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

Umwelt Bundesamt

| CLIMATE CHANGE | 04/2010

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

Federal Environment Agency, Germany

UMWELTBUNDESAMT

<u>Authors</u>

Management of the report as a whole: Michael Strogies, Patrick Gniffke (UBA I 2.6)

For the individual chapters:

Summary   Patrick Gniffke (UBA I 2.6)

Part I: Annual deliveries for the inventories [i.p. = in part]:

Chapter 1.1.1 & 1.1.2	Rosemarie Benndorf (UBA I 2.1)
Chapter 1.1.3, 1.2.1 i.p., 1.2.3, 1.3 i.p., 1.6 i.p.	Dirk Günther (UBA I 2.6)
Chapter 1.2.1.6, 1.2.2, 1.3.1.2, 1.3.2, 1.3.3, 1.6 i.p.	Stephan Schiller (UBA I 2.6)
Chapter 1.3.3.1.7, 1.6.2 i.p.	Robert Kludt (UBA I 2.6)
Chapter 1.3.2.4, 1.5, 2, 3.2.1, 3.2.3-5, 3.2.13	Michael Strogies (UBA I 2.6)
Chapter 1.7., 1.8	Detlef Rimkus (UBA I 2.6)
Chapter 3.2	Petra Icha. Jens Langenfeld (UBA I 2.5), Kathrin Werner / Marion Dreher (UBA I 2.5), Kristina Juhrich (UBA I 2.6),
Chapter 3.2.1, 3.2.3 - 3.2.5	Michael Strogies (UBA I 2.6)
Chapter 3.2.2.2	Sabine Gores (Öko-Institut Berlin), Michael Kotzulla (UBA I 2.6), Frank Wetzel (UBA I 3.2)
Chapter 3.2.2.3	Katharina Koppe (UBA I 3.2), Michael Kotzulla (UBA I 2.6)
Chapter 3.2.6 – 3.2.8, 3.2.9.6	Petra Icha, Jens Langenfeld (UBA I 2.5), Rolf Beckers (UBA III 2.3-K)
Chapter 3.2.9.1	Petra Icha (UBA I 2.5), Sebastian Plickert (UBA III 2.2)
Chapter 3.2.9.2 - 3.2.9.3, 3.2.9.5, 3.2.9.7 - 3.2.9.11	Petra Icha (UBA I 2.5)
Chapter 3.2.9.4	Petra Icha (UBA I 2.5), Almut Reichart (UBA III 2.3-K)
Chapter 3.2.10.1	Sabine Gores (Öko-Institut Berlin), Michael Kotzulla (UBA I 2.6), Frank Wetzel (UBA I 3.2)
Chapter 3.2.10.2 - 3.2.10.5	Gunnar Gohlisch, Nadja Richter (UBA I 3.1)
Chapter 3.2.11 + 3.2.12	Anja Behnke (UBA III 2.3-K), Reinhard Böhnke (UBA I 2.5)
Chapter 3.3.1	Jürgen Ilse (Gesamtverband Steinkohle), Christian Böttcher (UBA I.2.6); Sebastian Plickert (UBA III 2.2)
Chapter 3.3.2	Edda Hoffmann (UBA III 2.3-K), Karen Pannier (UBA III 2.3-K); Thomas Charissé (UBA I 2.3) Christian Böttcher (UBA I.2.6)
Chapter 4.2.1 - 4.2.3	Maja Bernicke (UBA III 2.2)
Chapter 4.2.4	Birgit Brahner (UBA III 2.3-K)
Chapter 4.2.5 & 4.2.6	Robert Kludt (UBA I 2.6)
Chapter 4.2.7	Sandra Leuthold (UBA III 2.2)
Chapter 4.2.8	Maja Bernicke (UBA III 2.2)
Chapter 4.3.1 & 4.3.2	Birgit Brahner (UBA III 2.3-K)
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)
Chapter 4.4.1 & 4.4.2	Sebastian Plickert (UBA III 2.2)
Chapter 4.4.3	Maja Bernicke (UBA III 2.2)
Chapter 4.4.4	Cornelia Elsner, Kerstin Martens (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 4.4.5	Cornelia Elsner (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 4.5.1	Almut Reichart (UBA III 2.3-K)
Chapter 4.5.2	Dr. Zueleyha Iyimen-Schwarz (UBA I 1.4)
Chapter 4.6 - 4.7	Cornelia Elsner, Kerstin Martens (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 5.2	Folke Dettling (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 5.3	Folke Dettling (UBA III 1.4), David Kuntze (UBA I 2.6)
Chapter 6	Johann Heinrich von Thünen-Institut (vTI AK): Claus Rösemann, Hans-Dieter Haenel
Chapter 7.2	Johann Heinrich von Thünen-Institut: Karsten Dunger, Katja Oehmichen & Wolfgang Stümer (vTI WOI), Thomas Riedel (vTI WFW)
Chapter 7.3 -7.8	Johann Heinrich von Thünen-Institut (vTI AK): Annette Freibauer, Andreas Gensior
Chapter 8.2	Wolfgang Butz (UBA III 3.3)
Chapter 8.3	Dietmar Wunderlich, Christine Galander (UBA III 3.4)
Chapter 10	Michael Kotzulla (UBA I 2.6)

Part II: Supplementary information as required under Article 7 (1) of the Kyoto Protocol:

Chapter 11	Karsten Dunger, Katja Oehmichen, Wolfgang Stümer (vTI-WOI)
Chapter 11.7, 12, 14	Deutsche Emissionshandelsstelle (DEHSt):
Chapter 13	Dirk Günther (UBA I 2.6)
Chapter 15	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU), Referat KI 1.1

Annexes:

Annex 1, 4	Michael Strogies (UBA I 2.6)
Annex 2	Jens Langenfeld (UBA I 2.5), Kristina Juhrich (UBA I 2.6), Marcus Machat (UBA E 1.1), Petra Icha (UBA I 2.5)
Annex 2, Chapter 18.7	Kristina Juhrich (UBA I 2.6)
Annex 2, Chapter 18.8 & 18.9	Michael Strogies (UBA I 2.6)
Annex 3	Authors in keeping with specialised responsibility, in Chapter 3-15
Annex 3, Chapter 19.1.1	Marcus Machat (UBA E 1.1), Frank Zander (Institut für Energetik und Umwelt: IE gGmbH), Dr. Dieter Merten (IE gGmbH)
Annex 3, Chapter 19.5.1	Karsten Dunger, Katja Oehmichen, Wolfgang Stümer (vTI-WOI), André Iost, Thomas Riedel (vTI-WFW)
Annex 5	Detlef Rimkus (UBA I 2.6)
Annex 6	Dirk Günther (UBA I 2.6), Authors in keeping with specialised responsibility
Annex 6, Chapter 22.1.2	Stephan Schiller (UBA I 2.6)
Annex 6, Chapter 22.1.3	Kevin Hausmann (UBA I 2.6)
Annex 7	Detlef Rimkus (UBA I 2.6)

Contents

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 - AbfAblV)
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 rate
AWMS	Animal Waste Management System
BAFA	Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle)
BAT	Best Available Technique
BDZ	Federal Association of the German Cement Industry (Bundesverband der Deutschen Zementindustrie)
BEF	Biomass expansion factors
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 Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoffe)
BGW	Bundesverband der deutschen Gas- und Wasserwirtschaft (Federal Association of the German Gas and Water Industry)
BHD	Diameter at breast height (tree-trunk diameter at a height of 1.30 m above the ground)
BHKW	Combined heat and power (CHP) unit (Blockheizkraftwerk)
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)
BSB_5	Biological oxygen demand within 5 days (BOD_5)
BV Kalk	German Lime Association (Bundesverband der Deutschen Kalkindustrie)
BWI	Bundeswaldinventur (Federal Forest Inventory)

BZE	Survey of soil condition (Bodenzustandserhebung)
C_2F_6	Hexafluoroethane
CAPIEL	Coordinating Committee for the Associations of Manufacturers of Industrial Electrical Switchgear and Controlgear in the European Union
CFC	Chlorofluorocarbons
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
D7	Tree-trunk diameter at a height of 7 m above the ground
DEHSt	German Emissions Trading Authority
DESTATIS	German Federal Statistical Office
DFIU	Franco-German Institute for Environmental Research, at the University of 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	Deutsche Industrienorm (DIN standard)
DIW	German Institute for Economic Research (Deutsches Institut für Wirtschaftsforschung)
DLR	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)
DMKW	Diesel-engine power stations
D_N	Nitrogen in wastewater
DOC	Degradable organic carbon
DOC_F	Fraction of DOC dissimilated (converted into landfill gas)
DTKW	Steam-turbine power stations
DVGW	German Association of the Gas and Water Industry (Deutsche Vereinigung des Gas- und Wasserfachs eV.)
EB line	Energy Balance line in the BEC/BEU
EEA	European Environment Agency
EECA	European Electronic Component Manufacturers Association
EEG	Renewable Energy Sources Act (EEG); promulgated in Federal Law Gazette Part I No. 40 of 31 July 2004, p. 1918 ff.)
EF	Emission factor
EI	Emissions index = Emission factor
E_{KA}	Inhabitants connected to wastewater-treatment systems (Einwohner mit Kläranlagenanschluss)
EL	Fuel oil EL (especially easily liquid)
EM	Emissions
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)
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
FA	Combustion systems
FAP	Specialised contact person (Fachlicher Ansprechpartner) in the NaSE
FAL	Federal Agricultural Research Institute
FAO	United Nations Food and Agriculture Organisation
FCKW	Chlorofluorocarbons (CFCs; Fluorchlorkohlenwasserstoffe)
F gases	Hydrofluorocarbons (HFCs)
FHW	District heating stations
PFC	Perfluorocarbons
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)
GMKW	Gas-engine power stations
GPG	Good Practice Guidance
GT	Gas turbines
GTKW	Gas-turbine power stations
GuD	Gas and steam turbine power stations,
GWP	Global Warming Potential
HFC	Hydrofluorocarbons (= HFKW)
HFCKW	Hydrochlorofluorocarbons (HCFCs)
HFC	Hydrofluorocarbons
HQG	Key source: In the NIR, the term "key source" is used synonymously with the term "key category"; i.e. the term includes both emissions sources and sinks
HS-GIS	High-voltage gas-insulated switching systems
IAI	International Aluminium Institute
ICAO	International Civil Aviation Organisation
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
IMA	Interministerial Working Group (Interministerielle Arbeitsgruppe)
IPCC	Intergovernmental Panel On Climate Change
K	Fuel input for power generation (direct drive)
k.A.	No entry (keine Angabe)
KP	Kyoto Protocol
KS	Sewage sludge
I	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 (Mechanisch-Biologische Abfallbehandlung)
MCF	Methane Conversion Factor
MS	Medium voltage
MSW	Amount of municipal waste stored
MVA	Waste incineration plant
MW	Megawatt
N_2O	Nitrous oxide (laughing gas)
NA	Not Applicable Not Applicable)
NASA	National Aeronautics and Space Administration
NaSE	National System of Emissions Inventories
NBL	New German Länder
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
NEV	Non-energy-related consumption
NFR	New Format on Reporting, Nomenclature for Reporting to the UN ECE
NFZ	Utility vehicles
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
OX	Oxidation factor
PAH	Polycyclic aromatic hydrocarbons; also PAK
PAK	Polycyclic aromatic hydrocarbons; also PAH
PARTEMIS	Measurement and prediction of emissions of aerosols and gaseous precursors from gas turbine engines
PCDD/F	Polychlorinated dibenzo-dioxins/- furans
PF	Process furnaces
PFC	Perfluorocarbons

