	Description	Submission Date
RegistryInitialiazationReportGermany	Readiness Questionnaire	11/04/2007
Germany_ReadinessCarifications	Clarifications Response	05/11/2007

22.2.4.1.2.2 Connectivity

The following documents support the completion of the Connectivity testing process:

Document Reference	Description	Completion Date
UNFCCC ITL VPN Connectivty Testing v0.3 - DE	Test results from establishment of VPN from ITL Initialization environment to the nominated Registry environment.	16/05/2007
UNFCCC ITL SSL Connectivty Testing v0.3 - DE	Test results from establishment of SSL from ITL Initialization environment to the nominated Registry environment.	16/05/2007

22.2.4.1.2.3 Interoperability

The following documents support the completion of the Interoperability testing process:

Document Reference	Description	Completion Date
DE – Germany – Interoperability Check List v1.3 (2)	Interoperability planning document	23/08/2007
Testing Record Germany	Interoperability test results completed	21/11/2007
UNFCCC – Interoperability Testing Record_DE_01MAR11.doc	Re test following configuration changes – move to JBoss Application Server from WebLogic. Annex H test results completed	01/03/2011

22.2.4.1.3 Initialization Results

22.2.4.1.3.1 Readiness

The following scoring sheet was compiled by the ITL Operator during the Readiness review process:

Registry	Germany	Date	28/08/2008	Readiness Scoring	CITL Test Report									
Section	Description	Quality				Evidence				Confidence				
		Max	*#1*	*#2*	*#3*	*Max*	*#1*	*#2*	*#3*	*Max*	*#1*	*#2*	*#3*	*Avg*
	Reviewer's Initials		NP	MS	MDS		NP	MS	MDS		NP	MS	MDS	
2.1	Database & Application Backup	7	7	6	6	3	3	3	3	10	10	9	9	9.3
2.2	Disaster Recovery Plan	7	7	7	7	3	2	3	2	10	9	10	9	9.3
2.3	Security Plan	7	7	7	7	3	3	3	3	10	10	10	10	10.0
2.4	Application Logging Documentation	3	3	3	3	7	6	7	6	10	9	10	9	9.3
2.5	Time Validation Plan	7	6	7	7	3	3	3	3	10	9	10	10	9.7
2.6	Version Change Management	7	6	6	7	3	2	3	3	10	8	9	10	9.0
2.7	Test Plan	7	6	6	6	3	3	3	3	10	9	9	9	9.0
2.8	Test Report	3	3	3	2	7	6	7	7	10	9	10	9	9.3
2.9	Operational Plan	7	7	7	6	3	2	3	2	10	9	10	8	9.0
2.9	*Ops Plan* - Incident management	3	3	3	3	2	2	2	2	5	5	5	5	5.0
2.9	*Ops Plan* - Change management	3	3	3	3	2	2	2	2	5	5	5	5	5.0
3.0	CITL Test Report (AR)	3		2		7		6		10		8		8.0
	Total Score	**64**	**60**	**58**	**57**	**46**	**40**	**39**	**36**	**110**	**100**	**97**	**93**	**102**

The following documents were provided by the Registry in support of the Readiness review process:

Appendix_6-3_RfC_Form.pdf
Appendix_6-1_Process_VersionCh…
Appendix_6-2_Process_DataMigr…
Appendix_7-1_Testplan.xls
Appendix_8-1_Tech_Spec_Regist…
Appendix_8-2_DEHSt_ITSEC.pdf
Appendix_8-3_Obligation.pdf
Appendix_0-1_Emissions_Trading…
Appendix_0-2_IT_infrastructure_…

Annex_1_e.jpg
Annex_3_b.pdf
Annex_3_c.jpg
Annex_3_d.pdf
Annex_3_e.pdf
Annex_4_a.pdf
Annex_4_b.pdf
Annex_4_c.tif
Annex_4_d.tif
Annex_4_e.tif
Annex_4_f.pdf
Annex_1_f.jpg
Annex_4_g.pdf
Annex_5_a.jpg
Annex_6_a.pdf
Annex_6_b.pdf
Annex_7_a.jpg
Annex_7_b.pdf
Annex_7_c.pdf
Annex_8_a.xls
Annex_9_a.pdf
Annex_9_b.pdf
Annex_1_g.jpg
Annex_9_c.pdf
Annex_9_d.jpg
Annex_9_e.jpg
Annex_9_f.jpg
Annex_9_g.jpg
Annex_1_a.pdf
Annex_1_b.pdf
Annex_1_c.pdf
Annex_1_d.jpg
Annex_1_h.jpg
Annex_1_i.pdf
Annex_2_a.pdf
Annex_2_b.pdf
Annex_2_c.tif
Annex_3_a.jpg

20080623.rar
20080624.rar
20080625_No1.1.rar
20080625_No1.rar
20080625_No1.txt
20080625_No2.rar
20080625_No3.1.rar
20080625_No3.rar
20080625_No4.1.rar
20080625_No4.rar
App_4_1st_rehearsal_logs.rar
coordinated_testing_23062008_logs_No1.txt
coordinated_testing_23062008_logs_No2.txt
ReadinessReport.pdf

22.2.4.1.3.2 Connectivity

The following results were generated by the ITL Operator during the Connectivity testing process:

Activity	Result	Date
Establish VPN connection from ITL Initialization environment to nominated Registry test environment	Pass	16/05/2007
Establish SSL connection from ITL Initialization environment to nominated Registry test environment	Pass	16/05/2007

22.2.4.1.3.3 Interoperability

The results of the latest round of interoperability testing on 17th February and 1st March 2011 with the national registry of Germany are recorded below. These results build on the previous interoperability testing undertaken on 6 and 7/9/2007 and 21/11/2007.

Section of DES Annex H	Description	Result
3.1	Issuance	Completed
3.2	Conversion	Completed
3.3	External Transfer	Completed
3.4	Cancellation	Completed
3.5	Retirement	Completed
3.6	Replacement	Completed
3.7	Carry Over	Completed
3.8	Expiry Date Change	Completed

Section of DES Annex H	Description	Result
4.1	Issuance transaction	Completed
4.2	Conversion transaction	Completed
4.3	External Transfer transaction	Completed
4.4	Cancellation transaction	Completed
4.5	Expiry Date Change transaction	Completed
4.6	Retirement transaction	Completed
4.7	Replacement	Completed
4.8	Carry Over	Completed

The previous and the following sections are omitted/completed if an ETS member

Section of DES Annex H	Description	Result
5.1	Account Management Web Services	Completed
5.2	EU ETS Member Registry Specific Tests	Completed

The following documents were generated by the ITL Operator as part of the Interoperability testing process:

	DE_Logs_Section3	30/03/2011 03:50 PM
	DE_Logs_Section4	30/03/2011 03:49 PM
	DE - Interoperability Checklist ! NEW	30/03/2011 03:47 PM
	Section_3_Message_Logs ! NEW	30/03/2011 03:47 PM
	Section_3_Notifications ! NEW	30/03/2011 03:47 PM
	Section_3_Reconciliations ! NEW	30/03/2011 03:47 PM
	Section_3_Transactions ! NEW	30/03/2011 03:47 PM
	Section_3_Unit_Blocks ! NEW	30/03/2011 03:47 PM
	Section_4_Message_Logs ! NEW	30/03/2011 03:47 PM
	Section_4_Notifications ! NEW	30/03/2011 03:47 PM
	Section_4_Reconciliations ! NEW	30/03/2011 03:47 PM
	Section_4_Transactions ! NEW	30/03/2011 03:47 PM
	Section_4_Unit_Blocks ! NEW	30/03/2011 03:47 PM

22.3 Additional information about trends for greenhouse gases

This section presents the detailed tables relative to the trend discussion in Chapters 0.2 and 2.

Table 344: Emissions trends in Germany, by greenhouse gas and source category

GHG emissions / sinks, in CO_2 equivalents (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Net CO_2 emissions / storage	1,014,194	976,776	929,763	920,848	905,049	903,576	924,456	895,716	888,162	861,018	864,835	874,937	905,746	908,023	898,527
CO_2 emissions (not including LULUCF)	1,042,161	1,004,807	957,623	948,770	932,615	931,040	951,996	923,194	915,285	888,024	891,624	907,652	890,960	893,161	883,168
CH_4	107,109	102,492	99,066	98,730	94,702	91,223	88,512	83,959	78,706	76,807	73,444	70,297	66,994	64,145	58,578
N_2O	85,289	81,899	82,247	79,673	79,771	79,981	81,618	78,677	65,508	61,993	62,117	63,133	61,795	60,825	64,062
HFCs	4,369	4,013	4,189	6,159	6,330	6,470	5,855	6,392	6,962	7,204	6,483	7,891	8,794	8,623	9,233
PFCs	2,708	2,333	2,102	1,961	1,650	1,773	1,724	1,378	1,488	1,236	781	717	789	851	822
SF_6	4,785	5,118	5,634	6,405	6,993	7,221	6,932	6,905	6,705	5,070	4,826	4,346	3,570	3,490	3,658
Total emissions / storage, including LULUCF	**1,218,453**	**1,172,631**	**1,123,002**	**1,113,775**	**1,094,494**	**1,090,244**	**1,109,097**	**1,073,027**	**1,047,530**	**1,013,328**	**1,012,486**	**1,021,322**	**1,047,688**	**1,045,956**	**1,034,880**
Total emissions, not including CO_2 from LULUCF	**1,246,419**	**1,200,663**	**1,150,862**	**1,141,697**	**1,122,061**	**1,117,709**	**1,136,636**	**1,100,506**	**1,074,653**	**1,040,334**	**1,039,275**	**1,054,037**	**1,032,902**	**1,031,094**	**1,019,521**

GHG emissions / sinks, in CO_2 equivalents (Gg)	2005	2006	2007	2008	2009	2010
Net CO_2 emissions / storage	881,490	886,283	864,814	862,545	801,417	835,879
CO_2 emissions (not including LULUCF)	865,959	871,041	849,040	846,526	784,457	818,850
CH_4	55,587	52,572	50,485	50,646	48,553	47,699
N_2O	61,574	60,800	62,532	63,781	63,679	54,993
HFCs	10,001	10,539	11,145	11,474	11,955	11,434
PFCs	709	571	530	531	363	309
SF_6	3,726	3,651	3,537	3,288	3,229	3,413
Total emissions / storage, including LULUCF	**1,013,086**	**1,014,416**	**993,042**	**992,264**	**929,195**	**953,726**
Total emissions, not including CO_2 from LULUCF	**997,555**	**999,174**	**977,268**	**976,245**	**912,236**	**936,697**

GHG emissions / sinks, by source and sink categories, in CO_2 equivalents (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1. Energy	**1,020,759**	**985,491**	**936,448**	**928,512**	**907,001**	**903,824**	**925,733**	**894,102**	**884,686**	**859,897**	**857,935**	**878,144**	**862,603**	**858,661**	**843,457**
2. Industrial processes	**94,580**	**90,635**	**92,620**	**92,777**	**99,004**	**97,094**	**95,818**	**95,549**	**81,486**	**74,385**	**77,213**	**74,469**	**72,923**	**78,331**	**83,438**
3. Solvent and other product use	**4,477**	**4,337**	**4,157**	**4,074**	**3,547**	**3,553**	**3,471**	**3,446**	**3,420**	**3,165**	**2,909**	**2,687**	**2,484**	**2,267**	**2,195**
4. Agriculture	**83,224**	**76,314**	**73,892**	**73,423**	**70,953**	**73,154**	**73,515**	**72,739**	**72,906**	**73,828**	**73,872**	**73,168**	**70,841**	**69,456**	**70,689**
5. Land use, land-use changes & forestry	**-27,698**	**-27,767**	**-27,567**	**-27,653**	**-27,300**	**-27,201**	**-27,270**	**-27,215**	**-26,860**	**-26,743**	**-26,525**	**-32,453**	**15,049**	**15,135**	**15,626**
CO_2	*-27,967*	*-28,032*	*-27,860*	*-27,922*	*-27,566*	*-27,465*	*-27,539*	*-27,479*	*-27,123*	*-27,006*	*-26,789*	*-32,715*	*14,786*	*14,862*	*15,359*
N_2O & CH_4	*269*	*264*	*293*	*269*	*267*	*263*	*269*	*264*	*263*	*263*	*265*	*262*	*263*	*273*	*267*
6. Waste	**43,111**	**43,622**	**43,453**	**42,642**	**41,288**	**39,820**	**37,830**	**34,407**	**31,892**	**28,797**	**27,081**	**25,307**	**23,787**	**22,106**	**19,475**

GHG emissions / sinks, by source and sink categories, in CO_2 equivalents (Gg)	2005	2006	2007	2008	2009	2010
1. Energy	**827,035**	**830,553**	**808,417**	**807,421**	**753,379**	**782,313**
2. Industrial processes	**80,735**	**81,998**	**84,683**	**82,077**	**75,114**	**72,631**
3. Solvent and other product use	**2,052**	**2,074**	**1,949**	**1,812**	**1,786**	**1,770**
4. Agriculture	**69,864**	**68,517**	**67,623**	**70,478**	**68,671**	**67,490**
5. Land use, land-use changes & forestry	**15,798**	**15,510**	**16,039**	**16,286**	**17,221**	**17,283**
CO_2	*15,531*	*15,242*	*15,774*	*16,019*	*16,959*	*17,028*
N_2O & CH_4	*267*	*268*	*265*	*266*	*262*	*255*
6. Waste	**17,602**	**15,764**	**14,331**	**14,190**	**13,024**	**12,239**

Table 345: Contributions to emissions trends in Germany, by greenhouse gas and source category

GHG emissions / sinks; shares for various GHG, not including CO_2 from LULUCF (%)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
CO_2 emissions (not including LULUCF)	83.6	83.7	83.2	83.1	83.1	83.3	83.8	83.9	85.2	85.4	85.8	86.1	86.3	86.6	86.6	86.8	87.2	86.9	86.7	86.0	87.4
CH_4	8.6	8.5	8.6	8.6	8.4	8.2	7.8	7.6	7.3	7.4	7.1	6.7	6.5	6.2	5.7	5.6	5.3	5.2	5.2	5.3	5.1
N_2O	6.8	6.8	7.1	7.0	7.1	7.2	7.2	7.1	6.1	6.0	6.0	6.0	6.0	5.9	6.3	6.2	6.1	6.4	6.5	7.0	5.9
HFCs	0.4	0.3	0.4	0.5	0.6	0.6	0.5	0.6	0.6	0.7	0.6	0.7	0.9	0.8	0.9	1.0	1.1	1.1	1.2	1.3	1.2
PFCs	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
SF_6	0.4	0.4	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.4	0.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

GHG emissions / sinks; shares for emission & sink categories, not including CO_2 from LULUCF (%)	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
1. Energy	81.9	82.1	81.4	81.3	80.8	80.9	81.4	81.2	82.3	82.7	82.6	83.3	83.5	83.3	82.7	82.9	83.1	82.7	82.7	82.6	83.5
2. Industrial processes	7.6	7.5	8.0	8.1	8.8	8.7	8.4	8.7	7.6	7.2	7.4	7.1	7.1	7.6	8.2	8.1	8.2	8.7	8.4	8.2	7.8
3. Solvent and other product use	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4. Agriculture	6.7	6.4	6.4	6.4	6.3	6.5	6.5	6.6	6.8	7.1	7.1	6.9	6.9	6.7	6.9	7.0	6.9	6.9	7.2	7.5	7.2
5. Land use, land-use changes & forestry (N_2O)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6. Waste	3.5	3.6	3.8	3.7	3.7	3.6	3.3	3.1	3.0	2.8	2.6	2.4	2.3	2.1	1.9	1.8	1.6	1.5	1.5	1.4	1.3
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 346: Emissions of direct and indirect greenhouse gases and SO_2 in Germany since 1990