PKW	Automobile (Personenkraftwagen)
PU	Polyurethane
QK	Quality control (QC)
QS	Quality assurance
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 (RWI)
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")
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)
TAN	Total Ammoniacal Nitrogen
GG	Greenhouse gases (Treibhausgase = GHG)
TM	Dry mass (Trockenmasse)
TOC	Total Organic Carbon
TREMOD	Traffic Emission Estimation Model
TS	Dry matter (Trockenstoff)
TÜV	Technischer Überwachungsverein (Certifying body for technical and product safety)
TVF	Tonne of utilisable production (Tonne verwertbare Förderung)
UBA	Federal Environmental Agency (UBA)
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)
VDEW	Electricity Industry Association (Verband der Elektrizitätswirtschaft)
VDI	Association of German Engineers (Verein Deutscher Ingenieure e.V.)
VDN	Association of German network operators (VDN)
VDZ	German Cement Works Association (Verein Deutscher Zementwerke e.V.)
VfmD	Solid cubic meters of standing timber (Vorratsfestmeter Derbholz)
VGB	Technical association of operators of large power stations (Technische Vereinigung der Großkraftwerksbetreiber e.V.)
VIK	Verband der Industriellen Energie- and Kraftwirtschaft e.V. (VIK) (Association of the Energy and Power Industry), Essen
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 (AK)
vTI-WOI	Johann Heinrich von Thünen Institute, Institute of Forest Ecology and Forest Inventory (WOI)
W	Fuel input for heat generation
WS	Portion of a specific wastewater treatment system (e.g. aerobic, anaerobic)
XPS	Extruded polystyrene
ZSE	Central System of Emissions (CSE)

Units and sizes

Multiplication factors, abbreviations, prefixes and symbols

Multiplication factor	Abbreviation	Prefix	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}	Hekto	h
0.1	10^{-1}	Dezi	d
0.01	10^{-2}	Zenti	c
0.001	10^{-3}	Milli	m
0.000,001	10^{-6}	Mikro	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

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

How to read 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.1.x (Sample table)					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2008 - contribution to total emissions**	**Trend**
Solid fuels	l / t	CO_2	13.37 %	23.23 %	rising
Gaseous fuels	l / t	CO_2	2.38 %	7.07 %	rising
Liquid fuels	l / t	CO_2	0.64 %	0.19 %	falling
Solid fuels	l / -	N_2O	0.25 %	0.15 %	falling

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	< 3	+/-50	-	-	-	+/-50				
Distribution of uncertainties	T	U	-	-	-	U				
EF-determination method	CS	Tier 2	-	-	-	Tier 2				

Key source

The upper section of the table shows the key-source-analysis lines that are relevant for the source category in question, including the category's percentage shares in 1990 and in the last reported year and the pertinent emissions trend. In the NIR, the term "key source (category)" is used synonymously with the term "key category"; i.e. the term includes both emissions sources and sinks.

Gas

The lower section of the table provides information about the emission factors used (EF), the percentage uncertainties for the EF, the uncertainties distribution and the method used to determine the emission factors for the substances in question.

Emission factor (EF)

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

Maximum EF uncertainties in %, and distribution of uncertainties

See Chapters 1.7 and 18 for more details
N   =   Normal
L   =   Lognormal
T   =   Triangular
U   =   Uniform (even distribution)

EF-determination method

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

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.

Germany now presents its eighth National Inventory Report (NIR 2010), following its inventories for the years 1990 to 2008. This latest report covers the same period (1990 to 2008), and it describes the methods and the data sources on which the 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, as far as possible, 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). This year, the NIR contains, for the first time, an additional Part II, along with additional sub-chapters in the existing part, in conformance with expanded requirements under the Kyoto Protocol and the relevant decisions 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 storage 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-source assessment and describes the Quality

---

[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)

System for Emissions Inventories (QSE). The chapter concludes with sections on uncertainties analysis and completeness analysis.

Chapter 2 provides a general overview of development of emissions of direct and indirect greenhouse gases and of storage 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**, presented more-detailed descriptions of key sources, 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 areas 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) 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 on the selected additional activities pursuant to Article 3 (4) Kyoto Protocol; (cf. Chapter 11)
- Information regarding the certificates under the Kyoto Protocol in connection with decisions 13/CMP.1 and 5/CMP.1; (cf. Chapter 12)

---

[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 storage in sinks, and emissions and storage from KP-LULUCF activities (ES.2)

0.2.1 Greenhouse-gas inventory (ES.2.1)

As of 2008, Germany had again fulfilled its obligations within the framework of the aforementioned European burden-sharing, amounting to a reduction of 22.2 % with regard to the base-year emissions reported in 2006[5], 1,232,429.543 Gg (CO_2 equivalent). As a result of a number of factors (a mild winter period in 2008, further expansion of use of renewable energies and methodological changes), emissions in 2008 were about the same as those in 2007 and, overall, considerably lower than those in the years prior to 2007 (cf. Chapter 0).
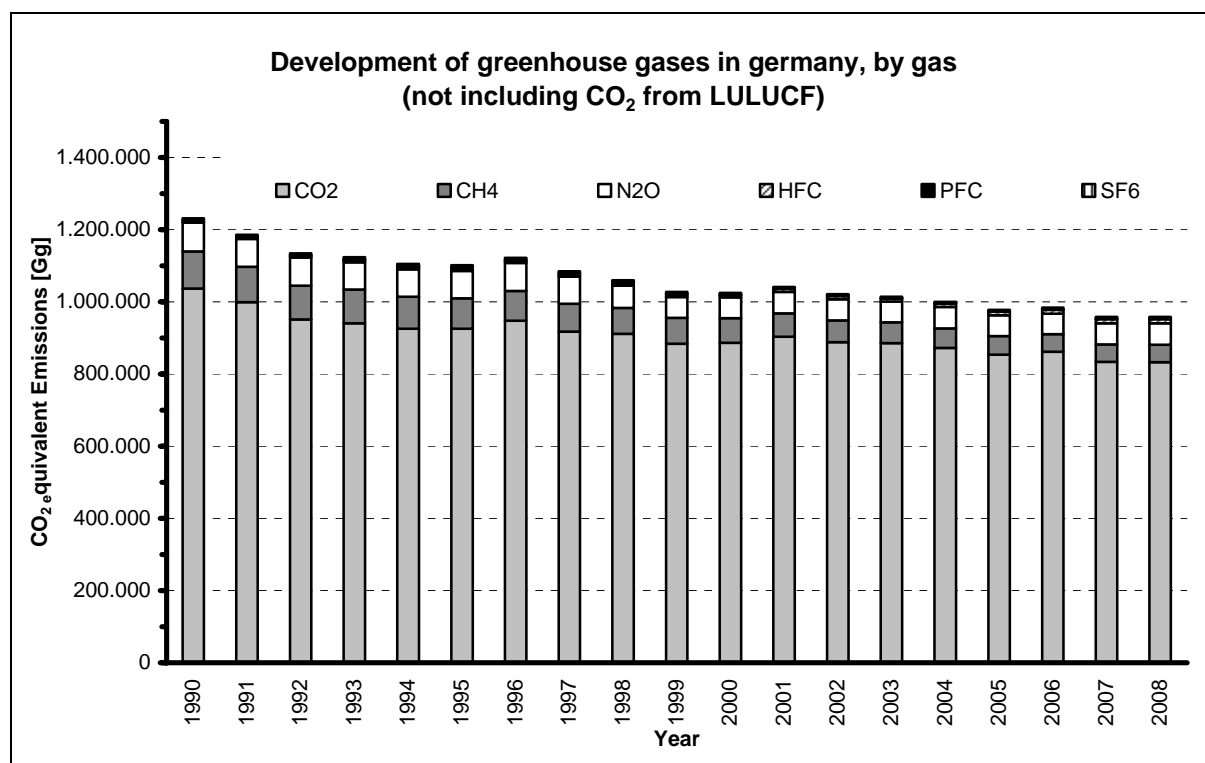
Figure 1:   Development of greenhouse gases in Germany since 1990, by greenhouse gases[6]

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.

---

[5] 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 %.