Emissions change (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Net CO_2 emissions / storage	1,014,192	976,774	929,762	920,846	905,048	903,574	924,455	895,714	888,160	861,016	864,834	874,937	905,746	908,022	898,527
CO_2 emissions (not including LULUCF)	1,042,161	1,004,807	957,623	948,770	932,615	931,040	951,996	923,194	915,285	888,024	891,624	907,652	890,960	893,161	883,168
CH_4	5,100	4,881	4,717	4,701	4,510	4,344	4,215	3,998	3,748	3,657	3,497	3,347	3,190	3,055	2,789
N_2O	275	264	265	257	257	258	263	254	211	200	200	204	199	196	207
HFCs (CO_2 equivalent)	4,592	4,212	4,372	6,333	6,784	6,912	6,327	6,894	7,494	7,778	7,040	8,304	9,129	8,932	9,490
PFCs (CO_2 equivalent)	2,627	2,277	2,062	1,930	1,637	1,773	1,724	1,378	1,488	1,236	781	717	789	851	822
SF_6 (CO_2 equivalent)	4,642	4,975	5,491	6,262	6,551	6,779	6,460	6,404	6,173	4,497	4,269	3,933	3,236	3,181	3,400
CO	12,368	10,109	8,723	7,928	7,011	6,556	6,080	5,921	5,457	5,085	4,804	4,598	4,308	4,110	3,872
NMVOC	3,127	2,676	2,459	2,313	1,891	1,805	1,736	1,712	1,674	1,533	1,390	1,289	1,228	1,162	1,174
NO_X	2,884	2,638	2,495	2,388	2,229	2,176	2,106	2,037	2,009	1,983	1,925	1,848	1,768	1,712	1,648
SO_2	5,292	3,915	3,193	2,847	2,383	1,718	1,455	1,218	981	803	653	643	590	573	547

Emissions change (Gg)	2005	2006	2007	2008	2009	2010
Net CO_2 emissions / storage	881,490	886,282	864,814	862,545	801,257	835,991
CO_2 emissions (not including LULUCF)	865,959	871,041	849,040	846,526	784,297	818,962
CH_4	2,647	2,503	2,404	2,412	2,312	2,271
N_2O	199	196	202	206	205	177
HFCs (CO_2 equivalent)	10,252	10,794	11,369	11,657	12,128	11,597
PFCs (CO_2 equivalent)	709	571	510	521	359	309
SF_6 (CO_2 equivalent)	3,475	3,396	3,332	3,114	3,059	3,250
CO	3,651	3,571	3,473	3,387	3,002	3,322
NMVOC	1,143	1,131	1,069	1,015	929	1,051
NO_X	1,576	1,562	1,489	1,415	1,318	1,319
SO_2	517	520	497	490	435	449

Table 347: Changes in emissions of direct and indirect greenhouse gases and SO_2 in Germany since 1990

Change in emissions with respect to the base year, i.e. 1990 (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Net CO_2 emissions / storage	0.0	-3.7	-8.3	-9.2	-10.8	-10.9	-8.8	-11.7	-12.4	-15.1	-14.7	-13.7	-10.7	-10.5	-11.4	-13.1	-12.6	-14.7	-15.0	-21.0	-17.6
CO_2 emissions (not including LULUCF)	0.0	-3.6	-8.1	-9.0	-10.5	-10.7	-8.7	-11.4	-12.2	-14.8	-14.4	-12.9	-14.5	-14.3	-15.3	-16.9	-16.4	-18.5	-18.8	-24.7	-21.4
CH_4	0.0	-4.3	-7.5	-7.8	-11.6	-14.8	-17.4	-21.6	-26.5	-28.3	-31.4	-34.4	-37.5	-40.1	-45.3	-48.1	-50.9	-52.9	-52.7	-54.7	-55.5
N_2O	0.0	-4.0	-3.6	-6.6	-6.5	-6.2	-4.3	-7.8	-23.2	-27.3	-27.2	-26.0	-27.5	-28.7	-24.9	-27.8	-28.7	-26.7	-25.2	-25.3	-35.5
HFCs (CO_2 equivalent)						0.0	-8.5	-0.3	+8.4	+12.5	+1.9	+20.1	+32.1	+29.2	+37.3	+48.3	+56.2	+64.5	+68.6	+75.5	+67.8
PFCs (CO_2 equivalent)						0.0	-2.7	-22.3	-16.0	-30.3	-55.9	-59.5	-55.5	-52.0	-53.6	-60.0	-67.8	-71.2	-70.6	-79.7	-82.6
SF_6 (CO_2 equivalent)						0.0	-4.7	-5.5	-8.9	-33.7	-37.0	-42.0	-52.3	-53.1	-49.8	-48.7	-49.9	-50.8	-54.1	-54.9	-52.1
Development of GHG overall																					
Total emissions with respect to EU burden-sharing[115]	+1.1	-2.6	-6.6	-7.4	-9.0	-9.3	-7.8	-10.7	-12.8	-15.6	-15.7	-14.5	-16.2	-16.3	-17.3	-19.1	-18.9	-20.7	-20.8	-26.0	-24.0
CO	0.0	-18.3	-29.5	-35.9	-43.3	-47.0	-50.8	-52.1	-55.9	-58.9	-61.2	-62.8	-65.2	-66.8	-68.7	-70.5	-71.1	-71.9	-72.6	-75.7	-73.1
NMVOC	0.0	-14.4	-21.4	-26.0	-39.5	-42.3	-44.5	-45.2	-46.5	-51.0	-55.5	-58.8	-60.7	-62.8	-62.5	-63.5	-63.8	-65.8	-67.5	-70.3	-66.4
NO_X	0.0	-8.5	-13.5	-17.2	-22.7	-24.5	-27.0	-29.4	-30.3	-31.2	-33.3	-35.9	-38.7	-40.6	-42.8	-45.3	-45.8	-48.4	-50.9	-54.3	-54.2
SO_2	0.0	-26.0	-39.7	-46.2	-55.0	-67.5	-72.5	-77.0	-81.5	-84.8	-87.7	-87.8	-88.8	-89.2	-89.7	-90.2	-90.2	-90.6	-90.7	-91.8	-91.5

115 Defined base-year emissions of 1,232,430 Gg CO_2 equivalent; cf. Chapter 0.2

Table 348: Changes in emissions of direct and indirect greenhouse gases and SO_2 in Germany, in each case since the relevant previous year

Emissions change with respect to the previous year (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Net CO_2 emissions / storage	**0.0**	-3.7	-4.8	-1.0	-1.7	-0.2	+2.3	-3.1	-0.8	-3.1	+0.4	+1.2	+3.5	+0.3	-1.0	-1.9	+0.5	-2.4	-0.3	-7.1	+4.3
CO_2 emissions (not including LULUCF)	**0.0**	-3.6	-4.7	-0.9	-1.7	-0.2	+2.3	-3.0	-0.9	-3.0	+0.4	+1.8	-1.8	+0.2	-1.1	-1.9	+0.6	-2.5	-0.3	-7.4	+4.4
CH_4	**0.0**	-4.3	-3.3	-0.3	-4.1	-3.7	-3.0	-5.1	-6.3	-2.4	-4.4	-4.3	-4.7	-4.3	-8.7	-5.1	-5.4	-4.0	+0.3	-4.1	-1.8
N_2O	**0.0**	-4.0	+0.4	-3.1	+0.1	+0.3	+2.0	-3.6	-16.7	-5.4	+0.2	+1.6	-2.1	-1.6	+5.3	-3.9	-1.3	+2.9	+2.0	-0.2	-13.6
HFCs (CO_2 equivalent)	**0.0**	-8.3	+3.8	+44.8	+7.1	+1.9	-8.5	+9.0	+8.7	+3.8	-9.5	+18.0	+9.9	-2.2	+6.3	+8.0	+5.3	+5.3	+2.5	+4.0	-4.4
PFCs (CO_2 equivalent)	**0.0**	-13.3	-9.4	-6.4	-15.2	+8.3	-2.7	-20.1	+8.0	-17.0	-36.8	-8.2	+10.0	+7.8	-3.3	-13.8	-19.4	-10.7	+2.2	-31.1	-14.2
SF_6 (CO_2 equivalent)	**0.0**	+7.2	+10.4	+14.0	+4.6	+3.5	-4.7	-0.9	-3.6	-27.2	-5.1	-7.9	-17.7	-1.7	+6.9	+2.2	-2.2	-1.9	-6.6	-1.8	+6.2
Changes in total GG emissions and storage																					
Total emissions / storage, including LULUCF	**0.0**	-3.8	-4.2	-0.8	-1.7	-0.4	+1.7	-3.3	-2.4	-3.3	-0.1	+0.9	+2.6	-0.2	-1.1	-2.1	+0.1	-2.1	-0.1	-6.4	+2.7
Total emissions, not including CO_2 from LULUCF	**0.0**	-3.7	-4.1	-0.8	-1.7	-0.4	+1.7	-3.2	-2.3	-3.2	-0.1	+1.4	-2.0	-0.2	-1.1	-2.2	+0.2	-2.2	-0.1	-6.6	+2.7
CO	**0.0**	-18.3	-13.7	-9.1	-11.6	-6.5	-7.3	-2.6	-7.8	-6.8	-5.5	-4.3	-6.3	-4.6	-5.8	-5.7	-2.2	-2.7	-2.5	-11.4	+10.7
NMVOC	**0.0**	-14.4	-8.1	-6.0	-18.2	-4.6	-3.8	-1.4	-2.3	-8.4	-9.3	-7.2	-4.7	-5.4	+1.0	-2.6	-1.0	-5.5	-5.0	-8.5	+13.2
NO_X	**0.0**	-8.5	-5.4	-4.3	-6.6	-2.4	-3.3	-3.3	-1.4	-1.3	-2.9	-4.0	-4.3	-3.1	-3.7	-4.4	-0.9	-4.7	-5.0	-6.8	+0.1
SO_2	**0.0**	-26.0	-18.4	-10.8	-16.3	-27.9	-15.3	-16.2	-19.5	-18.2	-18.7	-1.5	-8.2	-2.9	-4.5	-5.5	+0.5	-4.4	-1.4	-11.4	+3.4

Table 349: Changes in emissions in Germany, by source categories, since 1990 / since the relevant previous year

Emissions change with respect to 1990; change in %	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1. Energy	**0.0**	**-3.5**	**-8.3**	**-9.0**	**-11.1**	**-11.5**	**-9.3**	**-12.4**	**-13.3**	**-15.8**	**-16.0**	**-14.0**	**-15.5**	**-15.9**	**-17.4**	**-19.0**	**-18.6**	**-20.8**	**-20.9**	**-26.2**	**-23.4**
2. Industrial processes	**0.0**	**-4.2**	**-2.1**	**-1.9**	**4.7**	**2.7**	**1.3**	**1.0**	**-13.8**	**-21.4**	**-18.4**	**-21.3**	**-22.9**	**-17.2**	**-11.8**	**-14.6**	**-13.3**	**-10.5**	**-13.2**	**-20.6**	**-23.2**
3. Solvent and other product use	**0.0**	**-3.1**	**-7.1**	**-9.0**	**-20.8**	**-20.6**	**-22.5**	**-23.0**	**-23.6**	**-29.3**	**-35.0**	**-40.0**	**-44.5**	**-49.4**	**-51.0**	**-54.2**	**-53.7**	**-56.5**	**-59.5**	**-63.7**	**-57.9**
4. Agriculture	**0.0**	**-8.3**	**-11.2**	**-11.8**	**-14.7**	**-12.1**	**-11.7**	**-12.6**	**-12.4**	**-11.3**	**-11.2**	**-12.1**	**-14.9**	**-16.5**	**-15.1**	**-16.1**	**-17.7**	**-18.7**	**-15.3**	**-17.5**	**-18.9**
5. Land use, land-use changes & forestry	**0.0**	**0.3**	**-0.5**	**-0.2**	**-1.4**	**-1.8**	**-1.5**	**-1.7**	**-3.0**	**-3.4**	**-4.2**	**17.2**	**-154.3**	**-154.6**	**-156.4**	**-157.0**	**-156.0**	**-157.9**	**-158.8**	**-162.2**	**-162.4**
CO_2 (net sink)	0.0	0.2	-0.4	-0.2	-1.4	-1.8	-1.5	-1.7	-3.0	-3.4	-4.2	17.0	-152.9	-153.1	-154.9	-155.5	-154.5	-156.4	-157.3	-160.6	-160.9
N_2O & CH_4	0.0	-1.7	8.8	0.0	-0.8	-2.1	0.1	-1.9	-2.3	-2.2	-1.6	-2.5	-2.1	1.6	-0.8	-0.7	-0.3	-1.3	-0.9	-2.5	-5.3
6. Waste	**0.0**	**1.2**	**0.8**	**-1.1**	**-4.2**	**-7.6**	**-12.3**	**-20.2**	**-26.0**	**-33.2**	**-37.2**	**-41.3**	**-44.8**	**-48.7**	**-54.8**	**-59.2**	**-63.4**	**-66.8**	**-67.1**	**-69.8**	**-71.6**

Emissions change, in each case with respect to the previous year; change in %	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1. Energy	**0.0**	**-3.5**	**-5.0**	**-0.8**	**-2.3**	**-0.4**	**2.4**	**-3.4**	**-1.1**	**-2.8**	**-0.2**	**2.4**	**-1.8**	**-0.5**	**-1.8**	**-1.9**	**0.4**	**-2.7**	**-0.1**	**-6.7**	**3.8**
2. Industrial processes	**0.0**	**-4.2**	**2.2**	**0.2**	**6.7**	**-1.9**	**-1.3**	**-0.3**	**-14.7**	**-8.7**	**3.8**	**-3.6**	**-2.1**	**7.4**	**6.5**	**-3.2**	**1.6**	**3.3**	**-3.1**	**-8.5**	**-3.3**
3. Solvent and other product use	**0.0**	**-3.1**	**-4.1**	**-2.0**	**-12.9**	**0.2**	**-2.3**	**-0.7**	**-0.7**	**-7.5**	**-8.1**	**-7.7**	**-7.5**	**-8.7**	**-3.2**	**-6.5**	**1.1**	**-6.0**	**-7.0**	**-10.3**	**15.8**
4. Agriculture	**0.0**	**-8.3**	**-3.2**	**-0.6**	**-3.4**	**3.1**	**0.5**	**-1.1**	**0.2**	**1.3**	**0.1**	**-1.0**	**-3.2**	**-2.0**	**1.8**	**-1.2**	**-1.9**	**-1.3**	**4.2**	**-2.6**	**-1.7**
5. Land use, land-use changes & forestry	**0.0**	**0.3**	**-0.7**	**0.3**	**-1.3**	**-0.4**	**0.3**	**-0.2**	**-1.3**	**-0.4**	**-0.8**	**22.3**	**-146.4**	**0.6**	**3.2**	**1.1**	**-1.8**	**3.4**	**1.5**	**5.7**	**0.4**
CO_2 (net sink)	0.0	0.2	-0.6	0.2	-1.3	-0.4	0.3	-0.2	-1.3	-0.4	-0.8	22.1	-145.2	0.5	3.3	1.1	-1.9	3.5	1.6	5.9	0.4
N_2O & CH_4	0.0	-1.7	10.7	-8.1	-0.9	-1.3	2.2	-2.0	-0.4	0.2	0.6	-0.9	0.4	3.7	-2.4	0.2	0.4	-1.0	0.4	-1.6	-2.9
6. Waste	**0.0**	**1.2**	**-0.4**	**-1.9**	**-3.2**	**-3.6**	**-5.0**	**-9.0**	**-7.3**	**-9.7**	**-6.0**	**-6.5**	**-6.0**	**-7.1**	**-11.9**	**-9.6**	**-10.4**	**-9.1**	**-1.0**	**-8.2**	**-6.0**

23 ANNEX 7: TABLE 6.1 OF THE IPCC GOOD PRACTICE GUIDANCE

The uncertainties for the German greenhouse-gas inventories have been determined completely, for all source categories.

Efforts in this area, which began with determination of uncertainties pursuant to Tier 1, are being carried out by data-supplying experts of Federal Environment Agency departments and by external institutions.

Since then, the basis for Tier 2 uncertainties analysis has been created, and the "Crystal Ball" programme for Monte Carlo simulation has been implemented. Tier 2 uncertainties analysis is carried out every three years (it was last carried out for the 2010 report); when it is carried out, it is carried out in addition to Tier 1 uncertainties determination.

At the same time, additional uncertainties have been determined via experts' assessments and added to the CSE database. An uncertainties data set is now available in which most of the uncertainties have been determined via expert estimation. In cases in which experts' assessments are not yet available, a complete data set is obtained by adopting uncertainties from data reported in the relevant technical literature. The expert assessment process is being continued, systematically and completely.

The results of this year's Tier 1 uncertainties analysis are shown, in keeping with the specifications given in Table 6.1 of IPCC Good Practice Guidance, in Table 350.