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

In 2008, carbon-dioxide releases were the most significant greenhouse-gas emissions, accounting for 86.9 % of all such emissions. Most of the carbon dioxide is released via stationary and mobile combustion. As a result of a disproportionately large reduction of other greenhouse-gas emissions, CO_2 emissions' share of total emissions has increased by 3 percentage points since the base year. Methane (CH_4) emissions from animal husbandry, fuel distribution and landfills account for 5.0 %. Emissions of nitrous oxide (N_2O), caused primarily by agriculture, industrial processes and burning of fossil fuels, contribute 6.3 % of greenhouse-gas releases. Fluorocarbons (so-called "F gases") account for about 1.9 % of total emissions. The distribution of Germany's greenhouse-gas emissions 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
Net CO_2 emissions / storage	1,016,438	903,407	864,733	887,701	897,128	871,887	862,488
CO_2 emissions (not including LULUCF)	1,036,716	925,413	886,900	853,540	861,339	833,926	833,092
CH_4	103,299	84,839	67,959	51,474	49,498	48,146	47,745
N_2O	79,989	75,749	57,572	57,775	56,654	59,028	60,166
HFCs	4,369	6,469	6,483	9,990	10,527	11,141	11,469
PFCs	2,708	1,750	781	707	569	528	531
SF_6	4,785	7,220	5,082	4,898	5,510	5,567	5,846
Total emissions / storage, including LULUCF	1,211,588	1,079,434	1,002,611	1,012,544	1,019,887	996,296	988,246
Total emissions, not including CO_2 from LULUCF	1,231,865	1,101,440	1,024,777	978,383	984,097	958,335	958,850
GG emissions / sinks, by source and sink categories, in CO_2 equivalents (Gg)	**1990**	**1995**	**2000**	**2005**	**2006**	**2007**	**2008**
1. Energy	989,661	873,671	829,786	796,201	800,687	769,714	772,788
2. Industrial processes	118,227	120,565	100,447	99,533	103,065	108,976	104,894
3. Solvent and other product use	5,396	4,458	3,723	3,402	3,345	3,316	3,316
4. Agriculture*	78,046	68,405	68,697	65,359	64,056	63,763	66,203
5. Land use, land-use changes & forestry	-20,165	-21,901	-22,061	34,959	36,450	38,961	30,185
CO_2	-20,277	-22,006	-22,166	34,161	35,790	37,961	29,396
N_2O & CH_4	113	105	105	798	661	1,000	789
6. Waste	40,423	34,234	22,020	13,090	12,283	11,566	10,859

*   The increase in greenhouse-gas emissions, with respect to the NIR 2009, is due primarily to methodological changes (cf. Chapters 2.3 and 6.1.1)

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

GG emissions / sinks; shares for various GHG, not including CO_2 from LULUCF (%)	1990	1995	2000	2005	2006	2007	2008
CO_2 emissions (not including LULUCF)	84.2	84.0	86.5	87.2	87.5	87.0	86.9
CH_4	8.4	7.7	6.6	5.3	5.0	5.0	5.0
N_2O	6.5	6.9	5.6	5.9	5.8	6.2	6.3
HFCs	0.4	0.6	0.6	1.0	1.1	1.2	1.2
PFCs	0.2	0.2	0.1	0.1	0.1	0.1	0.1
SF_6	0.4	0.7	0.5	0.5	0.6	0.6	0.6
Total	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
1. Energy	80.3	79.3	81.0	81.4	81.4	80.3	80.6
2. Industrial processes	9.6	10.9	9.8	10.2	10.5	11.4	10.9
3. Solvent and other product use	0.4	0.4	0.4	0.3	0.3	0.3	0.3
4. Agriculture	6.3	6.2	6.7	6.7	6.5	6.7	6.9
5. Land use, land-use changes & forestry (N_2O)	0.0	0.0	0.0	0.1	0.1	0.1	0.1
6. Waste	3.3	3.1	2.1	1.3	1.2	1.2	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

0.2.2   *KP-LULUCF activities (ES.2.2)*

Since the current year is the first inventory year under the Kyoto Protocol, it is not yet possible to describe any trend.

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 shares of the various source and sink categories and the absolute predominance of energy-related emissions. On the other hand, 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.

Overall, greenhouse-gas emissions have decreased considerably with respect to the base year (decrease of CO_2-equivalent emissions by 22.2 %). Considerations of the various components involved confirm this trend, to varying degrees. The emissions changes, with respect to the base-year emissions reported in the 2006 report[7], amounting to 1,232,429.543 Gg CO_2 equivalent, are as follows for the most important greenhouse gases in terms of quantity: - 19.6 % for carbon dioxide (CO_2); - 53.8 % for methane (CH_4); and - 24.8 % for nitrous oxide / laughing gas (N_2O). The corresponding trends for the so-called "F" gases, which contribute about 1.9 % of greenhouse-gas emissions overall, have not been as clearly

---

[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 %.

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 19.0 % and PFC emissions dropped by 69.7 %, while HFC emissions increased by 77.3 %.

With regard to the previous year, 2007, total emissions rose slightly, by 0.1 %. As to contributors to the overall result, a CO_2-emissions reduction of only 0.1 %, caused by a drop in energy consumption, and a 0.8 % reduction in methane emissions were offset by a + 1.9 % increase in nitrous oxide emissions and + 5.5 % growth in emissions of F gases. The main factors contributing to the methane reductions include further increases in use of mine/pit gas and continuing decreases in waste-sector emissions.
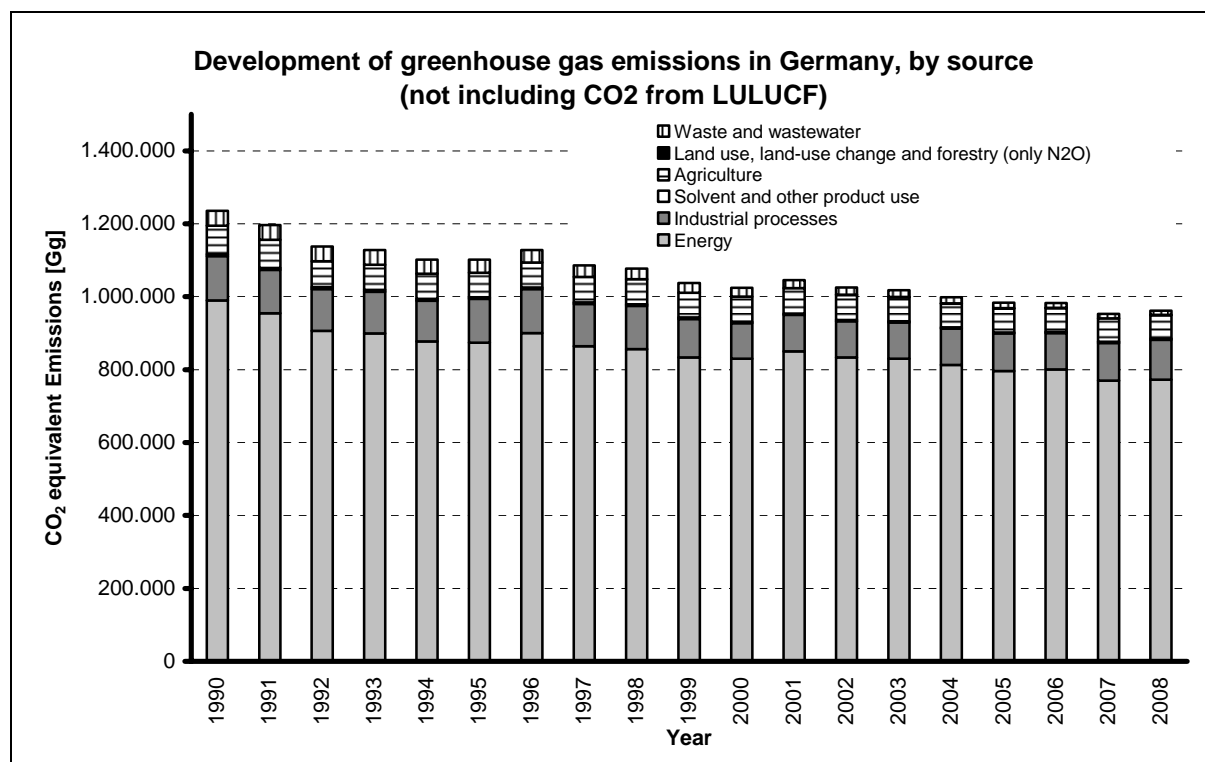
Figure 2:   Emissions trends in Germany since 1990, by source categories[8]

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. In the area of emissions from industrial processes, the emission-reducing effects of measures in the field of adipic acid production in 1997 were substantial. Emissions from solvent and other product use decreased slightly, 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.

---

[8] CO_2 emissions and storage in soils are reported under land-use changes and forestry.
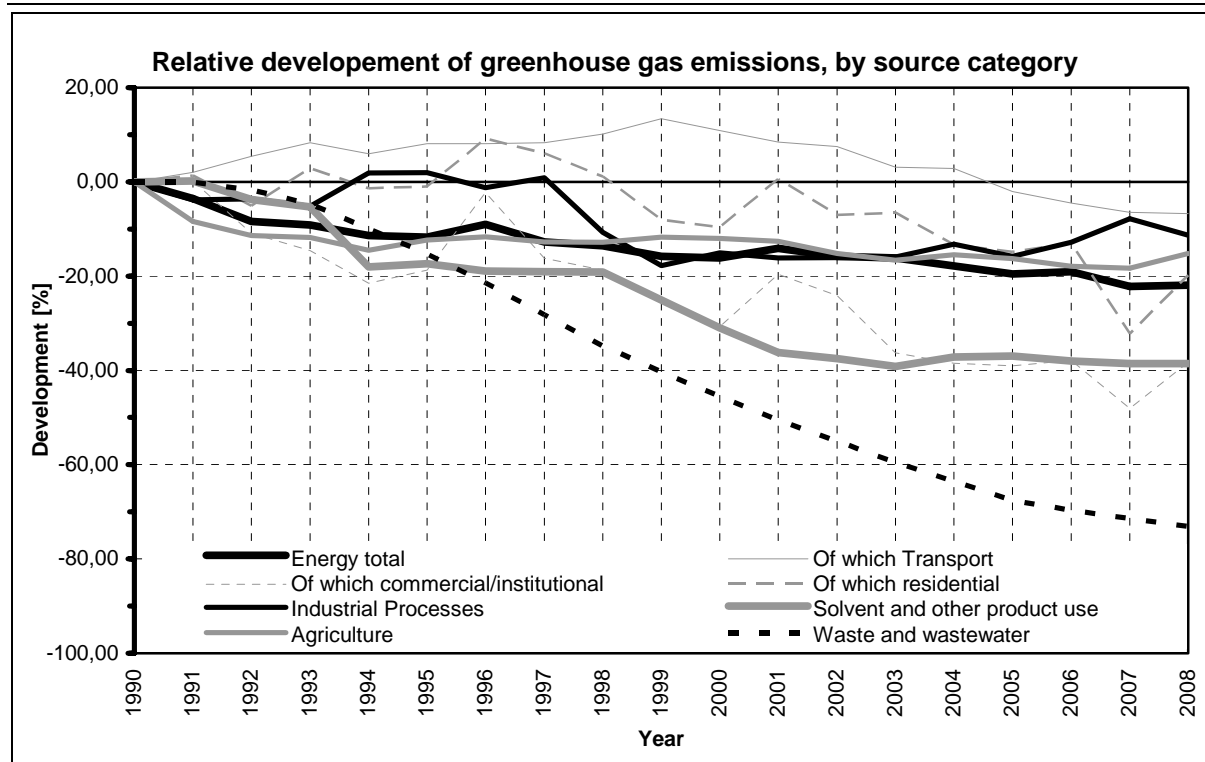
Figure 3:   Relative development of greenhouse-gas emissions since 1990, by source
                categories[9,10]

0.3.2   KP-LULUCF-Aktivitäten (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 methane, nitrous oxide and carbon
dioxide.

Under Article 3.3, it reports emissions of 13,778.4 Gg CO_2 equivalent. The emissions are
composed of storage of CO_2 via forestation and reafforestation, amounting to 2,615.20 Gg
CO_2 equivalent, and emissions from deforestation, amounting to 16,393.32 Gg CO_2
equivalent. Under Article 3.3, it reports CO_2 emissions of 13,778.18 Gg CO_2 equivalent and
N_2O emissions of 0.26 Gg CO_2 equivalent.

Under Article 3.4, it reports emissions of 20,331.81 Gg CO_2 equivalent. The relevant storage
consists of CO_2 storage of 20,380.47 Gg CO_2 equivalent and emissions of 49.86 Gg CO_2
equivalent. Under Artikel 3.4, it reports CO_2 storage of 20,331.81 Gg CO_2 equivalent, N_2O
emissions of 45.4 Gg CO_2 equivalent and CH_4 emissions of 3.36 Gg CO_2 equivalent.

Since the current year is the first inventory year under the Kyoto Protocol, it is not yet
possible to describe any trend.

---

[9] CO_2 emissions and storage in soils are reported under land-use changes and forestry.

[10] The reference consists of the emissions in 1990 (=100%), not the base-year emissions.

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 and that humans are primarily responsible for this trend. And the trend has intensified in recent years. The global warming process is evident in increases in global air and ocean temperatures, in extensive melting of snow and ice and in an increase in the mean global sea level. 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 preindustrial levels. To achieve this goal, greenhouse-gas trends must be reversed within the next 10 years. By 2050, global emissions will have to be reduced by 50 - 85 % in comparison to relevant levels in the year 2000. The IPCC's findings need to be incorporated within the political process, and recommendations based on those findings need to be rapidly implemented.

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.

---

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

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 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.

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 reporting required pursuant to Art. 7 of the Kyoto Protocol.

In submitting its eighth National Inventory Report (NIR 2010), Germany also submits its third 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 11. 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 Registries 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 arrangements 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.*

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 (cf. Chapter 1.2.1.2).

In recent years, decisive progress has been made in institutionalising the National System. This progress has been achieved via establishment of the National Co-ordinating Committee (cf. Chapter 1.2.1.1), via an in-house directive for the Federal Environment Agency (cf. Chapter 1.2.1.2), via the development of a procedure for using monitoring data from European emissions trading (cf. Chapter 1.6.2.1) and via drafts of pertinent agreements between the *Single National Entity*, other relevant federal institutions and non-governmental organisations (such as the agreements with the Federal Statistical Office and the chemical industry; cf. Chapter 1.2.1.4).

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

In Germany, the National System has been established at the ministerial level, under the leadership of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). 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.

In an agreement reached by the state secretaries of the aforementioned ministries, and set forth in the "Nationales System" ("National System") principles paper on emissions reporting of 5 June 2007, the relevant responsibilities of the various deparments were defined. In addition, it was resolved that the Federal Environment Agency (UBA) should serve as the Single National Entity (national co-ordinating agency) for Germany (cf. Chapter 1.2.1.2). In support of the reporting process, the participating ministries established a co-ordinating committee (cf. Chapter 1.2.1.1). 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 1.2.1.6). 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. Data flows are safeguarded as necessary via suitable agreements concluded by the Single National Entity (cf. Chapter 1.2.1.4). Such agreements also specify relevant requirements pertaining to quality assurance and quality control.

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

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

The National System on Agriculture and LULUCF, within the portfolio of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), is described in Chapter 1.2.1.5.
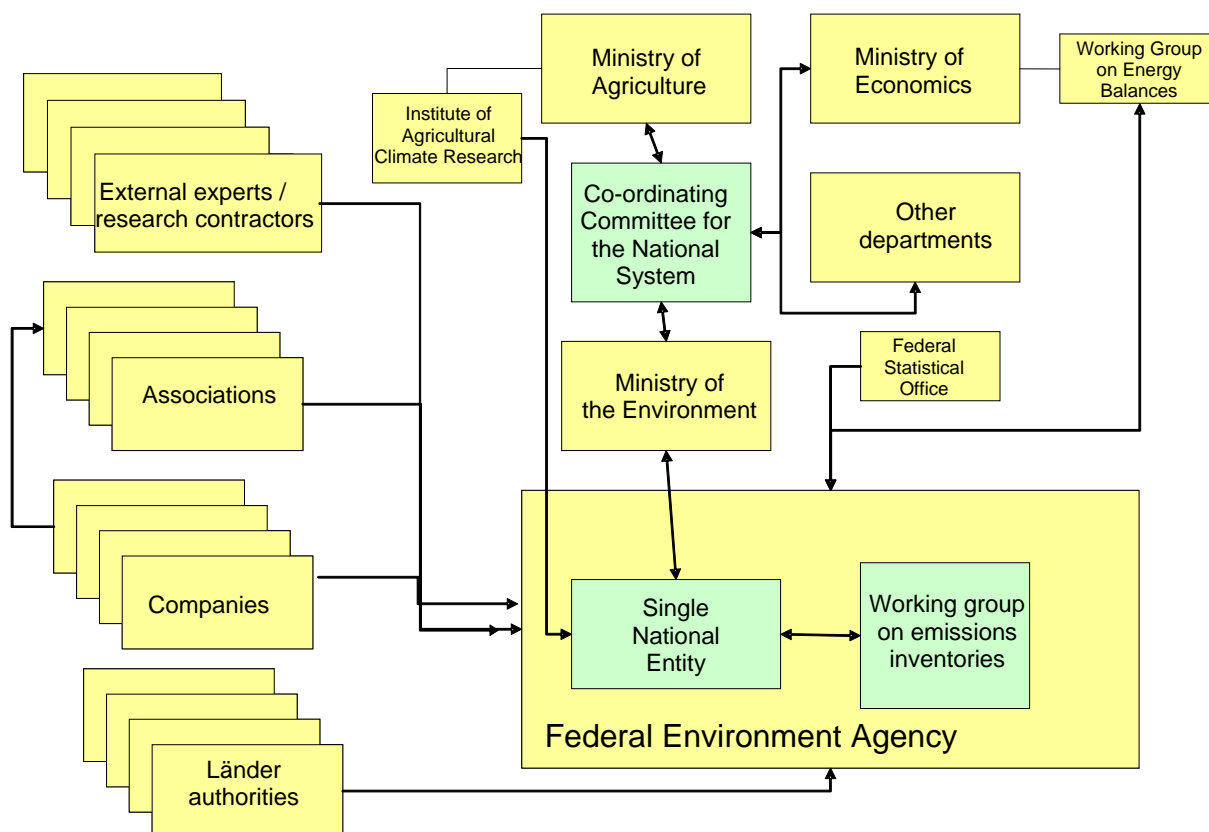
Figure 4:   Structure of the National System of Emissions (NaSE)

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 defines key-source and key-sink categories and resolves any pertinent uncertainties.

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 convened for the first time on 21 December 2007. To date, it has met three times, at the invitation of the BMU (the 3rd meeting was held on 1 July 2009). The Committee has become a basic component of the National System. This body's establishment has implemented the recommendation in the Initial Review 2007: Institutional, legal and procedural arrangements (Document FCCC/IRR/2007/DEU of 12 December 2007, Para 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 of 5 June 2007 on the National Emissions Reporting System appointed the Federal Environment Agency to carry out **tasks of the national co-**

ordination agency for emissions reporting (Single National Entity). Via its internal directive 11/2005, the Federal Environment Agency has made its Section I 2.6 (Emissions Situation) responsible for SNE tasks.

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 Federal Environment Agency has developed a range of **instruments** for supporting the Single National Entity in carrying out its tasks.

The Federal Environment Agency's *Central System of 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 rates, 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). 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 central instrument in the QSE framework is 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.). In addition, the database contains all tabular-form correspondence relative to inventory reviews, including German answers provided since the 2004 reporting year.

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

National System (NaSE)

objectives

Emission Inventory (CRF/NIR)

• Transparency,
• Consistency,
• Comparability,
• Completeness,
• Accuracy,
• ***Deadline compliance.***

experience

improvement activities

QSE

specific objectives, responsibilities and necessary activities

tools

• **CSE** (Central System on Emissions)
→ database

• **QSE (Act on climate-protection statistics (KSStatG), in-house directive)**
→ QA/QC procedures

• **PlaSte** (Planning and Steering tool)
→ meta-database

experience

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 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. The working group has met twelve times since it was established.

Necessary information is provided via the working group's events and through an intranet area devoted to emissions reporting.

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

1.2.1.4   Agreements of the Single National Entity regarding co-operation with other federal institutions and non-governmental organisations

In the "National System" policy paper of 5 June 2007 on emissions reporting (which is presented in Chapter 22.1.1), the involved departments 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, in particular, enables provision of data 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, data was already provided in 2009 on the basis of the agreement, however.

Furthermore, since the end of 2006, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has been negotiating with **EUROCONTROL, the European Organisation for the Safety of Air Navigation**, regarding an agreement on provision of air-traffic 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. To date, EUROCONTROL has neither responded to that draft nor accepted it, however. In spring 2009, the European Commission was requested to provide support to bring about the agreement's conclusion.

Involvement of 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.

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). Already in 2009, data for emissions reporting were provided in the framework of all of the aforementioned agreements.