Table 350: Table 6.1 of the IPCC Good Practice Guidance - Details

CRF	Category	Gas	Base-year emissions [t CO_2 equivalent]	Emissions, 2010 [Gg CO_2 equivalent]	Combined uncertainty of activity data [%]	Combined uncertainty of emission factors [%]	Combined uncertainty of emissions [%]	Combined uncertainty percentage [%]	Trend uncertainty for emission factors [%]	Trend uncertainty for activity data [%]	Trend uncertainty for emissions [%]
1.A.1.a	all fuels	CH4	185.769,03	1.683.990,13	10,15083217	70,18764965	70,91787896	0,125206232	0,136762671	0,019779191	0,138185544
1.A.1.a	all fuels	CO2	339.017.879,12	315.557.523,47	3,957666164	1,753207581	4,328609279	1,432048051	0,640146258	1,445057169	1,580499115
1.A.1.a	all fuels	N2O	3.610.029,89	3.498.902,54	4,520285831	22,47735363	22,92737251	0,084104028	0,091000621	0,018300589	0,092822543
1.A.1.b	all fuels	CO2	20.179.812,65	19.857.182,62	3,038548972	4,815056328	5,693640953	0,118532753	0,110633419	0,069815395	0,130820269
1.A.1.b	all fuels	CH4	13.286,21	6.805,19	2,493269576	27,66664782	27,77876518	0,000198191	0,000217853	1,96326E-05	0,000218736
1.A.1.b	all fuels	N2O	121.864,81	61.103,15	2,707328021	32,86733941	32,97865408	0,002112648	0,002323782	0,000191413	0,002331653
1.A.1.c	all fuels	CH4	85.304,42	18.365,17	6,786786162	109,5023922	109,7125078	0,002112427	0,002326943	0,00014422	0,002331408
1.A.1.c	all fuels	N2O	684.167,61	176.428,91	3,745679258	19,61321148	19,96767833	0,003693414	0,004003924	0,000764659	0,004076286
1.A.1.c	all fuels	CO2	64.393.840,73	13.645.766,23	4,360903666	2,684431467	5,120903541	0,073261396	0,042385526	0,068855994	0,080855926
1.A.2.a	all fuels	CH4	52.462,15	58.997,46	8,049358305	23,90081522	25,21985601	0,001559935	0,001631599	0,000549493	0,001721643
1.A.2.a	all fuels	N2O	161.350,51	126.183,53	4,704048059	34,2280916	34,54316063	0,004569781	0,004997499	0,000686818	0,005044474
1.A.2.a	all fuels	CO2	34.741.967,20	34.269.113,65	3,964800866	2,67788024	4,784421437	0,171894889	0,106184556	0,157214132	0,189714109
1.A.2.b	all fuels	CO2	1.601.180,10	1.462.940,81	10,64926546	0,906873849	10,68780965	0,016392535	0,001535115	0,018026597	0,018091842
1.A.2.b	all fuels	CH4	1.164,38	1.351,19	10,80812503	67,55682181	68,41593192	9,69182E-05	0,000105622	1,6898E-05	0,000106965
1.A.2.b	all fuels	N2O	17.833,99	7.933,98	9,803913117	61,797324	62,57016834	0,000520462	0,00056732	9,00032E-05	0,000574415
1.A.2.d	all fuels	CO2	3.646,96	8.984,58	5,217525336	2,236082287	5,676498447	5,34698E-05	2,32462E-05	5,42412E-05	5,90127E-05
1.A.2.d	all fuels	CH4	549,27	2.335,62	3,980122521	42,64416987	42,82950617	0,000104876	0,000115247	1,07564E-05	0,000115748
1.A.2.d	all fuels	N2O	2.918,98	12.412,15	3,980122521	51,17300384	51,327553	0,000667926	0,000734946	5,71624E-05	0,000737165
1.A.2.e	all fuels	CO2	1.989.239,00	458.634,62	6,167251955	1,126325485	6,26925879	0,003014489	0,00059772	0,003272848	0,003326981
1.A.2.e	all fuels	CH4	3.765,41	374,51	6,890464492	44,38953782	44,92114835	1,7638E-05	1,9236E-05	2,98595E-06	1,94664E-05
1.A.2.e	all fuels	N2O	25.637,78	3.799,41	4,715792563	54,33041867	54,53469623	0,00021723	0,000238851	2,07319E-05	0,000239749
1.A.2.f	all fuels	CO2	137.298.795,28	77.896.239,69	2,991292773	0,477890945	3,029226338	0,247388144	0,043073744	0,269614191	0,273033257
1.A.2.f	all fuels	CH4	178.687,13	112.297,05	5,096486656	43,75335555	44,04918044	0,005186052	0,005685217	0,000662227	0,005723656
1.A.2.f	all fuels	N2O	1.204.642,54	585.537,33	2,172358222	12,232853	12,42424375	0,007627026	0,008287999	0,001471815	0,00841767
1.A.3.a	Aviation Gasoline	CO2	2.309.638,04	1.989.606,43	7,208274083	3,605155017	8,059550729	0,016811585	0,008299625	0,016594562	0,018554333
1.A.3.a	Aviation Gasoline	CH4	1.998,96	1.737,84	9,440835295	94,53433695	95,00458006	0,000173095	0,000190093	1,8984E-05	0,000191039
1.A.3.a	Aviation Gasoline	N2O	23.988,04	20.812,65	7,082397935	106,2667093	106,5024594	0,002323902	0,002559128	0,000170559	0,002564806
1.A.3.b	all fuels	CO2	150.358.325,67	145.437.918,06	9,043221343	0,708105031	9,070902105	1,383116602	0,119163338	1,52183701	1,526495263
1.A.3.b	all fuels	CH4	1.094.419,88	155.584,64	16,54710708	33,40350168	37,27759542	0,006080584	0,006013482	0,002978901	0,006710873
1.A.3.b	all fuels	N2O	1.164.548,70	1.250.165,54	9,075779211	28,57533935	29,98199105	0,039296933	0,041335791	0,013128611	0,04337059
1.A.3.c	all fuels	CO2	2.880.820,12	945.366,56	9,994240086	2,998271528	10,43429125	0,010341746	0,003279733	0,010932446	0,011413809
1.A.3.c	all fuels	CH4	2.309,52	371,27	9,397219036	31,97754365	33,32973183	1,29733E-05	1,37372E-05	4,03695E-06	1,43181E-05
1.A.3.c	all fuels	N2O	12.636,22	4.221,23	9,397219036	70,47914277	71,10286415	0,000314671	0,000344244	4,58992E-05	0,000347291
1.A.3.d	Diesel Oil	CO2	2.065.668,20	758.233,67	46,84668237	2,990213043	46,94200634	0,037316025	0,002623448	0,041100702	0,041184344
1.A.3.d	Diesel Oil	CH4	1.674,21	543,08	44,07401962	31,95054472	54,43672027	3,09948E-05	2,00776E-05	2,76959E-05	3,42078E-05
1.A.3.d	Diesel Oil	N2O	8.590,10	3.376,55	44,07401962	70,47914277	83,12537982	0,000294264	0,00027536	0,000172196	0,000324768
1.A.3.e	all fuels	CO2	4.751.743,58	4.140.500,22	42,26205348	2,061532073	42,37137406	0,183931463	0,009876663	0,202474688	0,202715436
1.A.3.e	all fuels	CH4	7.083,45	2.851,45	26,57017423	26,34742538	37,49791746	0,0001121	8,69304E-05	8,76654E-05	0,000123459
1.A.3.e	all fuels	N2O	32.743,34	19.110,59	38,40244791	48,73950125	62,0877783	0,001243973	0,001077761	0,000849181	0,001372107
1.A.4.a	all fuels	CO2	63.949.629,39	36.399.262,55	7,443457909	1,249871978	7,547664911	0,288028764	0,05264116	0,313497913	0,317886824
1.A.4.a	all fuels	CH4	1.216.099,17	61.488,30	10,85502144	48,17931658	49,38702296	0,003183728	0,003427839	0,000772308	0,003513765
1.A.4.a	all fuels	N2O	144.213,47	92.343,92	6,299080905	45,15880362	45,59600821	0,00441434	0,004825231	0,000673059	0,004871946

CRF	Category	Gas	Base-year emissions [t CO_2 equivalent]	Emissions, 2010 [Gg CO_2 equivalent]	Combined uncertainty of activity data [%]	Combined uncertainty of emission factors [%]	Combined uncertainty of emissions [%]	Combined uncertainty percentage [%]	Trend uncertainty for emission factors [%]	Trend uncertainty for activity data [%]	Trend uncertainty for emissions [%]
1.A.4.b	all fuels	CO2	129.473.971,12	101.946.492,60	8,106406212	1,331094926	8,214964113	0,878028524	0,157017713	0,956242371	0,969048004
1.A.4.b	all fuels	CH4	1.200.405,63	745.689,80	14,74184293	64,53307602	66,19546687	0,051750806	0,055681112	0,012719713	0,057115474
1.A.4.b	all fuels	N2O	801.899,28	417.490,33	7,061555774	26,99866371	27,90687034	0,012214852	0,013042355	0,003411255	0,013481086
1.A.4.c	all fuels	CO2	11.059.780,98	6.211.453,98	12,80517396	1,973337796	12,95622654	0,084372802	0,014182802	0,092033531	0,093119938
1.A.4.c	all fuels	CH4	178.493,92	22.677,10	18,32350188	52,49726768	55,60026808	0,001321889	0,0013775	0,000480799	0,001458997
1.A.4.c	all fuels	N2O	41.727,27	31.367,28	11,39482062	42,23648113	43,66902602	0,001436088	0,001532964	0,000413572	0,001587772
1.A.5	all fuels	CO2	11.811.085,44	1.297.620,88	4,621171307	1,412662743	4,832270714	0,006574001	0,002121063	0,006938526	0,007255484
1.A.5	all fuels	CH4	235.607,83	4.358,32	4,518492723	36,2759283	36,5562546	0,000167037	0,000182938	2,27866E-05	0,000184352
1.A.5	all fuels	N2O	70.377,15	9.352,49	3,442973413	57,00464648	57,10852639	0,000559962	0,000616886	3,72588E-05	0,00061801
1.B.1.a	Solid Fuels	CH4	18.415.177,65	2.769.917,39	0,042382478	2,282453572	37,25196872	0,108179934	0,007315367	0,000135838	0,007316628
1.B.1.b	Solid Fuels	CH4	18.089,82	8.407,96	3	10	10,44030651	9,20311E-05	9,72877E-05	2,91863E-05	0,000101571
1.B.1.c	Solid Fuels	CH4	1.806.840,00	15.057,00	20	0	20	0,000315718	0	0,000348446	0,000348446
1.B.2.a	Liquid Fuels	CO2	1.415,74	1.308,38	0	7,217477017	7,578350919	1,03954E-05	1,09267E-05	0	1,09267E-05
1.B.2.a	Liquid Fuels	CH4	716.687,61	272.768,27	0,449682203	13,28661219	5,099415197	0,001458293	0,004193488	0,000141928	0,004195889
1.B.2.b	Gaseous Fuels	CO2	1.408.684,49	1.166.047,44	0	9,982299838	22,32013775	0,027286244	0,013468343	0	0,013468343
1.B.2.b	Gaseous Fuels	CH4	7.400.083,23	6.173.910,22	4,495972334	9,400771841	9,337626104	0,060440417	0,067156979	0,032118205	0,074442186
1.B.2.c		CO2	280.533,56	283.544,48	0	24,03646083	25,96237023	0,007717848	0,007886041	0	0,007886041
1.B.2.c		CH4	409.295,41	138.242,10	0	9,918291772	14,87593247	0,002156032	0,001586516	0	0,001586516
1.B.2.c		N2O	1.102,34	209,69	0	13,5159187	15,26731473	3,35636E-06	3,27935E-06	0	3,27935E-06
2.A.1		CO2	15.145.810,00	12.187.737,43	2,5	2	3,201562119	0,040908701	0,028204631	0,035255788	0,045149439
2.A.2		CO2	6.176.470,20	5.019.297,66	2,352565245	10,49013996	10,75070228	0,056573162	0,060924443	0,013663185	0,062437732
2.A.4		CO2	426.720,85	322.782,85	50	2	50,03998401	0,01693395	0,000746978	0,018674449	0,018689382
2.A.7.a		CO2	531.112,90	308.598,91	16,46360931	24,69541397	29,68019377	0,009602665	0,008818161	0,005878774	0,010598111
2.A.7.b		CO2	695.617,07	761.562,58	3,05662784	5,632033859	6,408024589	0,005116352	0,00496293	0,002693491	0,005646731
2.B.1		CO2	5.745.000,00	7.437.000,00	0,328842275	0	0,781403904	0,006092619	0	0,002829781	0,002829781
2.B.2		N2O	3.384.400,15	3.030.250,64	1	5	5,099019514	0,016199287	0,017531371	0,003506274	0,017878561
2.B.3		N2O	18.804.600,00	716.385,05	20	7	21,1896201	0,015914769	0,005802456	0,016578447	0,017564549
2.B.4		CO2	443.160,00	17.112,00	10	10	14,14213562	0,000253715	0,000198001	0,000198001	0,000280016
2.B.5		CO2	6.888.160,70	8.826.852,84	3,272947768	4,095990454	21,885246	0,202529357	0,041834266	0,033428146	0,05354948
2.B.5		CH4	252,86	431,06	15	2	15,13274595	6,83892E-06	9,97553E-07	7,48165E-06	7,54786E-06
2.B.5		N2O	C	C	20	75	150	0,009750202	0,005380471	0,001434792	0,005568491
2.C.1		CH4	3.918,60	4.451,97	4,43111628	12,43367847	12,43420172	5,80365E-05	6,40501E-05	2,28262E-05	6,79959E-05
2.C.1		CO2	22.711.891,28	18.208.004,15	6,579882716	4,979952235	8,128592084	0,155170207	0,104919172	0,138627001	0,173854761
2.C.1		N2O	27.613,10	17.297,52	6,925022668	60,20049477	58,05894578	0,001052892	0,001204901	0,000138603	0,001212847
2.C.2		CO2	429.000,00	5.500,00	50	7	50,48762225	0,000291124	4,4548E-05	0,0003182	0,000321303
2.C.3		CO2	1.011.923,12	550.567,45	1	15	15,03329638	0,008677516	0,009555846	0,000637056	0,009577057
2.C.3		CF4	1.358.500,00	114.939,50	1	0	15	0,001807554	0	0,000132995	0,000132995
2.C.3		C2F6	193.200,00	19.688,00	1	0	15,03	0,000310235	0	2,27808E-05	2,27808E-05
2.C.4		SF6	197.103,30	106.546,92	0	25,73379012	25,75941358	0,002877448	0,003172576	0	0,003172576
2.C.5		HFC-134a	C	C	0	30	30	0,000663448	0,000732223	0	0,000732223
2.E		HFC-134a	C	C	10	0	10	0,000144307	0	0,000159267	0,000159267
2.E		SF6	167.300,00	90.449,55	10	0	10	0,000948281	0	0,001046583	0,001046583
2.E		HFC-227ea	C	C	10	0	10	0,000242927	0	0,000268109	0,000268109

CRF	Category	Gas	Base-year emissions [t CO_2 equivalent]	Emissions, 2010 [Gg CO_2 equivalent]	Combined uncertainty of activity data [%]	Combined uncertainty of emission factors [%]	Combined uncertainty of emissions [%]	Combined uncertainty percentage [%]	Trend uncertainty for emission factors [%]	Trend uncertainty for activity data [%]	Trend uncertainty for emissions [%]
2.E		HFC-23	C	C	10	0	10	0,001349302	0	0,001489175	0,001489175
2.F		HFC-125	78.985,19	1.831.819,88	12,38397312	0	12,38397312	0,023783372	0	0,026248839	0,026248839
2.F		C2F6	122.529,42	73.063,51	9,418483686	0	9,418483686	0,00072146	0	0,000796249	0,000796249
2.F		C3F8	8.085,00	44.380,97	13,60276814	0	13,60276814	0,000632929	0	0,00069854	0,00069854
2.F		c-C4F8	0,00	2.003,82	12,2	0	12,2	2,563E-05	0	2,82869E-05	2,82869E-05
2.F		CF4	90.256,77	54.465,50	0	0,187127632	9,913459136	0,000566079	1,17931E-05	0	1,17931E-05
2.F		SF6	6.856.907,82	3.215.790,48	0	1,756396416	6,886845498	0,023218745	0,006535482	0	0,006535482
2.F		HFC-134a	1.991.198,80	6.555.075,40	0	5,313909985	7,072746124	0,048606732	0,040305027	0	0,040305027
2.F		HFC-143a	56.465,16	2.391.047,69	14,52482464	0	14,52482464	0,036410765	0	0,040185231	0,040185231
2.F		HFC-152a	101.239,25	51.601,54	0	0,00855928	2,142678039	0,000115918	5,11054E-07	0	5,11054E-07
2.F		HFC-227ea	445,51	77.495,11	0	4,147927472	4,68160823	0,000380365	0,00037194	0	0,00037194
2.F		HFC-23	22.882,14	254.740,97	0	4,800588696	13,09422164	0,003497109	0,001415014	0	0,001415014
2.F		HFC-236fa	0,00	10.440,17	0	9,344282743	9,344282743	0,000102278	0,000112881	0	0,000112881
2.F		HFC-32	206,00	73.036,34	7,868399224	0	7,868399224	0,000602499	0	0,000664956	0,000664956
2.F		HFC-43-10mee	C	C	2	0	2	3,81621E-06	0	4,21181E-06	4,21181E-06
3		CO2	2.552.000,00	1.583.265,20	8,016938274	0	8,016938274	0,01330739	0	0,01468688	0,01468688
3.D		N2O	C	C	19,05623538	0,622229576	47,63688391	0,014944113	0,000215434	0,006597822	0,006601338
4.A.1.a	Dairy cattle	CH4	13.498.433,99	10.898.605,97	6	40	40,44749683	0,46216097	0,504426942	0,075664041	0,510070178
4.A.1.b	Other cattle or dairy cattle	CH4	11.843.533,48	8.293.993,98	3,697532602	24,65021734	24,92771964	0,216758897	0,236565714	0,035484857	0,239212274
4.A.2	other animals	CH4	1.329.574,99	1.085.169,97	7,638277178	26,15240195	27,24306453	0,030994483	0,032837999	0,009590925	0,03420994
4.B.1.a	Dairy cattle	CH4	2.320.065,84	2.321.695,11	6	40	40,44749683	0,098452671	0,107456455	0,016118468	0,108658616
4.B.1.b	Other cattle and diry cattle	CH4	1.767.607,88	1.186.062,92	3,644712252	24,29808168	24,56536058	0,030546506	0,033346253	0,005001938	0,033719312
4.B.1.a	Dairy cattle	N2O	1.048.830,42	835.017,92	4,766240836	79,43734726	79,58020603	0,069667708	0,076751675	0,0046051	0,076889704
4.B.1.b	Other cattle or dairy cattle	N2O	1.020.632,29	839.617,35	2,4710738	41,18456333	41,25845695	0,036318261	0,04001135	0,002400681	0,040083305
4.B.2	other animals	N2O	96.415,79	83.743,62	8,817242803	74,95784344	75,46131687	0,006625319	0,007263336	0,000854382	0,007313414
4.B.9	Poultry	N2O	37.565,90	45.959,96	11,14114926	55,70574632	56,80070754	0,002736932	0,002962422	0,000592484	0,00302109
4.B.8	Swine	N2O	366.970,06	463.944,17	6,642494364	66,42494364	66,75700747	0,03247082	0,035658597	0,00356586	0,035836446
4.B.2	other animals	CH4	119.108,69	132.030,38	8,298680558	18,3103123	20,09851406	0,002782073	0,002797287	0,001267799	0,003071176
4.B.8	Swine	CH4	2.118.013,69	1.933.103,62	7,570609779	30,28243912	30,66451659	0,062147251	0,067735029	0,016933757	0,069819669
4.D.1		N2O	29.161.431,56	24.757.123,51	17,97214944	54,02708031	56,93789215	1,477856391	1,547672314	0,514834375	1,631056107
4.D.2		N2O	2.019.681,93	1.334.458,91	40	200	203,9607805	0,285353061	0,308817948	0,06176359	0,314933748
4.D.3		N2O	16.463.147,56	13.268.016,80	141,8840081	317,0431512	353,3020814	4,914539998	4,867340408	2,178245338	5,332518673
5.A		CO2	-73.408.002,65	-25.060.617,92	3,778510781	0	37,86465124	0,994847245	0	0,109567001	0,109567001
5.A		CH4	9.084,07	3.196,14	15	0	38	0,000127333	0	5,54733E-05	5,54733E-05
5.A		N2O	60.374,25	66.252,43	179,0030712	0	179,0034857	0,012433517	0	0,013722386	0,013722386
5.B		CO2	28.761.132,54	28.272.810,60	41,33271279	0	41,33758087	1,225306414	0	1,352166668	1,352166668

CRF	Category	Gas	Base-year emissions [t CO_2 equivalent]	Emissions, 2010 [Gg CO_2 equivalent]	Combined uncertainty of activity data [%]	Combined uncertainty of emission factors [%]	Combined uncertainty of emissions [%]	Combined uncertainty percentage [%]	Trend uncertainty for emission factors [%]	Trend uncertainty for activity data [%]	Trend uncertainty for emissions [%]
5.B		N2O	199.448,92	185.156,90	84,15862648	0	84,15862648	0,016336883	0	0,018030421	0,018030421
5.C		CO2	11.561.918,51	9.049.930,01	38,19017982	0	40,22480641	0,381654026	0	0,399911834	0,399911834
5.D		CO2	2.248.393,86	2.156.480,36	40,85946914	0	41,40429554	0,093609855	0	0,101954303	0,101954303
5.E		CO2	2.751.623,76	2.551.372,95	25,82843371	0	32,08640677	0,085827349	0	0,076249912	0,076249912
5.G		CO2	116.784,72	58.286,02	100	0	100	0,006110758	0	0,00674422	0,00674422
6.A		CH4	38.598.000,00	8.967.000,00	12,5	0	12,5	0,117513523	0	0,129695383	0,129695383
6.B		CH4	2.226.211,52	70.916,58	75	0	75	0,005576218	0	0,006154268	0,006154268
6.B		N2O	2.223.526,40	2.302.516,57	75	0	75	0,181048401	0	0,199816506	0,199816506
6.D		CH4	49.777,90	544.632,31	1,402725249	42,08175747	42,10512974	0,024041916	0,026519456	0,000883982	0,026534185
6.D		N2O	13.982,61	353.845,28	1,197647243	48,55765534	48,57242274	0,018019131	0,01988101	0,000490354	0,019887057
Total			**1.222.215.158,896**	**953.826.391,267**				**5,873**			**6,305**

Uncertainties for source categories have been determined successively, within the framework of UBA sections' data deliveries for current emissions reporting. On the other hand, external experts have carried out additional uncertainties determination, in research projects, for source categories for which no uncertainties information, or incomplete information, has been available to date. The results of such uncertainties analysis have been integrated within the current report.

The uncertainties in the source category Agriculture (CRF 4) were estimated by experts of the Johann Heinrich von Thünen Institute (vTI).

Current work planning calls for Tier 2 uncertainties analysis to be carried out every three years. Uncertainties determination pursuant to Tier 1 will be carried out, and reported, every year.

24 REFERENCES

AGEB, 2003: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanzen der Bundesrepublik Deutschland - Jahre 1990-1999, Verlags- und Wirtschaftsgesellschaft der Elektrizitätswerke, Frankfurt a. M.AGEB, 2002: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Sonderauswertung für das UBA zur Darstellung von ausgewählten Energieverbräuchen in der Struktur der Energiebilanz vor 1995 für Zeitreihen von 1995 bis 1999 (unveröffentlicht)

AGEB, 2010: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanz für die Bundesrepublik Deutschland URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63 , (Aufruf: 25.08.2010 & 10.11.2010), Köln, Berlin.

AGEB, 2011: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanz für die Bundesrepublik Deutschland URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63, (Aufruf: 27.09.2011), Köln, Berlin.

AGEB, 2011a: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Heizwerte der Energieträger und Faktoren für die Umrechnung von spezifischen Mengeneinheiten in Wärmeinheiten (2000-2009) (veröffentlicht am 21. März.2011); URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=65 (Aufruf: 10.10.2011), Köln, Berlin.

AMD, 2002/2003**:** Amd Saxony LLC&Co. KG, Dresden, Umweltbericht. S. 16

AMTSBLATT DER EUROPÄISCHEN GEMEINSCHAFT: Richtlinie des Rates vom 21.Mai 1991 über die Behandlung von kommunalem Abwasser; Nr. L 135/40 , 30 S. 91, Artikel 2 Nr. 6

ARBEITSGRUPPE BODEN (1994): Bodenkundliche Kartieranleitung, 4. Auflage, Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, 392 S.

ARBEITSGRUPPE BODEN (2005): Bodenkundliche Kartieranleitung. 5. verbesserte und erweiterte Auflage, Hannover

ATV, 2004: ATV-DVWK-M 374: Produktionsspezifische Abwässer und Abfälle aus der Glas- und Mineralfaserindustrie, ATV-DVWK Deutsche Vereinigung der Wasserwirtschaft, Abwasser und Abfall e.V., 08/2004

AUGUSTIN, J. (2001): Emission, Aufnahme und Klimarelevanz von Spurengasen. - In: Succow, M. & H. Joosten [Hrsg.]: Landschaftsökologische Moorkunde. 2., völlig neubearb. Aufl.: 28-38; Stuttgart (Schweizerbart`sche Verlagsbuchhandlung).

AUST, o.J.: Vorlesungsscript TC-7: Abwasserbehandlung, siehe http://www.fh-nuernberg.de/tc/lab-aust/lim/wasserbeh_1_kap5_3.pdf

BAFA, 2011: Bundesamt für Wirtschaft und Ausfuhrkontrolle, Amtliche Mineralöldaten für die Bundesrepublik Deutschland, URL: http://www.bafa.de/bafa/de/energie/mineraloel_rohoel/amtliche_mineraloeldaten /index.html, (Aufruf: 27.09.2011), Eschborn.

BAKER, J.M., OCHSNER, T.E., VENTEREA, R.T., GRIFFIS, T.J., 2007: Tillage and soil carbon sequestration - What do we really know? Agriculture, Ecosystems and Environment, 118, 1 – 5

BARITZ, R.; SEUFERT, G.; MONTANARELLA, L.; VAN RANST, E. 2010: Carbon concentrations and stocks in forest soils of Europe. Forest Ecology and Management, 260, 262–277

BASt, 2007: Bundesanstalt für Straßenwesen: Unterreihe Verkehrstechnik; V 164: "Straßenverkehrszählung 2005: Ergebnisse", Thorsten Kathmann, Hartmut Ziegler, Bernd Thomas; 62 Seiten; Bergisch Gladbach, 2007

BASt, 2008: Bundesanstalt für Straßenwesen: Unterreihe Verkehrstechnik; V 166: Verkehrsentwicklung auf Bundesfernstraßen 2006, Arnd Fitschen, Ingo Koßmann, 239 Seiten; Bergisch Gladbach, 2008

BATZ, 1995: Kokereien und Produktemissionen. Mündliche Mitteilung. Umweltbundesamt.

BAYERISCHE LANDESANSTALT FÜR LANDWIRTSCHAFT (LfL) (2007): 20 Jahre Boden-Dauerbeobachtung in Bayern, Teil 3: Entwicklung der Humusgehalte zwischen 1986 und 2007; Schriftenreihe, 10, Freising-Weihenstephan.

BDZ 1995: Sonderauswertung des Bundesverbandes der deutschen Zementindustrie, erstellt für das UBA für die Jahre 1990-1994

BGR 1995, 1997: Digitale Bodenübersichtskarte der BRD (BUEK 1000); Maßstab: 1:1.000.000; Hannover

BGR (Bundesanstalt für Geowissenschaften und Rohstoffe), 2011: Schätzprofile der BÜK 1000 n 2.3; FISBo BGR

BEYER et al., 2004: Beyer, M.; Chudy, A.; Hoffmann, L.; Jentsch, W.; Laube, W.; Nehring, K.; Schiemann, R.: Rostocker Futterbewertungssystem. Kennzahlen des Futterwertes und Futterbedarfs auf der Basis von Nettoenergie. Dummerstorf: Forschungsinstitut für die Biologie landwirtschaftlicher Nutztiere. 392 pp.

BFI 2012: VDEh-Betriebsforschungsinstitut GmbH: Emissionsfaktoren zur Eisen- und Stahlindustrie für die Emissionsberichtserstattung. Forschungsbericht, Düsseldorf 2010. – gemeinsame Sonderpublikationvon BFI und Umweltbundesamt, Dessau-Roßlau 2012 (in Veröffentlichung)

BLE (Bundesanstalt für Landwirtschaft und Ernährung) (Hrsg.), 2011: Waldbrandstatistik der Bundesrepublik Deutschland für das Jahr 2010, Bonn, 18 S.

BLUM, W., HEINBACH, R. 2006: Endbericht zum BZE Ringversuch Humus 2006. Bayerische Landesanstalt für Wald und Forstwirtschaft (LWF), Freising, 216 S.

BLUM, W.; HEINBACH, R. 2007: Endbericht zum BZE Ringversuch Mineralboden 2007. Teil 1. Bayerische Landesanstalt für Wald und Forstwirtschaft (LWF), Freising, 218 S.

BMBF, 1997: Verbundvorhaben des Umweltbundesamtes mit dem BMBF: Deponiekörper, Förderkennzeichen 1460799A bis G (Teilvorhaben), Projektträger Abfallwirtschaft und Altlasten im Umweltbundesamt Berlin, Koordinierung Fachgebiet Abfall- und Siedlungswasserwirtschaft, Bergische Universität - Gesamthochschule Wuppertal

BMELF (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft), 1990: Bundeswaldinventur 1986 – 1990. Inventurbericht und Übersichtstabellen für das Bundesgebiet nach dem Gebietsstand bis zum 3. 10. 1990 einschließlich Berlin (West)

BMELF (Bundesministerium für Ernährung, Landwirtschaft und Forsten), 1994: Der Wald in den neuen Bundesländern - Eine Auswertung vorhandener Daten nach dem Muster der Bundeswaldinventur, Bonn, 38 S.

BMVEL (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft) (Hrsg.), 2001. Aufnahmeanweisung für die Bundeswaldinventur II (2001 - 2002), 2. korrigierte, überarbeitete Ausgabe, Mai 2001, Bonn, 108 S.

BMELV (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft) (Hrsg.), 2005. Die zweite Bundeswaldinventur – BWI²: Der Inventurbericht. Bonn, 231 S.

BMELV (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz) (Hrsg.), 2009: Waldbericht der Bundesregierung 2009. Berlin, 117 S.BMELV (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz) (Hrsg.), 2010: Aufnahmeanweisung für die Inventurstudie 2008 im Rahmen der Treibhausgasberichterstattung. 2. korrigierte, überarbeitete Aufl., Bonn, 60 S.

BMELV (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz), 2012: Konzept zur Erstellung von THG-Emissions- und Kohlenstoffinventaren der Quell- und Senkengruppen 4 und 5 im Zuständigkeitsbereich des BMELV, AZ: 521-65408/0002, unveröffentlicht.

BMLFUW – Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft Österreich (2005): Abschätzung der Auswirkungen des Tanktourismus auf den Treibstoffverbrauch und die Entwicklung der CO_2-Emissionen in Österreich. Wien.

BMU, 1990: Bundesminister für Umwelt, Naturschutz und Reaktorsicherheit, Karl Eugen Huthmacher: Eckwerte der ökologischen Sanierung und Entwicklung in den neuen Ländern, Bonn

BMVg, 2011: Bundesministerium der Verteidigung: Energieeinsatz zur Wärmeversorgung der Bundeswehr (unveröffentlicht).

BPB, 2002: Bundeszentrale für politische Bildung. Projektgruppe Zukunft der Wirtschaft, Die Zukunft der Wirtschaft, Landwirtschaft und Ernährung, herausgegeben von Margarete Wohlan

BOSSHARD, H.H. 1984: Holzkunde. Band 2: Zur Biologie, Physik und Chemie des Holzes. Birkhäuser, Basel. 312 S.

BURSCHEL, P.; KÜRSTEN, E.; LARSON, B.C. (1993): Die Rolle von Wald und Forstwirtschaft im Kohlenstoffhaushalt - eine Betrachtung für die Bundesrepublik Deutschland. Forstliche Forschungsberichte München, Forstwissenschaftliche Fakultät d. Universität München u. Bayrische Landesanstalt f. Wald u. Forstwirtschaft, Freising, 135 S.

BV Glas, 2011: Jahresbericht des Bundesverband Glasindustrie e.V., mit statistischem Anhang

BV Kalk, 2011 (Bundesverband der deutschen Kalkindustrie e.V.): Kalk Daten nationaler Inventarbericht; per E-Mail an das UBA übermittelt.