In addition to ensuring long-term data availability, the agreements with the chemical industry and the VDD association 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 2009, discussions with Wirtschaftsvereinigung Metalle (WVM) metal-industry association, regarding renewal of the German primary aluminium industry's voluntary commitment from 1997, were initiated with a view to data provision for purposes of emissions reporting. The Single National Entity, in co-operation with the BMWi, has prepared a relevant draft text to this end. Furthermore, the Single National Entity and the BMWi have initiated discussions with the industry-gas association regarding a voluntary commitment on data provision.

1.2.1.5   National system relative to agriculture and LULUCF, within the portfolio of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV)

Via state-secretary resolution of 22 December 2006, the Federal Government has decided to have forestry activities credited pursuant to Art. 3 (4) of the Kyoto Protocol. In keeping with this state-secretary resolution, the BMELV will carry out pertinent required data collection, emissions calculation and provision for reporting (in CRF tables), and will provide the relevant NIR chapters.

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, for purposes of the UN Framework Convention on Climate Change, and reporting on LULUCF, for purposes of the UN Framework Convention and the Kyoto Protocol (including reporting pursuant to Art. 3.3 KP).

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.

Furthermore, a working group on emissions reporting has been established within the vTI, to serve as liaison to the National System. That working group also has responsibility for planning and QC/QA. The establishment of the new body addresses the reference provided in Paragraph 16 of the 2007 Initial Review.

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 figure below provides details relative to the National System in the area of agriculture and LULUCF.

At the National Co-ordinating Committee's third meeting, held on 1 July 2009, the BMELV presented a revised draft of a monitoring concept for LULUCF (Arts. 3.3. and 3.4 KP) and of a concept for the National System in the area of agriculture and forestry. Following the meeting, the concept was refined, via exchanges between the Single National Entity and the vTI. It has been in place since August 2009.

The monitoring concept for LULUCF and for the National System in the area of agriculture and forestry is available at the Internet link provided under the imprint.
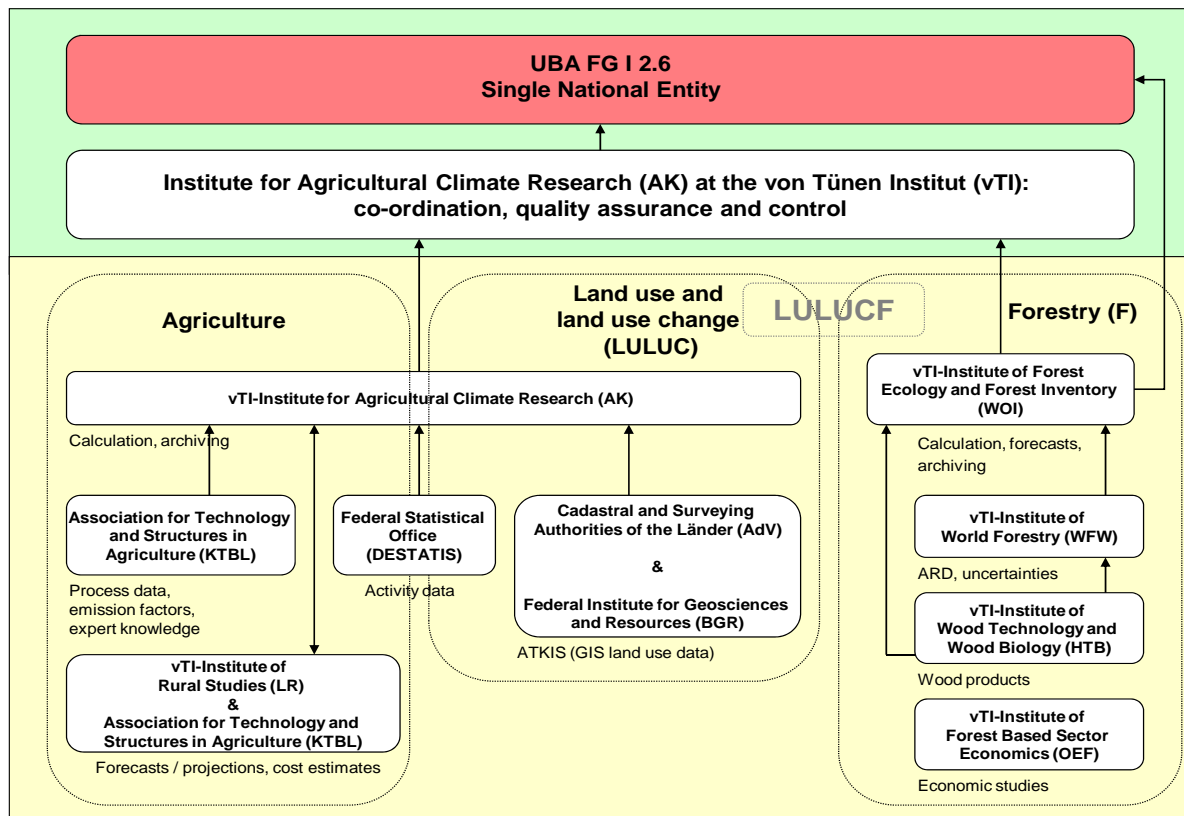
Figure 6:   National System in the area of agriculture and LULUCF

1.2.1.6   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 institutions and procedures, and for definition, pursuant to Paragraph 12 (c), of specific responsibilities at the Agency level.

1.2.1.7   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:

19 May	The Federal Environment Agency's national co-ordinating agency (Single National Entity) requests relevant responsible sections 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 section and quality managers, taking account of review results
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
2 November	Internal co-ordination within the Federal Environment Agency
as of 11 November	Final quality assurance by the QSE/CSE/NIR co-ordinator
16 November	Report of the Single National Entity to the Ministry, for commencement of inter-ministerial co-ordination relative to the CRF data
30 November	Report of the Single National Entity to the Ministry, for commencement of inter-ministerial co-ordination relative to the National Inventory Report
17 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 Climate Secretariat)
August	Synthesis and assessment report II (country-specific; by the UN FCCC Secretariat)
September - October	Inventory review by the 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 addition, a separate budget item for the National System, over and above research funding, was established within the Federal Environment Agency as of 2005 (Title 526 02, Chapter 1605). This budget item can be used to fund short-term projects for inventory improvement, within the Agency's responsibility.

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. A decentralised process, carried out by a range of different persons, it can vary extensively, depending what part of the inventory is concerned. In 2003, prior to the introduction of the QSE, 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 7).

With submission of this year's inventory report (NIR 2010), the totality of all information required pursuant to Article 7 of the Kyoto Protocol has been integrated, for the first time, within the reporting processes.

The process of inventory preparation is co-ordinated closely with preparation of the National Inventory Report, with provision of information as required pursuant to Article 7 of the Kyoto Protocol and with execution of measures for quality control and quality assurance.

Experience has shown that workflow in the inventory planning and preparation process can significantly affect inventory quality, i.e. that the order in which relevant steps are taken is important. 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*.
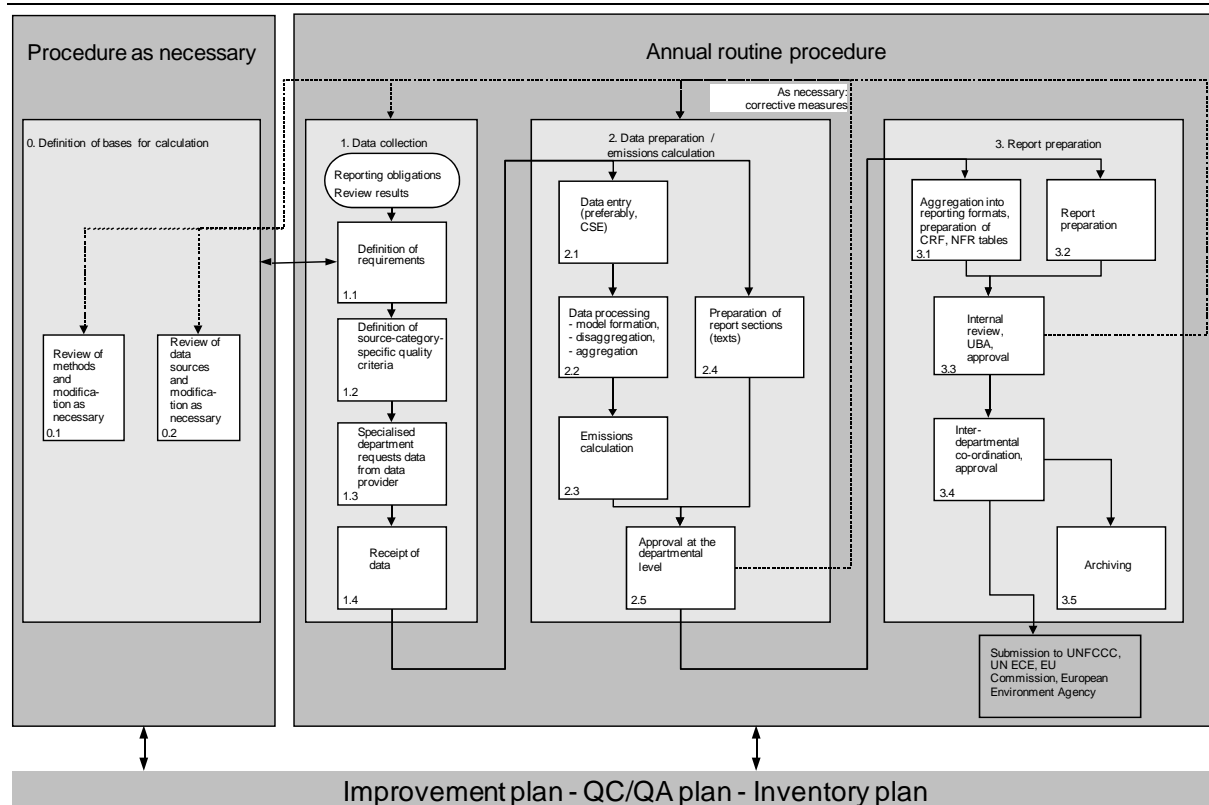
Figure 7:   Overview of the emissions-reporting process

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

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

1.3   Inventory preparation

As the overview in Chapter 1.2.3 shows, inventory preparation is a regular, annual process that functions in accordance with a decentralised 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. 1.3.1.2), 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 relevant processes for greenhouse-gas inventories and for KP-LULUCF inventories – i.e. the upstream processes for inventory preparation and for definition of the bases for calculation – are carried out together for both inventory types.