BVE, 2011: Bundesvereinigung der Deutschen Ernährungsindustrie e.V., Jahresbericht 2010_2011, URL: www.bve-online.de

BYRNE, K.A., B. Chojnicki, T.R. Christensen, M. Drösler, A. Freibauer, T. Friborg, S. Frolking, A. Lindroth, J. Mailhammer, N. Malmer, P. Selin, J. Turunen, R. Valenti & L. Zetterberg, 2004: EU Peatlands: Current Carbon Stocks and Trace Gas Fluxes. CarboEurope-GHG Report 4/2004. Specific Study, Tipo-Lito Recchioni, Viterbo, October 2004, S.58.

CAIRNS, M.A.; BROWN, S.; HELMER, E.H.; BAUMGARDNER, G.A., 1997: Root biomass allocation in the world's upland forests. Oecologia, Vol. 111 (1), pp. 1-11

COOLS, N.; VERSCHELDE, P.; QUATAERT, P.; MIKKELSEN, J.; DE VOS, B. 2006: Quality Assurance and Quality Control in Forest Soil Analysis: 4th Forest Soil Co-ordinating Centre (FSCC) Interlaboratory Comparison, Research Institute for Nature and Forest, Geraardsbergen, 66p + annex, http://www.icp-forests.org/DocsSoil/4thSoilRingtest.pdf [zitiert am 20.08.2010]

CORINAIR, 2006 - EMEP/CORINAIR Emission Inventory Guidebook - 2006, EEA technical report No. 11/2006; Dezember 2006, Kopenhagen 2006
URL: http://www.eea.europa.eu/publications/EMEPCORINAIR4

CLODIC., D & BEN YAHIA, M. 1997: Centre d'Energétique, Ecole des Mines de Paris: New Test Bench for Measuring Leak Flow Rate of Mobile Air Conditioning Hoses and Fittings. Earth Technology Conference, Baltimore.

DÄMMGEN et al. (2011a): Dämmgen, U.; Amon, B.; Gyldenkærne, S.; Hutchings, N.J.; Kleine Klausing, H.; Haenel, H.-D.; Rösemann, C.: Reassessment of the calculation procedure for the volatile solids excretion rates of cattle and pigs in the Austrian, Danish and German agricultural emission inventories. Landbauforschung, 61: 115 - 126

Dämmgen et al. (2011b): Dämmgen, U.; Brade, W.; Schulz, J.; Kleine Klausing, H.; Hutchings, N.J.; Haenel, H.-D.; Rösemann, C.: The effect of feed composition and feeding strategies on excretion rates in German pig production. Landbauforschung (zur Veröffentlichung angenommen)

DÄMMGEN, U.; HUTCHINGS N.J., 2005: The assessment of emissions of nitrogen species from agriculture using the methodology of the atmospheric emission inventory guidebook. In: Kuczyński T, Dämmgen U, Webb J, Myczko A (eds) Emissions from European agriculture. Wageningen Academic Publishers, Wageningen. pp 51-62

DÄMMGEN et al, 2002: Dämmgen, U., Lüttich, M., Döhler, H., Eurich-Menden, B., Osterburg, B.: GAS-EM – A Procedure to Calculate Gaseous Emissions from Agriculture. Landbauforschung Völkenrode 52, S. 19-42.

DAV, 2011: Deutscher Asphaltverband e.V., Schieffelingsweg 6, 53123 Bonn, Veröffentlichung zur Asphaltproduktion in Deutschland, http://www.asphalt.de/site/startseite/aktuelles/asphaltproduktion/ (Dokument asphaltp10.pdf), Stand April 2011

DBU, 2002: Vogt, R., Knappe, F., Giegrich, J., Detzel, A., IFEU-Institut für Energie und Umweltforschung Heidelberg (Hrsg.): Ökobilanz Bioabfallverwertung. Untersuchung zur Umweltverträglichkeit von Systemen zur Verwertung von biologisch-organischen Abfällen. Initiativen zum Umweltschutz, Band 52. Erich Schmidt Verlag, Berlin 2002

DEBRIV, 2004: Deutscher Braunkohlen-Industrie-Verein e.V., Mitteilung vom 15. September 2004 an das IKP Stuttgart.

DE VRIES, W.; REINDS, G.J.; GUNDERSON, P; STERBA, H. 2006: The impact of nitrogen deposition on carbon sequestration in European Forests and forest soils. Global Change Biology, 12, 1151-1173

DGE, 2000: Deutsche Gesellschaft für Ernährung e.V.: Ernährungsbericht 2000, ISBN 3-921 606-40-3

DGMK, 1992: Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V.: Forschungsbericht 448-2 - Ansatzpunkte und Potentiale zur Minderung des Treibhauseffektes aus Sicht der fossilen Energieträger, Hamburg, Seite II-89

DIE VERBRAUCHER INITIATIVE e.V., 2005: Distickstoffmonoxid, (Online Dokument) http://www.zusatzstoffe-online.de/html/zusatz.php3?nr=942 , Zugriff Mai 2005

DIETER, M., ELSASSER, P., 2002: Carbon Stocks and Carbon Stock Changes in the Tree Biomass of Germany's Forests. In: Forstwissenschaftliches Centralblatt (121. Jahrgang), S. 195-210. Berlin: Blackwell Wissenschafts-Verlag

DIETER, M.; ENGLERT, H. 2005: Gegenüberstellung und forstpolitische Diskussion unterschiedlicher Holzeinschlagsschätzungen für die Bundesrepublik Deutschland. Arbeitsbericht des Instituts für Ökonomie 2005/2, Bundesforschungsanstalt für Forst- und Holzwirtschaft, Institut für Ökonomie

DIN, 2003: DIN EN 1279-3: Glas im Bauwesen - Mehrscheiben-Isolierglas - Teil 3: Langzeitprüfverfahren und Anforderungen bezüglich Gasverlustrate und Grenzabweichungen für die Gaskonzentration; Deutsche Fassung EN 1279-3:2002

DIN, 2004: Deutsches Institut für Normung e. V. (DIN). DIN 1343. Referenzzustand, Normzustand, Normvolumen; Begriffe und Werte. Internetseite mit Recherchefunktionen. URL: http://www2.din.de. Berlin.

DIW, 1991: Deutsches Institut für Wirtschaftsforschung, Entwicklung des Energieverbrauchs und seiner Determinanten in der ehemaligen DDR. Von Hans-Joachim Ziesing. Untersuchung im Auftrag des Bundesministers für Wirtschaft. Im Unterauftrag: Institut für Energetik (IfE), Leipzig; Institut für Wirtschaftswissenschaften der Akademie der Wissenschaften, Berlin; Staatliche Vorratskommission für nutzbare Ressourcen der Erdkruste, Berlin. Berlin, April 1991

DIW, 2002: Rieke, H. (DIW): Fahrleistungen und Kraftstoffverbrauch im Straßenverkehr; in: DIW Wochenbericht Nr. 51-52/2002; Berlin, Dezember 2002; Ergebnisse auch kontinuierlichveröffentlicht in „Verkehr in Zahlen“

DLG, 2005: Deutsche Landwirtschafts-Gesellschaft (ed.) Bilanzierung der Nährstoff-ausscheidungen landwirtschaftlicher Nutztiere. Arbeiten der DLG/Band 199. DLG-Verlag, Frankfurt/Main. 69 pp

DMT 2005: Freundliche persönliche Mitteilung von Herrn Meiners, Deutsche Montan Technologie. 28.09.2005. Gelsenkirchen.

DMT 2011: Meiners et al: „Diffuse Emissionen fester Brennstoffe (Kohlen) – Emissionen von Grubengas aus stillgelegten Bergwerken; Potential zur Freisetzung und Verwertung von Grubengas“, FKZ 360 16 028 im Auftrag des Umweltbundesamtes 2011

DÖPELHEUER, 2002: Anwendungsorientierte Verfahren zur Bestimmung von CO, HC und Ruß aus Luftfahrttriebwerken, Dissertationsschrift des DLR, Institut für Antriebstechnik, Köln, 2002

DRÖSLER, M., ADELMANN, W., AUGUSTIN, J., BERGMAN, L., BEYER, C., CHOJNICKI, B., FÖRSTER, C., FREIBAUER, A., GIEBELS, M., GÖRLITZ, S., HÖPER, H., KANTELHARDT, J., LIEBERSBACH, H., HAHN-SCHÖFL, M., MINKE, M., PETSCHOW, U., PFADENHAUER, J., SCHALLER, L., SCHÄGNER, P., SOMMER, M., THUILLE, A., WEHRHAN, M., 2011: Klimaschutz durch Moorschutz. Schlussbericht des Vorhabens „Klimaschutz - Moornutzungsstrategien“ 2006-2010; 174 S.

DüV - Düngeverordnung (2007) Verordnung über die Anwendung von Düngemitteln, Bodenhilfsstoffen, Kultursubstraten und Pflanzenhilfsmitteln nach den Grundsätzen der guten fachlichen Praxis beim Düngen (Düngeverordnung – DüV). In der Fassung der Bekanntmachung vom 27. Februar 2007 (BGBl. I S.221).

DÜWEL, O., SIEBNER, C.S., UTERMANN, J., KRONE, F., 2007: Gehalte an organischer Substanz in Oberböden Deutschlands – Bericht über länderübergreifende Auswertung von Punktinformationen im FISBo BGR-“; BGR, Hannover

DUNGER, K.; OEHMICHEN, K.; STÜMER, W.; IOST, A.; RIEDEL, T. 2010c: Annex 3, Chapter 19.5.1: Other detailed methodological descriptions for the source/sink category “Land-use change and forestry” – Forest land (5.A), 575-585. In: Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2010. National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2008. Dessau: Federal Environment Agency, ISSN 1862-4359, 672 p.

EC, 2006a: European Commission, Joint Research Centre, Institute for Prospective Technological Studies: Integrated Pollution Prevention and Control – Reference Document on Best Available Techniques in the Production of Polymers. October 2006. Sevilla, Spain.

EC, 2007: European Commission, Joint Research Centre, Institute for Prospective Technological Studies: Integrated Pollution Prevention and Control – Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Solids and Others industry. October 2006. Sevilla, Spain.

EC, 2011: Fleet Register der Europäischen Kommission; URL:http://ec.europa.eu/fisheries/fleet/index.cfm?method=Search.SearchAdvanced&country=DEU, (Aufruf 10.10.2011)

EINIG, K., A. JONAS & B. ZASPEL, 2009: Eignung von CORINE-Geodaten und Daten der Flächenerhebung zur Analyse der Siedlungs- und Verkehrsflächenentwicklung in Deutschland. Statistisches Bundesamt - Wirtschaft und Statistik 4/2009, S.355 - 364

EMEP, 2003: Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook, 3rd Edition September 2003 UPDATE, EEA, Copenhagen, 2003

EMEP, 2005: European Environment Agency: EMEP/CORINAIR Emission Inventory Guidebook - 2005. Technical report No 30., Stand: 31.12.2005
URL: http://reports.eea.europa.eu/EMEPCORINAIR4/en/

EMEP (2006) -EMEP/CORINAIR Emission Inventory Guidebook – 2006, Technical Report No 11/2006. http://www.eea.europa.eu/publications/EMEPCORINAIR4

EMEP, 2009: EMEP (2009) -EMEP/EEA air pollutant emission inventory guidebook – 2009, Technical Report No 6/2009. http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009

EUROCONTROL, 2004 – The Advanced Emission Model (AEM3) - Validation Report, Jelinek, F., Carlier, S., Smith, J., EEC Report EEC/SEE/2004/004, Brüssel 2004. URL: http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2004_016.html

EUROCONTROL, 2006 – The Advanced Emission Model (AEM3) - Validation Report, Jelinek, F., Carlier, S., Smith, J., EEC Report EEC/SEE/2004/004, Brüssel 2004 URL: http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2004_016.html http://www.eurocontrol.int/eec/public/standard_page/DOC_Report_2006_030.html

FAO (Food and Agriculture Organization of the United Nations) 1990: Soil Map of the World. Revised Legend. Reprinted with corrections. FAO, Rome, World Soil Resources Report 60

FAO, Statistical Yearbook 2007-2008 (2010) ; Table D1: Dietary energy protein and fat consumption
http://www.fao.org/fileadmin/templates/ess/ess_test_folder/Publications/yearbook_2010/d01.xls

FAUSTZAHLEN (1993): Faustzahlen für Landwirtschaft und Gartenbau. 12th ed., Landwirtschaftsverlag, Münster, 1993

FHG ISI, 1993: Fraunhofer-Institut für Systemtechnik und Innovationsforschung: Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland: Emissionsbilanz, Identifikation von Forschungs- und Handlungsbedarf sowie Erarbeitung von Handlungsempfehlungen ; Phase 1, UBA-Berichte 93/09, FKZ 10402682, E. Schmidt-Verlag Berlin, 1993

FICHTNER et al. 2011: Fichtner, W; Karl, U; Hartel, R; Balussou, D: Fortschreibung der Emissionsfaktoren für Feuerungs- und Gasturbinenanlagen nach 13./17. BImSchV und TA Luft; Bericht zum Forschungsvorhaben des Umweltbundesamtes unter FKZ 3708 42 301, durchgeführt vom Deutsch-Französischen Institut für Umweltforschung (DFIU) und dem Europäischen Institut für Energieforschung (EIFER)

FISCHER, 1997: Klimawirksame Emissionen durch PKW-Klimaanlagen. Diplomarbeit an der TU Berlin, FB 10, ISS-Fahrzeugtechnik.

FOEN (Federal Office for the Environment) 2010: Switzerland´s Greenhouse Gas Inventory 1990 - 2008, Bern,Switzerland

FORTMANN, H., P. RADEMACHER, H. GROH & H. HÖPER (in Veröffentlichung): Stoffgehalte und –vorräte im Boden und deren Veränderungen; GeoBerichte des LBEG;

FRAVER et. al 2002, Fraver, S.; Wagner, R.G.; Day, M.; 2002. Dynamics of coarse woody debris following gap harvesting in the Acadian forest of central Main, U.S.A. Can. J. For. Res. 32, 2094-2105.

FRAUENHOFER ISI 2000: Reichert und Schön: "Methanemissionen durch den Einsatz von Gas in Deutschland von 1990 bis 1997 mit einem Ausblick auf 2010"; Auftragsnummer AG GI5-46043-3/31 im Auftrag des Deutschenvereins des Gas- und Wasserfaches e.V., Karlsruhe 2000

FREIBAUER, A. (2003): Regionalised inventory of biogenic greenhouse gas emissions from European agriculture. European Journal of Agronomy 19(2): 135-160

FREIBAUER, A.; GENSIOR, A. 2011: Annex 3, Chapter 19.5.2: Other detailed methodological descriptions for the source/sink category “Land-use change and forestry” (5) – Cropland, grassland, wetlands, settlements and other areas (5.B/5.C/5.D/5.E/5.F), 650-671. In: Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2011. National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2009. Dessau: Federal Environment Agency, ISSN 1862-4359, 755 p.

FULLER, R., SMITH, G. und DEVEREUX, B. (2003): The characterisation and measurement of land cover change through remote sensing: problems in operational applications. International Journal of Applied Earth Observation and Geoinormation 4: 234-253.

GDA, 2010: Gesamtverband der Aluminiumindustrie e.V. (GDA) – GDA Startseite – Produktion, URL: : http://www.aluinfo.de/index.php/produktion.html (Aufruf vom)

GENSIOR, A. & J. ZEITZ (1999): Einfluss einer Wiedervernässungsmaßnahme auf die Dynamik chemischer und physikalischer Bodeneigenschaften eines degradierten Niedermoores. Archiv für Naturschutz und Landschaftsforschung, 38, S. 267 – 302

GICON, 2008: Implementierung der Bilanz der Emissionsursachen auf Basis der MESAP-Datenbank Bachmann, Thomas; Kalies, Heiko GICON, Großmann Ingenieur Consult GmbH Niederlassung Leipzig 2008

GRUNDNER, F.; SCHWAPPACH, A. 1952: Massentafeln zur Bestimmung des Holzgehaltes stehender Waldbäume und Waldbestände. 10. Aufl. Verlag Paul Parey, Berlin, Hamburg, 216 S.

GSE 2003: Service ‘Forest Monitoring Inputs for Greenhouse Gas (GHG) Reporting’. Service Results 2003, Reporting Area: Main parts of the Federal State “Saxony”, Issue 1.0, 50 p.

GSE 2006: S6 Service Operations Report. Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting. Service to BMELV. GSEFM-T2-S6-Ph1. Issue 1.0, 125 p.

GSE 2007: S6 Service Operations Report. Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting. Service to BMELV. GSEFM-T3-S6-Ph2. Issue 2.1, 93 p.

GSE 2009: S6 Service Operations Report. Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting. Service to BMELV. GSEFM-T3-S6-Ph3. Issue1.0, 211 p.

HAENEL et al. (2011a): Haenel, H.-D.; Dämmgen, U.; Laubach, P.; Rösemann, C.: Update of the calculation of metabolizable energy requirements for pigs in the German agricultural emission inventory. Landbauforschung, 61: 217 – 228.

HAENEL et al. (2011b): Haenel, H.-D.; Dämmgen, U.; Rösemann, C.: Estimating numbers of piglets, weaners and fattening pigs for the German agricultural emission inventory. Landbauforschung, 61: 229 – 236.

HAENEL et al. (2012): Haenel, H.-D.; Rösemann, C.; Dämmgen, U.; Poddey, E.; Freibauer , A.; Döhler, H.; Eurich-Menden, B.; Wulf, S.; Dieterle, M.; Osterburg, B.: Calculation of gaseous and particulate emissions from German agriculture 1990 – 2010. Report on methods and data. Landbauforschung, Special Issue 356: http://www.vti.bund.de/fileadmin/dam_uploads/Institute/AK/PDFs/SH_356.zip

HÄUSSLER, T., SIEGMUND, R., RIEDEL, T. und KENTER, B. (2006): S6 Service Operations Report. Forest Monitoring Inputs for National Greenhouse Gas (GHG) Reporting. Service to BMELV. Stage 2 of the Earthwatch GMES Service Element. Technischer Bericht, GAF AG, München

HAKKILA, P. 1972: Utilisation of residual forest biomass. Springer-Verlag, Berlin, Heidelberg, New York, 568 S.

HENRICHSMEYER et al, 1996: Henrichsmeyer, W.; Cypris, Ch.; Löhe, W.; Meuth, M.; Isermeyer F; Heinrich, I.; Schefski, A.; Neander, E.; Fasterding, F.;, Neumann, M.; Nieberg, H.: Entwicklung des gesamtdeutschen Agrarsektormodells RAUMIS96. Endbericht zum Kooperationsprojekt. Forschungsbericht für das BMELF (94 HS 021), Bonn, Braunschweig

HOBBS et al., 2004: Hobbs P.J.; Webb J.; Mottram T.T.; Grant B.; Misselbrook T.M.: Emissions of volatile organic compounds originating from UK livestock agriculture. J Science of Food and Agriculture 84, 1414-1420

HÖPER, H. (2002): Carbon and nitrogen mineralization rates in German agriculturally used fenlands. In: Broll, G. Merbach, W. und E.-M. Pfeiffer (Hrsg.): Wetlands in Central Europe. Soil organisms, soil ecological processes, and trace gas emissions. Springer, Berlin, 149-164.

HVG, 2008: Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung. Teilvorhaben 02: Bereitstellung aktueller Emissionsdaten für die Glas- und Mineralfaserindustrie., Forschungsbericht in Veröffentlichung

IER, 2008: Institut für Energiewirtschaft und Rationelle Energieanwendung Stuttgart (Herausgeber),: Theloke, Jochen; Wagner, Susanne; Jepsen Dirk: Emissionen aus der Nahrungsmittelindustrie, Forschungsbericht UBA-FB 001480, FKZ 206 42 101/01.

IFE, 1991: IfE Leipzig GmbH, Energiebilanz 1990 für die neuen Bundesländer. Von Jochen Hesselbach und Mitarbeit von Bernd Lemmnitz, Elke Lindner, Hans-Albert Müller und Ursula Zehrfeld. Untersuchung im Auftrag des Bundesministers für Wirtschaft, Leipzig 1991

IFEU, 2002, Knörr, W. et al, IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Aktualisierung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen aus dem motorisierten Verkehr in Deutschland 1980 bis 2020; sowie TREMOD 3.0 ; im Auftrag des Umweltbundesamtes, FKZ 201 45 112; Berlin 2002

IFEU, 2003a: Detzel, A., Vogt, R., Fehrenbach, H., Knappe, F., Gromke, U., IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Anpassung der deutschen Methodik zur rechnerischen Emissionsermittlung an internationale Richtlinien. Teil Abfall/Abwasser, Februar 2003

IFEU, 2009: Helms, H., Lambrecht, U., Knörr, W. , IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Aktualisierung des Modells TREMOD-Mobile Machinery , im Auftrag des Umweltbundesamtes, FKZ 360 16 018, Heidelberg, Korrigendum 11.02.2010.

IFEU, 2011: Knörr, W. et al, IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motoriserten Verkehrs in Deutschland 1960-2030, , sowie TREMOD 5.3, im Auftrag des Umweltbundesamtes, FKZ 3707 45 101, Berlin.

IFEU & INFRAS, 2009: IFEU – Institut für Energie- und Umweltforschung Heidelberg gGmbH und INFRAS Zürich: Ermittlung der Unsicherheiten der mit den Modellen TREMOD und TREMOD-MM berechneten Luftschadstoffemissionen des landgebundenen Verkehrs in Deutschland, FKZ 360 16 023, Heidelberg & Zürich.

IFEU & ÖKO-INSTITUT, 2010: Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV), Endbericht zum F+E-Vorhaben 360 16 029, Berlin & Heidelberg, November 2010

IGZ (2007): IGZ – Institut für Gemüse- und Zierpflanzenbau, Großbeeren/Erfurt. Düngung im Freilandgemüsebau – Datenbasis für eine erfolgreiche Düngung im Freilandgemüsebau (2. Auflage). Berlin/Bonn. http://www.igzev.de/files/Dueng_im_FGB.pdf

IKP, 1996: Institut für Kunststoffprüfung und Kunststoffkunde (IKP), Universität Stuttgart: Ganzheitliche Bilanzierung von Dachbahnen aus Bitumen. In elektronischer Form über die UBA-Fachbibliothek zu beziehen (Signatur UM 381318)

INFRAS, 2010: Handbuch der Emissionsfaktoren 3.1 -, Bern, Januar 2010: URL: http://www.hbefa.net

IPCC, 1996a: Intergovernmental Panel on Climate Change: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Workbook, 1996

IPCC, 1996b: Intergovernmental Panel on Climate Change: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3: Reference Manual, 1996

IPCC, 1996c: Intergovernmental Panel on the Climate Change, Emission Inventory Guidebook, 1996: B 465, B466, B 644

IPCC, 1999: Intergovernmental Panel on Climate Change: Aviation and the Global Atmosphere, Kapitel 9, Aircraft Emissions: Current Inventories and Future Scenarios, Cambridge University Press, 1999

IPCC, 2000: Intergovernmental Panel on Climate Change, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, IPCC Secretariat, 16th Session, Montreal, 1-8 May 2000 http://www.ipcc-nggip.iges.or.jp/public/gp/english/

IPCC, 2003: Intergovernmental Panel on Climate Change: Good Practice Guidance for Land Use, Land-Use Change and Forestry. vi + 307 S.

IPCC, 2004: Intergovernmental Panel on Climate Change: Synthesis and Assessment Report on the Greenhouse Gas Inventories submitted in 2004, Part I. FCCC/WEB/SAI/2004. Bonn.

IPCC, 2006: Intergovernmental Panel on Climate Change: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Reference Manual, Volume 4, 2006

IPCC 2006a – Intergovernmental Panel on Climate Change: Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 3_ Mobile Combustion, S. 3.61; URL: http://www.ipccnggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

IPCC, 2006b – Intergovernmental Panel on Climate Change: Datenbank für Emissionsfaktoren des IPCC; URL: http://www.ipcc-nggip.iges.or.jp/EFDB/main.php

IPCC 2006c: IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 6 Wastewater Treatment and Discharge, 2006

IPCC, 2007: Intergovernmental Panel on Climate Change: IPCC Fourth Assessment Report: Climate Change 2007 URL: http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html

IPCC, et al, 1997: IPCC/UNEP/OECD/IEA: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Greenhouse Gas Inventory. Volume 3. Reference Manual. URL: http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm

IVT 2004: Institut für angewandte Verkehrs- und tourismusforschung e.V.: Fahrleistungserhebung 2002, Teil: Begleitung und Auswertung. Untersuchung im Auftrag der Bundesanstalt für Straßenwesen, Projektnummer FE 82.201/2001. Heilbronn/Mannheim.

JARVIS & PAIN, 1994: Jarvis, S.C.; Pain, B.F.: Greenhouse gas emissions from intensive livestock systems: their estimation and technologies for reduction. Climatic Change 27, 27-38.

KIRCHGESSNER, M.; ROTH, F.X.; SCHWARZ, F.J.; STANGL, G.I. (2008): Tierernährung. 12. Auflage. DLG-Verlag, Frankfurt a.M., 635 S.

KNIGGE, W.; SCHULZ, H. (1966): Grundriss der Forstbenutzung. Paul Parey Verlag, Hamburg und Berlin, 584 S.

KÖNIG, H.-C., 2007. Waldbrandschutz - Kompendium für Forst und Feuerwehr, 1. Fachverlag Matthias Grimm, Berlin, 197 pp.

KÖNIG, N.; BLUM, U.; SYMOSSEK, F.; BUSSIAN, B.; ELLINGHAUS, R.; FURTMANN, K.; GÄRTNER, A.; GUTWASSER, F.; HAUENSTEIN, M.; KIESLING, G.; KLINGENBERG, U.; KLINGER, T; MÖLLER, A.; NACK, T.; REICHELT, L.; SCHIMMING, C.; STAHN, M.; TREFZ-

MALCHER, G.; UTERMANN, J. 2005: Handbuch Forstliche Analytik. Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Bonn, 510 S. http://www.bmelv.de/SharedDocs/Standardartikel/Landwirtschaft/Wald-Jagd/WaldBodenZustand/Handbuch-Forstliche-Analytik.html

KOLLMANN, F. 1982: Technologie des Holzes und der Holzwerkstoffe. Springer-Verlag, Berlin, Heidelberg, New York

KONOPATZKY, A. 2009: Die Veränderungen von Corg- und Nt-Zuständen der Waldböden im Norddeutschen Tiefland am Beispiel Brandenburgs. Tagungsbeitrag zu Kommission III, Böden eine endliche Ressource. DBG, Bonn, 4 S., http://eprints.dbges.de/373/

KORRESPONDENZ ABWASSER, ABFALL 2009: Organ der DWA und des Güteschutz Kanalbau, 56. Jahrgang, Nr. 11, November 2009

KTBL, 2005: Methodenaktualisierung für die Emissionsberechung 2003. F+E Vorhaben 203 412 53 des UFOPLAN 2003. Teilvorhaben 04: EF Landwirtschaft: Landwirtschaft – Ermittlung und Anpassung von Emissionsfaktoren (CRF 4). Abschlussbericht. KTBL, Darmstadt, 90 S.

KURZ, W.A.; BEUKEMA, S.J.; APPS, M.J. (1996): Estimation of root biomass and dynamics for the carbon budget model of the Canadian forest sector, Can. J. For. Res., Nr. 26 (11), pp.1973-1979

LABER, H. (2005): Biologische N_2-Fixierung von Gemüseerbsen und –buschbohnen. In: Infodienst 02/2005 für Beratung und Schule der Sächsischen Agrarverwaltung. Sächsische Landesanstalt für Landwirtschaft (Hrsg.), 81-89

LALE, Andreas 2000: Langzeitemissionsverhalten von Deponien für Siedlungsabfälle in den neuen Bundesländern. TU Dresden, Dissertation; Fakultät Forst-, Geo- und Hydrowissenschaften.

LANGE, Hans-Jürgen, 1988: Kokereien. VOC aus Produktemissionen. Umweltbundesamt. Vermerk. Blatt 2.2.88 vorbehaltlich weiterer Recherchen. Angaben für 1990 – 1995, Angenommener VOC Anteil von 50%. Unveröffentlicht.

LECHTENBÖHMER et al, 2005: Lechtenböhmer, S.; Harthan, R.; Dämmgen, U.; Strogies, M: Umsetzung des Inventarplanes und nationale unabhängige Überprüfung der Emissionsinventare für Treibhausgase. Teilvorhaben 01. Pilotstudie unabhängige bilaterale Inventarüberprüfung. Endbericht im Auftrag des Umweltbundesamts FKZ: 202 42 203. unveröffentlicht.

LENK et al., 2005: Auswirkungen des Tanktourismus auf das deutsche Steueraufkommen – eine finanzwissenschaftliche Bestandsaufnahme; Leipzig, 2005

LINDE GAS GMBH, 2005: Aufschäumen von Molkereiprodukten; URL: http://www.lindegas.at/international/web/lg/at/likelgatn.nsf/PrintView/63ED15ADE8FCF595C1256B7B004C6250 , Zugriff Mai 2005

LISKI, J. 1995: Variation in soil organic carbon and thickness of soil horizons within a boreal forest stand - effect of trees and implications for sampling. Silva Fennica, 29, 255–266

LISKI J.; PERRUCHOUD, D.; KARJALAINEN, T. 2002: Increasing carbon stocks in the forest soils of Western Europe. Forest Ecology and Management, 169, 159-175

LUO, Z., WANG, E., SUN, O.J., 2010: Can no-tillage stimulate carbon sequestration in agricultural soils? A meta-analysis of paired experiments. Agriculture, Ecosystems and Environment, 139, 224 – 231

MEYER, K., 1999: Die Flüsse der klimarelevanten Gase CO_2, CH_4, N_2O eines nordwestdeutschen Niedermoores unter dem Einfluss der Wiedervernässung. Göttinger Bodenkundliche Berichte, 111, 134 S.

MELLERT, K.; WEIS, W.; RÜCKER, G. 2007: Ermittlung der (potentiell) zu erwartenden Signalstärke von Bodenveränderungen – Grundlage für die Bewertung und Interpretation von Ergebnissen der BZE II. BFH, Eberswalde, 92 S., http://bfh-web.fh-eberswalde.de/bze/front_content.php?idcat=120&idart=224

MNUW, 1990:·Ministerium für Naturschutz, Umweltschutz und Wasserwirtschaft 1990): Umweltbericht der DDR – Informationen zur Analyse der Umweltbedingungen in der DDR und zu weiteren Maßnahmen, März 1990, statistische Angaben für das Aufkommen an Siedlungsabfall für das Gebiet der ehemaligen DDR Tabelle 12, S. 56

MOKANY, K., R.J. RAISON & A.S. PROKUSHKIN, 2006: Critical analysis of root:shoot ratios in terrestrial biomes. Global Change Biology, 12, 84 - 96

MÜLLER-BBM (2009a): „Inventarverbesserung 2008, Verbesserung und Ergänzung der aktuellen Inventardaten, IPCC-Kategorie (1996) 1.B.2 Diffuse Emissionen aus Erdöl und Erdgas“, Müller-BBM; Bericht Nr. M 76 595/4, UBA FKZ 360 16 012, 136 S.

MÜLLER-BBM (2009b): „Aufbereitung von Daten der Emissionserklärungen gemäß 11. BImSchV aus dem Jahre 2004 für die Verwendung bei der UNFCC- und UNECE-Berichterstattung - Bereich Lageranlagen“, Müller-BBM Bericht Nr. M74 244/7, UBA FKZ 3707 42 103/01, 31 S.

MÜLLER-USING, S.; BARTSCH, N.; 2009. Decay dynamic of coarse and fine woody debris of a beech (Fagus sylvatica L.) forest in Central Germany. Eur J Forest Res, 128, 287-296

MUNDEL, G. (1976): Untersuchungen zur Torfmineralisation in Niedermooren.- Archiv Acker-, Pflanzenbau und Bodenkunde. H. 10, 20: 669-679

MWV, 2006: Mineralölwirtschaftsverband, „Mineralölzahlen 2005“.

MWV, 2010: Mineralölwirtschaftsverband: „Mineralölzahlen 2009“
URL: http://www.mwv.de/cms/front_content.php?idcat=10, (Aufruf: 10.11.2010), und MWV Jahresbericht Mineralölzahlen 2009
URL: http://www.mwv.de/cms/upload/pdf/jahresberichte/2009_JB.pdf, (Aufruf: 10.11.2010), Berlin.

MWV, 2011: Mineralölwirtschaftsverband: „Mineralölzahlen 2010“
URL: http://www.mwv.de/index.php/daten/statistikeninfoportal, (Aufruf: 27.09.2011), und MWV Jahresbericht Mineralölzahlen 2010
URL: http://www.mwv.de/upload/Publikationen/dateien/JB_2010_dNrnbxXn6f7j2mf.pdf, (Aufruf: 27.09.2011), Berlin.