1.3.1.1   Preliminary/upstream processes

Apart from the sub-processes for emissions reporting, as outlined in Figure 7, 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:

- Continual improvement of the National System, via review and improvement of institutionalisation;
- Implementation of improvements in inventory planning and inventory preparation;
- Determination of key sources (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 sources, 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   *Improvement 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.

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 1.6.1. The improvements achieved for the present report are described in the relevant source-category chapters.

1.3.1.1.3   *Identification of key sources (with Tier 1 method)*

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 source/sink". Key sources/sinks are source categories that play an especially prominent role in the national inventory because their emissions/storage have a significant influence on the total emissions of direct greenhouse

gases, either in terms of absolute emissions, as a contribution to the emissions trend over time, or as a result of the uncertainties linked with them.

The Single National Entity identifies key sources 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 source 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 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 sources. These methods identify the relevant key sources 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 sources have been defined by applying two Tier 1 procedures, Level (for the base year and for 2008) and Trend (for 2008, 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 storage of greenhouse gases in sinks.

1.3.1.1.4   *Calculation and aggregation of uncertainties for emissions data*

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 rates and emission factors, which are normally estimated by experts at the structural-element level of the CSE, are converted into uncertainties for emissions and then aggregated. Uncertainties are aggregated once per year, at the end of the report-preparation cycle for the current report year. Tier 2 determination of uncertainties is carried out every three years. In the years in between, uncertainties are determined in accordance with Tier 1.

In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 2 method. For Tier 2 uncertainties determination, the uncertainties have been estimated, wherever possible to date, by data-supplying experts of the relevant Federal Environment Agency specialised sections and by external institutions.

Aggregated uncertainties serve as a basis for expanded identification of key sources.

1.3.1.1.5   *Expanded identification of key sources*

Expanded identification of key sources was carried out this year, in conjunction with detailed uncertainties determination via Monte Carlo simulation (in keeping with the IPCC Tier 2 method). For the German greenhouse-gas inventory, such analysis is carried out at 3-year intervals. Such work was carried out for the first time for the greenhouse-gas inventory

reported in 2007 (cf. the NIR 2007). The resulting findings confirmed the results of Tier-1 key-source analysis nearly completely.

1.3.1.2   Selection of calculation methods

Selection of calculation methods for determining emissions affects the entire emissions-reporting process. For this reason, review of the suitability of the methods used constitutes the beginning of the main process "definition of bases for calculation", which is described in Chapter 1.3.2.1. *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 source 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.

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

1.3.2.1   Definition of bases for calculation

As mentioned above, the sub-process "selection of calculation methods" takes place at the beginning of this main process (Chapter 1.3.1.2).

Another factor that is critical to the success of the overall process is **selection and review of 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 rates, 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,
- Specification of the source-category-specific quality and review 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) 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-source identification, are all communicated to the relevant experts via informational events held by the Federal Environment Agency's *Working Group on Emissions Inventories*, via the Federal Environment Agency's intranet site for emissions reporting and via an electronic inventory description (cf. Chapter 1.3.3.1.4). On this basis, responsible experts **define requirements** for relevant third parties, with regard to both data sources and 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 and review 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 is 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 – which enter into the table sections – for activity rates, 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 rate * 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 and preparation of XML files for export to the CRF reporter,
- Calculation of CO_2 equivalents for the greenhouse-gas emissions,
- 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,
- Import of XML files into the CRF reporter, and preparation of data tables for the CRF,
- Forwarding to the BMU,
- 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.

Before emissions data can be transferred into the report tables 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 sources. 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	$c\text{-}C_4F_8$	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

The report co-ordinator **compiles the submitted report texts to form the NIR draft**. Experts in the Single National Entity (national co-ordinating agency), assigned to cover specific source categories, then carry out **internal review of the data and report sections**, 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. Following such revision, the report co-ordinator carries out overall editing of the NIR.

Formal approval of the 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 internal directive (UBA-Hausanordnung) 11/2005 (cf. Chapter 1.2.1.6). 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 quality 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 departments approved them in the framework of the 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 of 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	Tasks	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)
Contact persons in Federal Environment Agency departments	Multipliers for departments and sections with regard to the national co-ordinating agency (SNE) information's and requirements relative to emissions reporting	An appointed member of each relevant Federal Environment Agency department

1.3.3.1.3   Workflow organisation of 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 8).
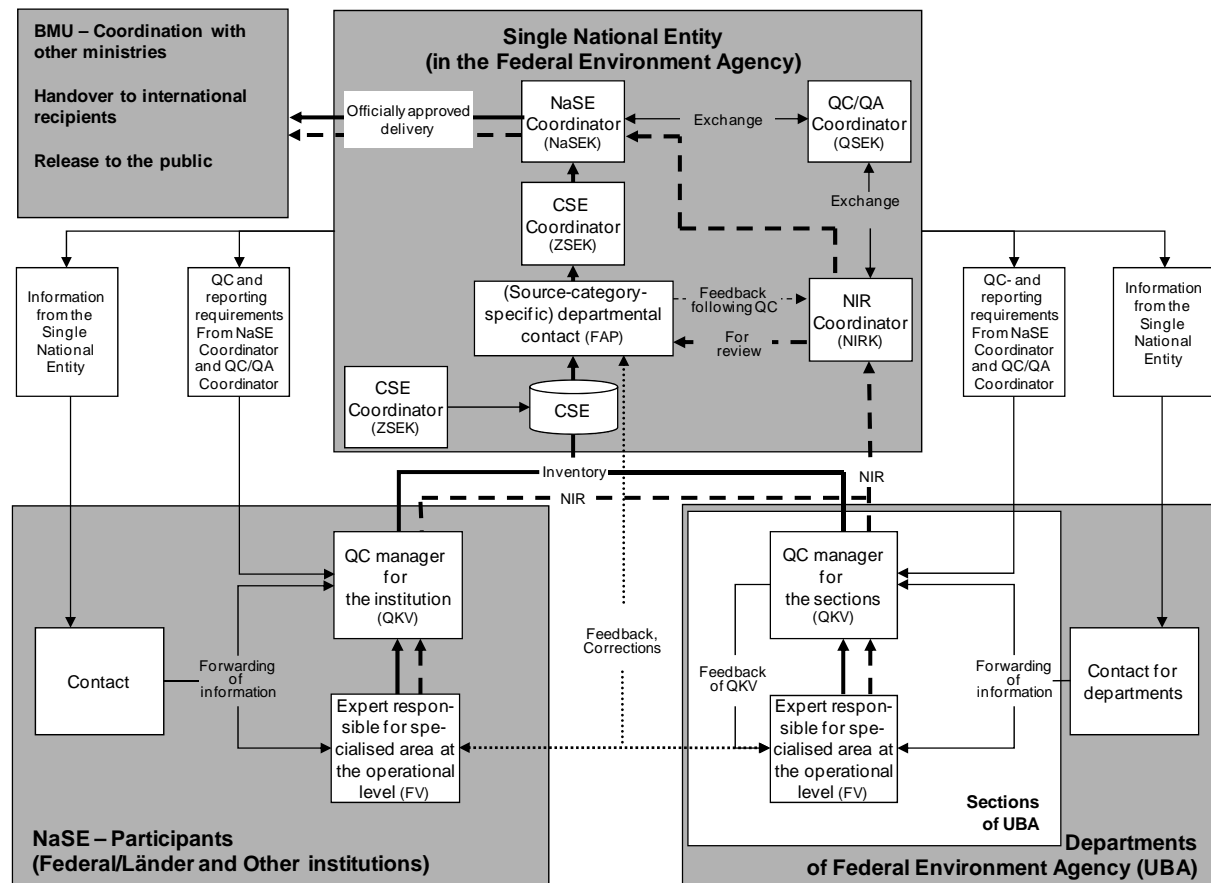
Figure 8:   QSE – Roles, responsibilities and workflow

The required QC reviews pursuant to Paragraph 14 (g) of the *Guidelines for National Systems* are provided, in the form of QC 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 9.
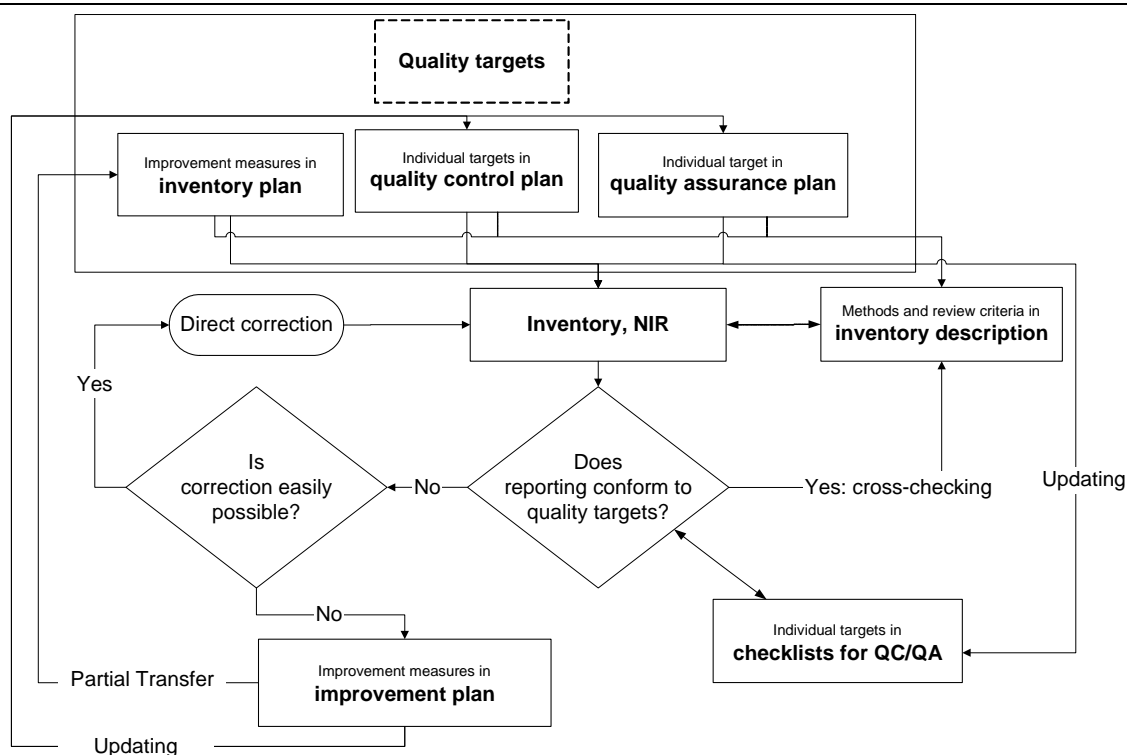
Figure 9:   NaSE & QSE – Control and documentation

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, QC 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 quality control checklists are to be filled

---

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

out by 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 quality control, 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 sources. 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** is a collection of all potential improvements, and criticisms, that result from independent inventory review and are identified in the framework of the relevant last completed emissions-reporting cycle. In the plan, such improvements and criticisms 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 internal directive (cf. Chapter 1.2.1.6). 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 1.2.1.6). 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,
- the requirements for reporting from the Guidelines,
- the results of inventory reviews,
- the available specific data for each source category (inventory description),
- the results of assessment of key sources,
- the NIR,
- the guide for calculations of uncertainties and determination of key sources pursuant to Tier 2,
- 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 from 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, since 2004 all tabular-form correspondence relative to inventory reviews, along with the pertinent German answers, and together with relevant documents from national QC/QA, has been archived in a searchable format.