NABUURS G.J.; SCHELHAAS M.J. 2002: Carbon profiles of typical forest types across Europe assessed with CO2FIX. Ecological Indicators, 1, 3, 213-223

OECD/IEA, 2011: CO_2-Emissions from fuel combustion 2011 Edition - Highlights, OECD & IEA, Paris, URL: http://www.iea.org/co2highlights/co2highlights.pdf

OEHMICHEN, K., DEMANT, B., DUNGER, K., GRÜNEBERG, E., HENNIG, P., KROIHER, K., NEUBAUER, M., POLLEY, H., RIEDEL, T., ROCK, J., SCHWITZGEBEL, F., STÜMER, W., WELLBROCK, N., ZICHE, D. und BOLTE, A. (2011): Inventurstudie 2008 und Treibhausgasinventar Wald, Band 343. Landbauforschung — vTI Agriculture and Forestry Research. ISBN 978-3-86576-069-2

OEHMICHEN, K.; DUNGER, K.; Steuk, J.; STÜMER, W.; RIEDEL, T. 2011b: Annex 3, Chapter 19.5.1: Other detailed methodological descriptions for the source/sink category "Land-use change and forestry" (5) – Forest land (5.A), 637-649. In: Submission under the United Nations Framework Convention on Climate Change and the Kyoto Protocol 2011. National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2009. Dessau: Federal Environment Agency, ISSN 1862-4359, 755 p.

ÖKO-INSTITUT, 2004a: Arbeitsergebnisse aus dem F+E-Vorhaben 201 42 258 Unterstützung beim Aufbau eines Nationalen Systems für eine transparente Erhebung der Grundlagendaten und für die Emissionsberichterstattung entsprechend Artikel 5(1) des Kyoto-Protokolls, Auftragnehmer Öko-Institut, noch bis 15.10.2005 laufend (unveröffentlicht)

ÖKO-INSTITUT, 2004b: Emissionen in Abwasser- und Schlammbehandlung. Arbeitspapier im Rahmen des dem F+E-Vorhaben 201 42 258 Unterstützung beim Aufbau eines Nationalen Systems für eine transparente Erhebung der Grundlagendaten und für die Emissionsberichterstattung entsprechend Artikel 5(1) des Kyoto-Protokolls (unveröffentlicht)

ÖKO-INSTITUT, 2004c: CO_2 Emisssionsfaktoren für die Erstellung der nationalen CO_2-Inventare. Teilbericht für den nationalen Inventarbericht 2004.

ÖKO-INSTITUT, 2005 Analyse, Dokumentation und Überarbeitung der Bilanz der Emissionsursachen(BEU) / Verena Graichen, Ralph O. Harthan, Julia Repenning Weitere Titel Zeitnahe Erfassung und Bewertung des Energieumsatzes von stationären Quellen als Grundlage für strategische Entscheidungen, Bewertungen von Maßnahmen und die Erfüllung internationaler Berichtspflichten im Bereich Klimaschutz und Luftreinhaltung

ÖKO-INSTITUT, 2006a: Kurzstudie - Stand und Entwicklung von Treibhausgasemissionen in den Vorketten für Erdöl und Erdgas für das Institut für wirtschaftliche Oelheizung e.V. (IWO), Endbericht erstellt von Uwe R. Fritsche. Darmstadt, Juli 2006.

ÖKO-INSTITUT, 2006b: Datenaustausch zwischen Emissionshandel und Nationaler Klimaschutzberichterstattung, Abschlussbericht zum F+E-Vorhaben FKZ 205 41 521, Berlin, Dezember 2006. Unveröffentlicht.

ÖKO-INSTITUT, 2009: Überarbeitung des Emissionsinventars des Flugverkehrs, vorläufiger Endbericht zum F+E-Vorhaben FKZ 360 16 019, Berlin, August 2009.

ÖKO-INSTITUT, 2011: Inventartool zum deutschen Flugverkehrsinventar 1990-2010, im Rahmen des F+E-Vorhabens FKZ 360 16 029: Entwicklung eines eigenständigen Modells zur Berechnung des Flugverkehrs (TREMOD-AV), Berlin, 2011ÖKO-INSTITUT / DIW 2007 (Öko-Institut – Institut für angewandte Ökologie e.V.) / DIW (Deutsches Institut für Wirtschaftsforschung) 2007: Dokumentation der Datenqualität von Aktivitätsdatenfür die Berichte über Emissionen aus stationären Feuerungen im Rahmendes Nationalen Inventarberichtes und des Monitoring Mechanismus nach RLEG 99/296; Endbericht zum F&E-Vorhaben FKZ 204 41 132 i.A. des UBA; Berlin

ÖKO-RECHERCHE, 1996, Büro für Umweltforschung und –beratung GmbH: Aktuelle und künftige Emissionen treibhauswirksamer fluorierter Verbindungen in Deutschland, im Auftrag des UBA, FKZ 106 01 074/01, Frankfurt am Main, 1996

ÖKO-RECHERCHE, 2001: Emissionen des Kältemittels R-134a aus mobilen Klimaanlagen. Jährliche Emissionsraten von bis zu sieben Jahre alten PKW-Klimaanlagen, Gutachten für das Umweltbundesamt Berlin, Frankfurt.

ÖKO-RECHERCHE, 2005: Emissionen und Emissionsprognose von H-FKW, FKW und SF6 in Deutschland - Aktueller Stand und Entwicklung eines Systems zur jährlichen Ermittlung (Emissionsdaten bis 2003 und Emissionsprognosen für die Jahre 2010 und 2020), Gutachten im Auftrag des Umweltbundesamtes, Dessau, FKZ 202 41 356. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennummer&Suchwort=3000

ÖKO-RECHERCHE, 2007: Daten von H-FKW, FKW und SF6 für die nationale Emissionsberichterstattung gemäß Klimarahmenkonvention für die Berichtsjahre 2004 und 2005 (F-Gas-Emissionen 2004/2005 und Unsicherheitsbestimmung im ZSE), Gutachten im Auftrag des Umweltbundesamtes, Dessau, FKZ 205 41 217/01. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennummer&Suchwort=3439

ÖKO-RECHERCHE, 2009: Öko-Recherche - Büro für Umweltforschung und –beratung GmbH, Dr. Winfried Schwarz: SF_6 und NF_3 in der deutschen Photovoltaik-Industrie - Inventarverbesserung 2008 – Verbesserung und Ergänzung der Daten für die nationale Emissionsberichterstattung gemäß Klimarahmenkonvention in der Quellgruppe Photovoltaik (2.F.9.h), Endbericht, FuE-Vorhaben FKZ 360 16 027, Frankfurt a.M., Dezember 2009.

ÖKO-RECHERCHE, Ecofys, 2003: Establishing the Leakage Rates of Mobile Air Conditioners. Report on the EU Commission (DG Environment). B4-3040/2002/337136/MAR/C1. Frankfurt/Nürnberg.

ORELLAS, D.L.,1982: Heat and Products of Detonation for Explosives, Lawrence Livermore National Laboratory, University of California, USA, April 5th

OSOWSKI, S., J. NEUMANN & H. FAHLENKAMP (2004): Nutzung biogener Festbrennstoffe in Vergasungsanlagen. Chemie Ingenieur Technik, 76, No. 7

PAUL, C.; WEBER, M.; MOSANDL, R. 2009: Kohlenstoffbindung junger Aufforstungsflächen. München: Karl Gayer Institut & Technische Universität München, Lehrstuhl für Waldbau, 70 S (unveröffentlicht)

PENNSTATE COLLEGE OF AGRICULTURAL SCIENCES (2011): Calf Rumen Images. http://www.das.psu.edu/research-extension/dairy/nutrition/calves/rumen [2011-02-15]

PISTORIUS, T.; ZELL, J.; HARTEBRODT, C. (2006): Untersuchungen zur Rolle des Waldes und der Forstwirtschaft im Kohlenstoffhaushalt des Landes Baden-Württemberg; Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg, Institut für Forstökonomie, Technischer Bericht; 224 S.

PÖPKEN, S., 2011: Obstanbau, Weinanbau und Weihnachtsbaumkulturen in Deutschland. Zwischenbericht des Forschungsprojekts „Methodenentwicklung zur Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Waldflächen"; Johann Heinrich von Thünen-Institut, Institut für Weltforstwirtschaft

PREISEGGER, 1999: Solvay Fluor und Derivate GmbH: Automotive Air Conditioning Impact of Refrigerant on Global Warming, in: Joint IPCC/TEAP Expert Meeting on Options for the Limitation of Emissions of HFCs and PFCs, Petten, 26-28 May 1999.

PRIETZEL, J.; STETTER, U.; KLEMMT, H.-J.; REHFUESS, K.E. 2006: Recent carbon and nitrogen accumulation and acidification in soils of two Scots pine ecosystems in Southern Germany. Plant and Soil, 289, 153-170

PROGNOS, 2000: Anwendung des IPCC-Referenzverfahrens zur Ermittlung der verbrennungsbedingten CO_2-Emissionen in Deutschland, Forschungsprojekt des UBA, FKZ 29744850, 2000

RENTZ et al, 2002: Rentz, Otto; Karl, Ute; Peter, H.: Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010, Bericht zum Forschungsprojekt des Umweltbundesamtes unter FKZ 299 43 142, durchgeführt vom DFIU (Universität Karlsruhe, Deutsch-Französisches Institut für Umweltforschung)

RENTZ et al. 2002b: O. Rentz, K. Gütling und U. Karl 2002: Erarbeitung der Grundlagen für das BVT-Merkblatt Großfeuerungsanlagen im Rahmen des Informationsaustausches nach Art. 16(2) IVU-Richtlinie, Forschungsbericht 200 46 317, Gutachten im Auftrag des Umweltbundesamtes.

RETTENBERGER et al, 1997: RETTENBERGER, STEGMANN: Neue Aspekte der Deponiegasnutzung. Trierer Berichte zur Abfallwirtschaft Band 11. Economia-Verlag Bonn 1997. u.a. S. 268, 319

RÖSEMANN et al. 2011: Rösemann C, Haenel H-D, Poddey E, Dämmgen U, Döhler H, Eurich-Menden B, Laubach P, Dieterle M, Osterburg B: Calculation of gaseous and particulate emissions from German agriculture 1990 – 2009. Methods and data. Landbauforschung - vTI Agriculture and Forestry Research, Sonderheft 342

SACHS, L. 1984: Angewandte Statistik. Bd. 6. Aufl., Springer-Verlag, Berlin, Heidelberg, New York, Tokyo.

SCHÖN, WALZ, et al. 1993: Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland : Emissionsbilanz, Identifikation von Forschungs- und Handlungsbedarf sowie Erarbeitung von Handlungsempfehlungen, ISBN 3-503-03495-1

SCHÖNING, I.; TOTSCHE, K.U.; KOGEL-KNABNER, I. 2006: Small scale spatial variability of organic carbon stocks in litter and solum of a forested Luvisol. Geoderma, 136, 631-642

SCHULZE, E-D.; HÖGBERG, P.; VAN OENE, H.; PERSSSON, T.; HARRISON, A. F.; READ, D. J.; KJÖLLER, A.; MATTEUCCI, G. 2000: Interactions between the carbon and nitrogen cycle and the role of biodiversity. Ecological Studies, 142, 468–492

SCHWITZGEBEL , F.; DUNGER, K.; POLLEY, H. 2009: Die Inventurstudie 2008. Ergebnisse einer Kohlenstoffinventur auf Bundeswaldinventur-Basis. Hintergrund, Methodik und Durchführung der Studie. Allg Forst Z Waldwirtsch Umweltvorsorge 64: 1070-1071

SENSER et al, 1991: SENSER F, SCHERZ H.: Der Kleine "Souci-Fachmann-Kraut", Lebensmitteltabelle für die Praxis, 2. Auflage Wissenschaftliche Verlagsgesellschaft mbH, Stuttgart

SIEGL et al., 2002: R-134a Emissions from Vehicles, ENVIRON. SCI & TECHNOL., VOL. 36, 561-566.

SIX, J.; CONTANT, R.T.; PAPUL, E.A.& PAUSTIAN, K. (2002): Stabilization Mechanisms Of Soil Organic Matter: Implications For C-Saturation Of Soils. Plant And Soil, 241, 155-176

STATISTIK DER KOHLENWIRTSCHAFT e.V o.J.: Statistik der Kohlenwirtschaft, „Herstellung von Braunkohlenbriketts, Braunkohlenkoks, Staub-, Trocken- und Wirbelschichtkohle nach Revieren“, www.kohlenstatistik.de (Aufruf: 10.10.2011)

STATISTISCHES BUNDESAMT, 1992: Statistisches Bundesamt, Statistisches Jahrbuch 1992 für die Bundesrepublik Deutschland, Tab. 26.2.1 An Abfallbeseitigungsanlagen angelieferte Abfallmengen nach Art der Anlagen, Tab. 26.2.2 An Abfallbeseitigungsanlagen angelieferte Abfallmengen nach Abfallarten

STATISTISCHES BUNDESAMT, 2002c: Statistisches Bundesamt, Klassifikation der Wirtschaftszweige, Ausgabe 1993 (WZ93), Wiesbaden 2002.

STATISTISCHES BUNDESAMT, 2008, Klassifikation der Wirtschaftszweige mit Erläuterungen 2008, Wiesbaden.
URL:
http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Klassifikationen/GueterWirtschaftklassifikationen/Content75/KlassifikationWZ08,templateId=renderPrint.psml

STATISTISCHES BUNDESAMT 2010a: Statistisches Bundesamt, Statistik 066 „Monatsberichte über die Elektrizitätsversorgung / Dezember 2009“ Tab. 3.2 und Tab. 5b.

STATISTISCHES BUNDESAMT, 2010b: Statistisches Bundesamt, Statistik 060: Auswertungen des Statistischen Bundesamtes der Bundesrepublik Deutschland „Energieverwendung der Betriebe des Verarbeitenden Gewerbes sowie Bergbaus und Gewinnung von Steinen und Erden“

STATISTISCHES BUNDESAMT, 2010c: Statistisches Bundesamt, Statistik 067: Auswertungen des Statistischen Bundesamtes der Bundesrepublik Deutschland „Stromerzeugungsanlagen der Betriebe des Verarbeitenden Gewerbes sowie Bergbaus und Gewinnung von Steinen und Erden“

STATISTISCHES BUNDESAMT, 2010e Umweltnutzung und Wirtschaft, Bericht zu den Umweltökonomischen Gesamtrechnungen (2010)

[STATISTISCHES BUNDESAMT, 2010f Umweltnutzung und Wirtschaft, Tabellen zu den umweltökonomischen Gesamtrechnungen, Teil 4: Wassereinsatz, Abwasser, Abfall, Flächennutzung, Umweltschutzmaßnahmen (2010)

STATISTISCHES BUNDESAMT, 2011: Statistisches Jahrbuch 2011, erschienen im September 2011 unter http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Navigation/Publikationen/Querschnittsveroeffentlichungen/Jahrbuch,templateId=renderPrint.psml__nnn=true

STATISTISCHES BUNDESAMT, 2011: Außenhandelsstatistik, Online-Abfrage (GENESIS) für die WA-Nr. 28362000 durch das UBA (Stand: 30.06.2011/ 14:49:01), Ausfuhr und Einfuhr nach Gewicht, Datei gesichert in der Inventarbeschreibung des UBA, Dessau-Roßlau 2011.

STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 3, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung und pflanzliche Erzeugung (div. Jgg.)

STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 3.1.2, Land- und Forstwirtschaft, Fischerei,– Bodennutzung der Betriebe (Landwirtschaftlich genutzte Flächen); (div. Jgg.)

STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 3.1.4, Land- und Forstwirtschaft, Fischerei, Landwirtschaftliche Bodennutzung - Baumobstflächen - 2007

STATISTISCHES BUNDESAMT, Fachserie 3, Reihe 3.2.1, Land- und Forstwirtschaft, Fischerei, Wachstum und Ernte – Feldfrüchte; (div. Jgg.)

STATISTISCHES BUNDESAMT, FACHSERIE 3, Reihe 3.2.2, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 3.2.2: Erhebung der Weinerzeugung - Wein- und Mostmengen nach Qualitätsstufen und Weinmostart (Weißmost/Rotmost)

STATISTISCHES BUNDESAMT, Fachserie 3 Reihe 4, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 4: Viehbestand und tierische Erzeugung.