1.3.3.1.7　　*Use of monitoring data from European emissions trading for improvement of GG-emissions inventories*

Monitoring data from the European Emissions Trading Scheme (ETS) 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 ETS CO_2 Emissions Trading Scheme.

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.

Procedural flow for annual inventory verification using ETS monitoring data
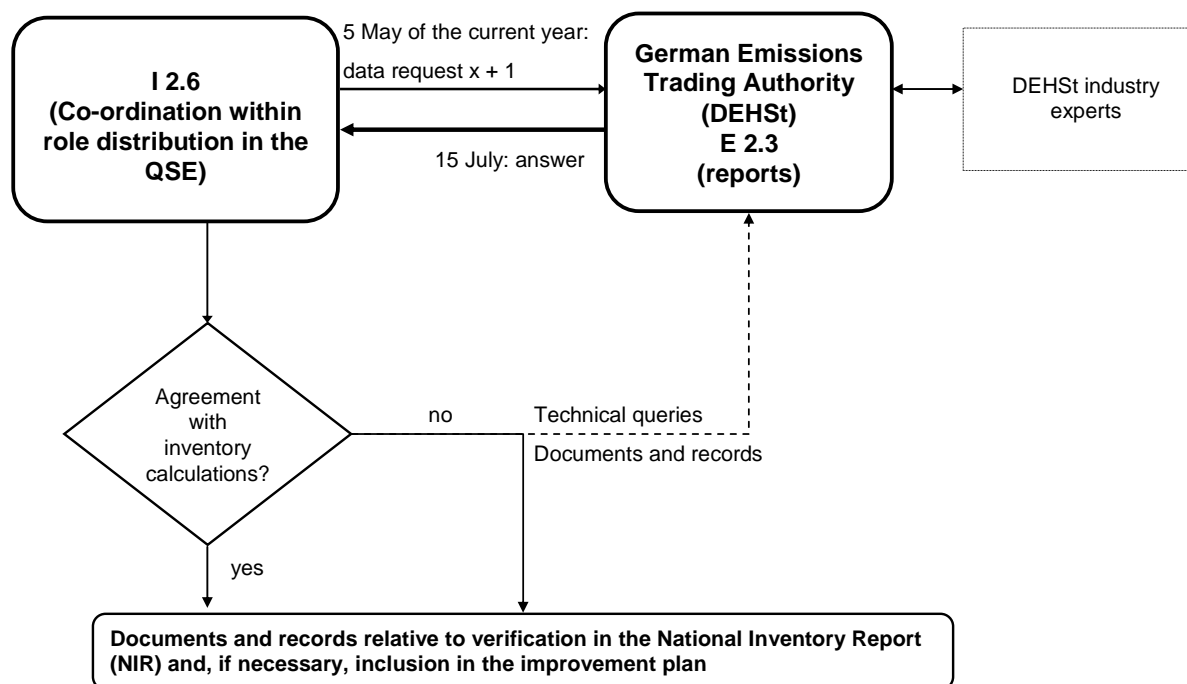
Figure 10:　　Procedural flow for annual inventory verification using ETS monitoring data

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
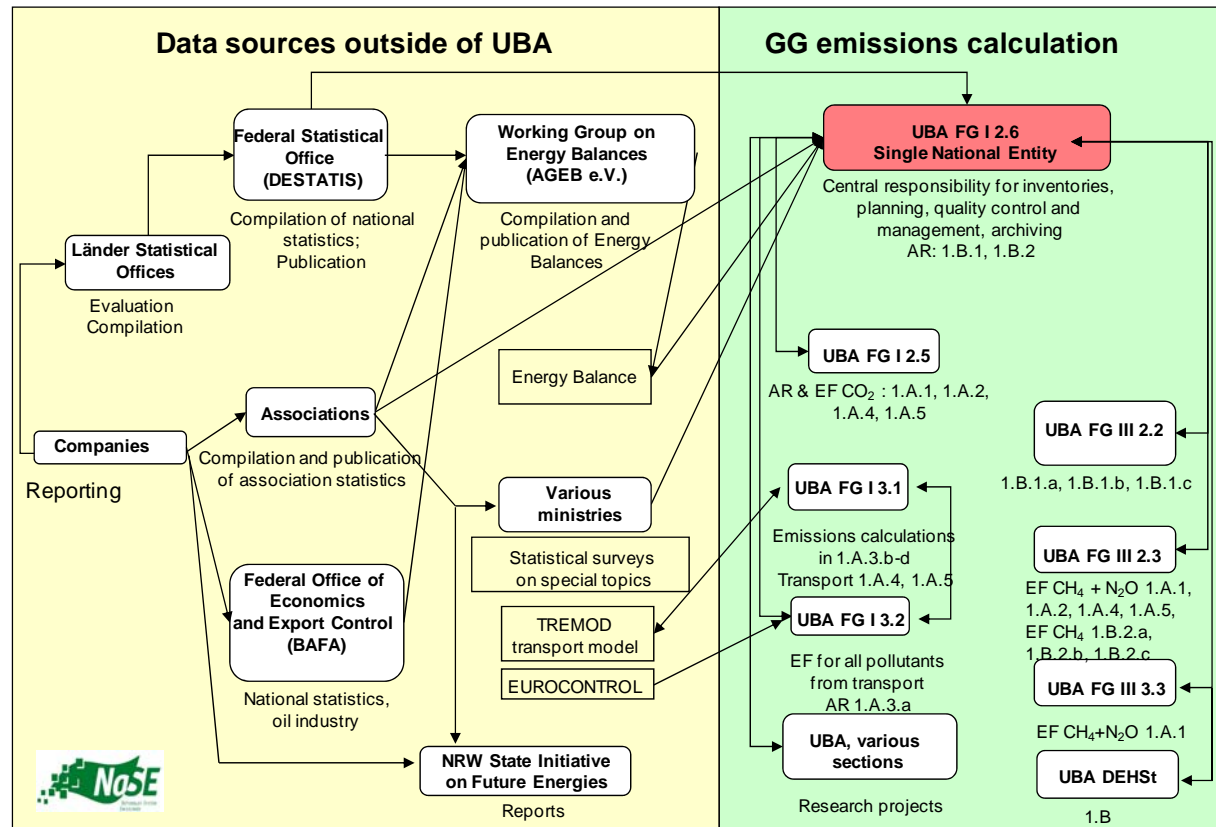
Figure 11:   Responsibilities and data flows for calculation of greenhouse-gas emissions in the energy sector

In all likelihood, the most important data sources for determination of activity rates for source category 1.A are the *"Energiebilanzen der Bundesrepublik Deutschland"* (Energy Balances of the Federal Republic of Germany, 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.

For the Energy Balances, 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 rates consists of *Fachserien 4 Reihe 4.1.1, Reihe 6.4, Reihe 8.1* and, for waste data, Fachserie 19 of the *Federal Statistical Office*. These publications contain data on production-related fuel consumption, 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.

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 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"*; IFEU, 2009)[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 2004).

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: For purposes of breaking down air-transport fuel consumption and emissions in accordance with national and international air transports, EUROCONTROL provides year-specific split factors determined on the basis of actual flights. For breakdown of consumption and emissions data in accordance with different flight phases, it has now been possible, for the first time ever, to use aircraft-movement data (numbers of take-offs and landings) collected by the *Federal Statistical Office*.

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, 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

---

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.