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 3.1, Jg. ab 1991: Statistisches Bundesamt, Fachserie 4, Reihe 3.1: Produzierendes Gewerbe - Produktion im produzierenden Gewerbe, Wiesbaden

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 4.1.1, Jg. ab 1991-2003: Statistisches Bundesamt, Fachserie 4, Reihe 4.1.1: Erhebung über die Energieverwendung der Betriebe des verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden, Wiesbaden

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 6.4, Jg. ab 1991: Statistisches Bundesamt, Fachserie 4, Reihe 6.4: Stromerzeugungsanlagen der Betriebe im Bergbau und im verarbeitenden Gewerbe, Wiesbaden.

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 8.1, versch. Jahrgänge bis 2009: Statistisches Bundesamt; Fachserie 4, Reihe 8.1; Eisen und Stahl, Poeschel-Verlag

STATISTISCHES BUNDESAMT, Fachserie 4 Reihe 8.2, Jg. ab 1990: Statistisches Bundesamt, Fachserie 4, Reihe 8.2: Produzierendes Gewerbe, Düngemittelversorgung, Wiesbaden.

STATISTISCHES BUNDESAMT, Fachserie 8 Reihe 4, Jg. ab 1991: Statistisches Bundesamt, Fachserie 8, Reihe 4: Binnenschifffahrt (für die Jahre 1990-2003), Wiesbaden.

STATISTISCHES BUNDESAMT, Fachserie 19 Reihe 1, Jg ab 1990: Statisisches Bundesamt, Fachserie 19, Reihe 1: Umwelt, Abfallentsorgung.

STATISTISCHES BUNDESAMT, Fachserie 19, Reihe 2.1, 2011: Statistisches Bundesamt, Fachserie 19, Reihe 2.1: Öffentliche Wasserversorgung und Abwasserbeseitigung, Klärschlamm (für die Jahre 1991, 1995, 1998, 2001, 2004, 2007), Wiesbaden

STATISTISCHES BUNDESAMT, Fachserie 19 Reihe 2.2: Umwelt, Nichtöffentliche Wasserversorgung und Abwasserbeseitigung 2007 (2009)

STATISTISCHES BUNDESAMT, BGS-Bögen unveröffentlicht (Brennstoff-, Gas- und Stromwirtschaft der Hochofen-, Stahl- und Walzwerke sowie Schmiede-, Press- und Hammerwerke einschließlich der oertlich verbundenen sonstigen Betriebe (ohne eigene Kokerei))- Zusammenfassung der Erfassungsbögen der Eisen- und Stahl-Statistik (FS 4 Reihe 8.1)

STATISTIK DER KOHLEWIRTSCHAFT e.V. Übersichten Download: URL:http://www.kohlenstatistik.de/home.htm (Aufruf 10.10.2011)

STEHFEST E, BOUWMAN L, 2006: N_2O und NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modelling of global emissions. Nutr. Cyl. Agroecosyst. 74, 207-228

STEUK, J. 2010: Vorgaben zur Bewirtschaftung von Wald in Deutschland im Kontext internationaler Vorgaben nach IPCC. vTI-WOI Eberswalde (unveröffentlicht).

STRAUSS, Karl 1998: Kraftwerkstechnik zur Nutzung fossiler, regenerativer und nuklearer Energiequellen. 4. Auflage. Springer-Verlag.

STRUSCHKA, 2008: Struschka, Dr. M., Kilgus, D., Springmann, M.; Baumbach, Prof.Dr. Günter: Effiziente Bereitstellung aktueller Emissonsdaten für die Luftreinhaltung; UBA-Forschungsbericht 205 42 322; Dessau, 2008.

TA LUFT, 1986: Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz, TA Luft - Technische Anleitung zur Reinhaltung der Luft, vom 27. Februar 1986, Gemeinsames Ministerialblatt S. 95, ber. S. 202)

TA LUFT, 2002: Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz, TA Luft - Technische Anleitung zur Reinhaltung der Luft, vom 24. Juli 2002, Gemeinsames Ministerialblatt (GMBl). Nr. 25 - 29 vom 30.7. 2002 S. 511ff.

TOMTER, S.M., HYLEN, G. & NILSEN, J.-E. 2010: Development of Norway's National Forest Inventory. In: Tomppo, E., Gschwantner, T., Lawrence, M. & McRoberts, R.E. (eds.): National Forest Inventories. Pathways for common reporting, pp. 411-424. Springer, Heidelberg. ISBN 978-90-481-3232-4.

UBA, 1983: Greiner, B., Barghoorn, M. Dobberstein, J., Eder, G., Fuchs, J., Gössele, P.: Chemisch-physikalische Analyse von Hausmüll. Forschungsbericht 83-033 im Auftrag des Umweltbundesamted, Berlin.

UBA, 1986: Barghoorn, M., Gössele, P., Kaworski, W.: Bundesweite Hausmüllanalyse 1983-85, Forschungsbericht 10303508 im Auftrag des Umweltbundesamtes, Berlin.

UBA, 1989b: Luftreinhaltung '88. Tendenzen - Probleme - Lösungen. Materialien zum Vierten Immissionsschutzbericht der Bundesregierung an den Deutschen Bundestag (Drucksache 11/2714) nach Paragraph 61 Bundes-Immissionsschutzgesetz Körperschaft, erschienen Berlin Schmidt, E.

UBA, 1993: Umweltbundesamt: UBA-Text 9/93, Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland. Auftragnehmer: Schön, M. et al. Fhg-ISI

UBA, 2000a: UBA-Text 14/00: Pfeiffer, Frank / Struschka, Michael / Baumbach, Günter: Ermittlung der mittleren Emissionsfaktoren zur Darstellung der Emissionsentwicklung aus Feuerungsanlagen im Bereich der Haushalte und Kleinverbraucher, Institut für Verfahrenstechnik und Dampfkesselwesen, Universität Stuttgart, Herausgeber: Umweltbundesamt, FKZ 299 42 245 / 02, Berlin

UBA, 2001: German Notes on BAT for the production of Large Volume Solid Inorganic Chemicals – Soda. URL: www.bvt.umweltbundesamt.de/archiv/sodad.pdf english: www.bvt.umweltbundesamt.de/archiv-e/sodae.pdf)

UBA, 2003a: Projekthandbuch Decor, Umweltbundesamt, Förderkennzeichen IT 20, in Bearbeitung

UBA, 2004: IZT, KPMG, DFIU: Arbeitsergebnisse aus dem F+E-Vorhaben 202 42 266 „Bestimmung und Einführung von Methoden zur Qualitätssicherung und Qualitätskontrolle für die deutschen Inventare der Treibhausgasemissionen entsprechend den Vorgaben der Klimarahmenkonvention (KRK) und der Anforderung der ECE-Luftreinhaltekonvention“ (unveröffentlicht)

UBA, 2004b: Dr. R. Joas; A. Potrykus; R. Schott; S. Wenzel: VOC-Minderungspotenzial beim Transport und Umschlag von Mineralölprodukten mittels Kesselwagen, FKZ 202 44 372, UBA-Texte 12/2004, Dessau.
URL: http://www.umweltdaten.de/publikationen/fpdf-l/2637.pdf

UBA 2005b, FKZ 20442203/02: Endbericht zum Forschungsprojekt „Einsatz von Sekundärbrennstoffen“

UBA 2005c, FKZ 20541115: unveröffentlichter Zwischenbericht zum Forschungsprojekt „Bereitstellung der Energiedaten für stationäre Feuerungsanlagen zur Erfüllung der Berichtspflichten im Rahmen des Nationalen Treibhausgasinventars (NIR 2006) und des Berichtes zur Festlegung der zugewiesenen Mengen nach Kyoto-Protokoll“

UBA 2005d: Umweltbundesamt: Qualitätssystem Emissionsinventare. Handbuch zur Qualitätskontrolle und –sicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU-Entscheidung 280/2004/EG, Dessau. Stand 24.08.2005.

UBA, 2006: Umweltbundesamt: UBA-Text 29/06,: Lechtenböhmer, Nanning, Buttermann, Hillebrand: Bilanzierung der Gewinnung und Verwendung von Kalkstein und Ausweisung der CO_2-Emissionen, Forschungsbericht FKZ 20541217/02, Dessau 2006

UBA, 2007: Dr. Matthias Kühle-Weidemeier, Wasteconsult International: Endbericht des UFOPlan-Projekts „Anlagen zur mechanisch-biologischen Restabfallbehandlung, FKZ 206 33 301. Juni 2007

UBA 2007b: Umweltbundesamt: Qualitätssystem Emissionsinventare. Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU-Entscheidung 280/2004/EG, Dessau. Stand 05.06.2007, unveröffentlicht.

UBA, 2010: Ableitung der Kalksteinbilanz aus den statistischen Daten der BGR für Zwecke der Emissionsberichterstattung nach Klimarahmenkonvention und Kyoto Protokoll (Kategorie CRF 2.A.3), Publikationsnummer 4033, direkt unter http://www.uba.de/uba-info-medien/4033.html

UBA, 2011, FKZ 3707 33 303: Endbericht zum Forschungsprojekt „Nutzung der Potenziale des biogenen Anteils im Abfall zur Energieerzeugung“ URL: http:///www.uba.de/uba-info-medien/4116.html

UMEG 2004: Umweltmessungen, Umwelterhebungen und Gerätesicherheit 2004: Emissionsfaktoren-Handbuch, Emissionserklärung 2004 Baden-Württemberg

UNECE (United Nations Economic Commission for Europe) 2006: Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests, part IIIa: sampling and analysis of soil. Project Coordinating Center (PCC9, Hamburg, 117 p, http://www.icp-forests.org/Manual.htm

UNFCCC, 1998: Kyoto Protocol to the United Nations Framework Convention on Climate Change, United Nations 1998

UNFCCC, 2005: Germany. Report of the individual review of the greenhouse gas inventory submitted in the year 2004. FCCC/WEB/IRI/2994/DEU, dd. January 17, 2005. http://unfccc.int/files/national_reports/annex_i_ghg_inventories/inventory_review_reports/application/pdf/2004_irr_in-country_review_germany.pdf

UNFCCC (United Nations Framework Convention on Climate Change) 2007: Germany. Report of the review of the initial report of Germany, United Nations 2007

UNFCCC 2010: National Inventory Submissions. http://unfccc.int/national_reports/annex_i_ghg_inventories/inventory_review_reports/items/4715.php, United Nations 2010

UNFCCC, 2011: Report of the individual review of the annual submission of Germany submitted in 2010. FCCC/ARR/2010/DEU, dd. May 18, 2011.

UU STS, 2007: Utrecht University (UU), Copernicus Institute Department of Science, Technology, and Society (STS): Estimating CO2 Emissions from the Non- Energy Use of Fossil Fuels in Germany - Methodenaktualisierung für die Emissionsberechnung 2003, FKZ 203 41 253/02.

VDD 2009: Datenübermittlung des Verbandes, Dokument in der Inventarbeschreibung als „2010_2.A.5_Bitumen_AREF_Zeitreihen_und_Unsicherheiten(offen).xls", Dessau-Roßlau 2009

VDD 2011: Datenübermittlung des Verbandes, Dokument in der Inventarbeschreibung als „Bitumen_AREF_Zeitreihen_und_Unsicherheiten_aktuell.xlsx", Dessau-Roßlau 2011

VDI, 1999: Verein Deutscher Ingenieure e.V: VDI-Richtlinie 2578 - Emissionsminderung - Glashütten, 11/1999

VDP, versch. JG: Verband Deutscher Papierfabriken e.V.: Ein Leistungsbericht, Bonn, verschiedene Jahrgänge seit 1990

VDP, 2004: Verband Deutscher Papierfabriken e.V.: Ein Leistungsbericht, Bonn

VdZ, 2009: Forschungsinstitut der Zementindustrie: Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung von internationalen Luftreinhalte- und Klimaschutzvereinbarungen für ausgewählte Industriebranchen: Teilvorhaben 03 Zementindustrie (FKZ 370742301/03); Ruppert, Johannes; Scheuer, Wilfried; Schäfer, Stefan; Düsseldorf, 2009.

VDZ, 2011 (Verein Deutscher Zementwerke e.V.): Zement – Produktionsdaten der deutschen Zementindustrie; per E-Mail an das UBA übermittelt.

VOGT, K.A.; VOGT, D.J.; PALMIOTTO, P.A.; OON, P.; OHARA, J.; ASBJORNSEN, H. (1996): Review of root dynamics in forest ecosystems grouped by climate, climatic forest type and species. Plant and Soil, Vol. 187 Nr.2, pp. 159-219

VOLK, F., 1997: Recherches sur les Fumees Produits par la Detonation de divers Explosifs, Explosifs

WALG, O., 2006: Humus contra Heizwert - Rebholzverwertung. Der Winzer, 3/2006

WASTECONSULT INTERNATIONAL, 2009: Methanemissionen aus passiv entgasten Deponien und der Ablagerung von mechanisch-biologisch vorbehandelten Abfällen, FKZ: 360 16 015, Dezember 2009

WEG 2008a: Erdgas-Erdöl, Entstehung-Suche-Förderung, Hannover, 34 S. URL: http://www.erdoel-erdgas.de/Erdgas_Erd%F6l___Entstehung___Suche___F%F6rderung-134-1-68b.html WEG, 2008b: WEG Bericht zur Schwefelgewinnung im Inland, URL: http://www.erdoel-erdgas.de/article/articleview/13/1/59/

WEG (2010): Jahresbericht des Wirtschaftsverbandes Erdöl- und Erdgasgewinnung e.V., WEG, 2010. URL: http://www.erdoel-erdgas.de/

WEG (2011): Jahresbericht des Wirtschaftsverbandes Erdöl- und Erdgasgewinnung e.V., WEG, 2011 URL: http://www.erdoel-erdgas.de/

WEILBACHER, 1987: Ausgasung von Zellgasen, interner Laborbericht vom 17.08.87 (überreicht von der BASF AG, Ludwigshafen).

WEINGARTEN, P., 1995: Das „Regionalisierte Agrar- und Umweltinformationssystem für die Bundesrepublik Deutschland“ (RAUMIS). Ber Landwirtschaft 73, 272-302

WEISBERG, S., 2005: Applied Linear Regression. 3. Auflage, Wiley Interscience, Hoboken, 310p.

WEISS, SCHIELER, SCHADAUER, RADUNSKY, ENGLISCH, 2000: Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Umweltbundesamt GmbH, Wien.

WELLBROCK et al. 2006: Wellbrock, N.; Aydin, C. - T.; Block, J.; Bussian, B.; Deckert, M.; Diekmann, O.; Evers, J.; Fetzer, K. D.; Gauer, J.; Gehrmann, J.; Kölling, C.; König, N.; Liesebach, M.; Martin, J.; Meiwes, K. J.; Milbert, G.; Raben, G.; Riek, W.; Schäffer, W.; Schwerhoff, J.; Ullrich, T.; Utermann, J.; Volz, H. - A.; Weigel, A.; Wolff, B. (2006): Bodenzustandserhebung im Wald (BZE II) Arbeitsanleitung für die Außenaufnahmen. Hrsg. BMELV. Berlin. pp. 413.

WINKLER, M. (2004): „Abschätzung von Emissionsfaktoren bei Transport und Lagerung von Mineralölprodukten“ aus Erdöl, Erdgas, Kohle 120. Jg. 2004, Heft 10 S. 312 ff; Urban Verlag Hamburg/Wien GmbH 2004

WIRTH, C.; SCHULZE, E.-D.; SCHWALBE, G.; TOMCZYK, S.; WEBER, G.; WELLER, E. (2004): Dynamik der Kohlenstoffvorräte in den Wäldern Thüringens. Thüringer Landesanstalt für Wald, Jagd und Fischerei, Jena, 308 S.

WOLFF & RIEK 1996: Wolff, B.; Riek, W. (1996): Deutscher Waldbodenbericht 1996 - Ergebnisse der bundesweiten Bodenzustandserhebung in Wald (BZE) 1987 - 1993. Hrsg.: Bundesministerium für Ernährung, Landwirtschaft und Forsten, Bonn, Bd. 1 u. 2.

ZEEMAN G., 1994: Methane production/emission in storages for animal manure. Fertilizer Research 37, 207-211

ZIESING et al, 2003: Ziesing, Hans-Joachim (DIW), Felix Christian Matthes, (Öko-Institut), Franz Wittke (AGEB), Heike Leonhardt (UBA) „Harmonisierung der Energiedaten zur CO_2-Berechnung“, Endbericht zum EUROSTAT-Vorhaben des Umweltbundesamtes, 24.04.2003, aktualisiert um die „Energiebilanz 1999“ vom 20.09.2003