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); the pertinent data sources are noted in the relevant categories. The total quantity of soda ash production (2.A.4) is determined via surveys of the Federal Statistical Office, while soda ash use (2.A.4) is reported under other source categories (included elsewhere); the pertinent data sources are noted in the relevant categories. 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 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 Ceramics) are determined via official statistics and via conversion factors provided by the Federal association of the German brick industry (Bundesverband der Deutschen Ziegelindustrie).
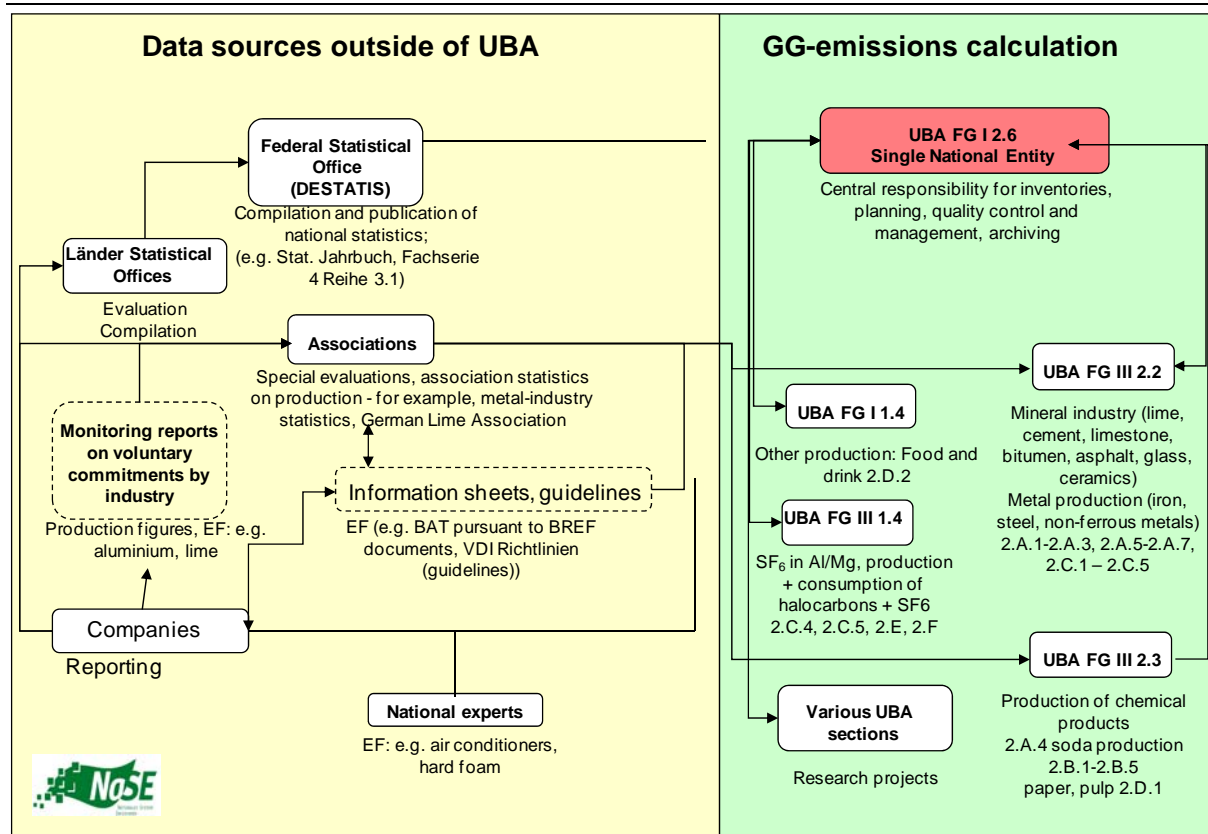
Figure 12:   Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of industrial processes

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) are calculated with the help of stoichiometric factors. Soda ash production (2.A.4) 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 Glass) have been derived from glass-composition data, while CO_2-emission factors for the ceramics industry (2.A.7 Ceramics) 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 data of the *Federal Statistical Office*, of the *Mineralölwirtschaftsverband* e.V. 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 rates 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 legally secured 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, emissions from several different production processes are reported: Production of sulphuric acid, titanium dioxide, organic substances, soot and other products. 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 source category Ferroalloys production (2.C.2) is an exception in this regard; Germany has only one producer, and it provides data directly.

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.

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.

Activity data for use of halogenated hydrocarbons and SF_6 (2.F) are determined from producers' and associations' figures, as well as via calculation models. The pertinent emission factors are determined by Federal Environment Agency experts and contracted researchers. 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   Solvents and other product use
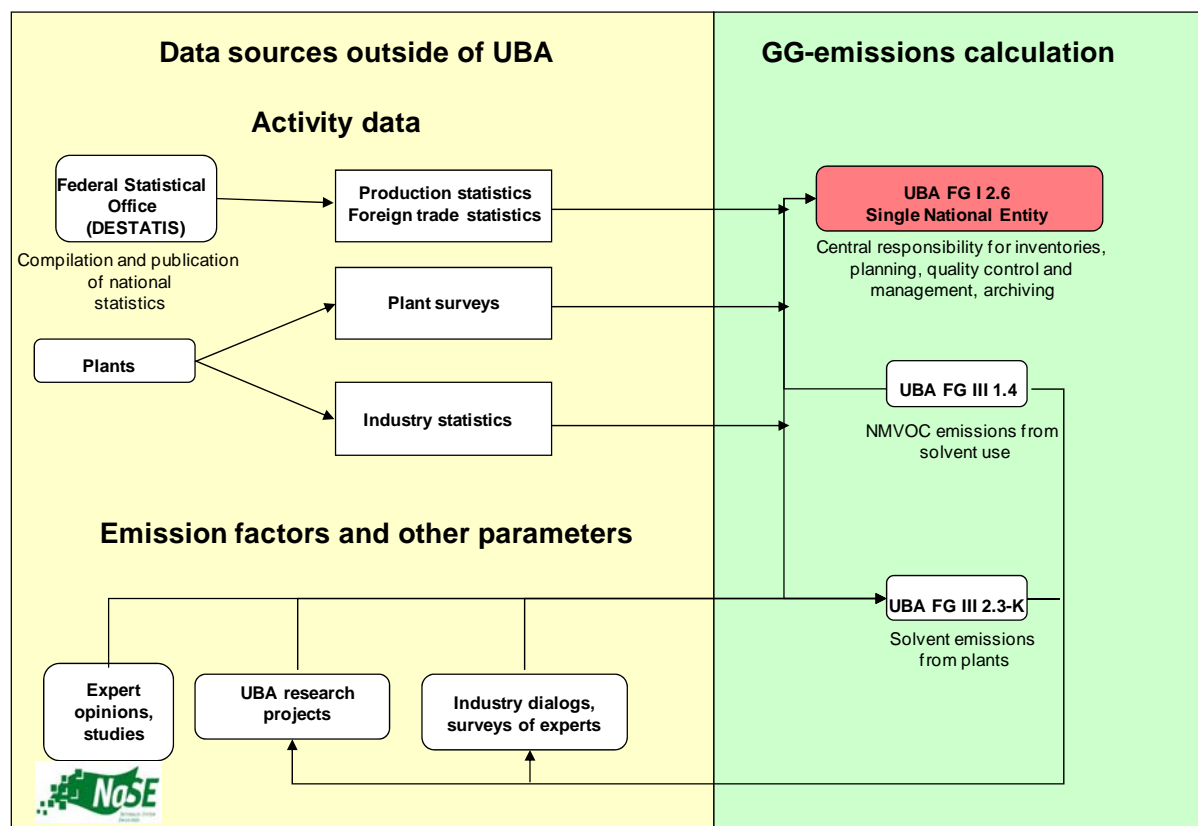
Figure 13:   Responsibilities and data flows for calculation of greenhouse-gas emissions from use of solvents and other products

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 III 1.4 *Substance-related Product Issues* is supported by the agency's Section (FG) III 2.3 *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. Older surveys of facilities are used in the area of N_2O emissions from narcotic uses.

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*
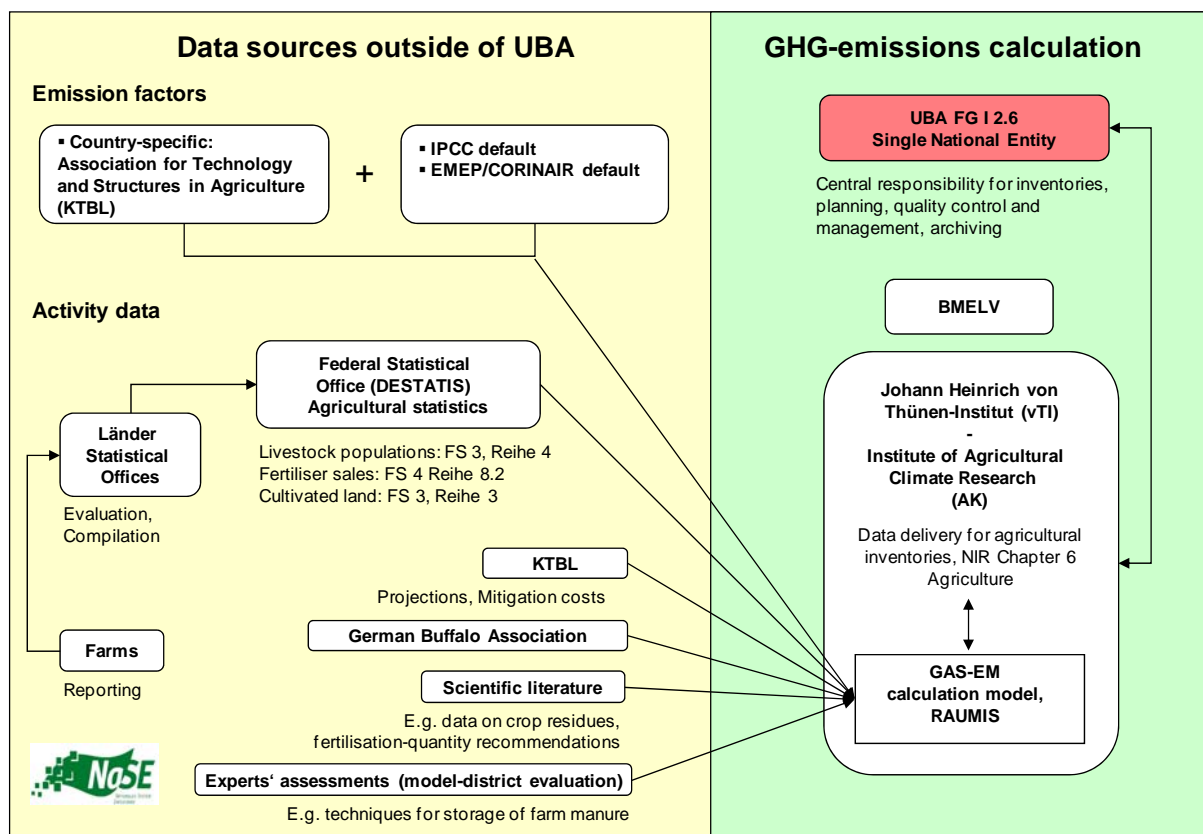
Figure 14:   Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of agriculture

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 & 2009a). 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 taken from *Fachserie 3, Reihe 4* of the Federal Statistical Office (*STATISTISCHES BUNDESAMT,* Fachserie 3 Reihe 4); 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 agricultural sector are based on simpler methods (EMEP/CORINAIR) or on Tier 1 methods (IPCC) – on methods that use standard emission factors from the 1996b and 2006 IPCC Guidelines or from the EMEP/CORINAIR manual of the United Nations Economic Commission for Europe (UN ECE). In addition, in a number of

areas country-specific factors and parameters are used that have been taken from research projects and the literature and that the vTI has compiled and integrated within the calculation model.

1.4.1.1.5   Land-use changes and forestry
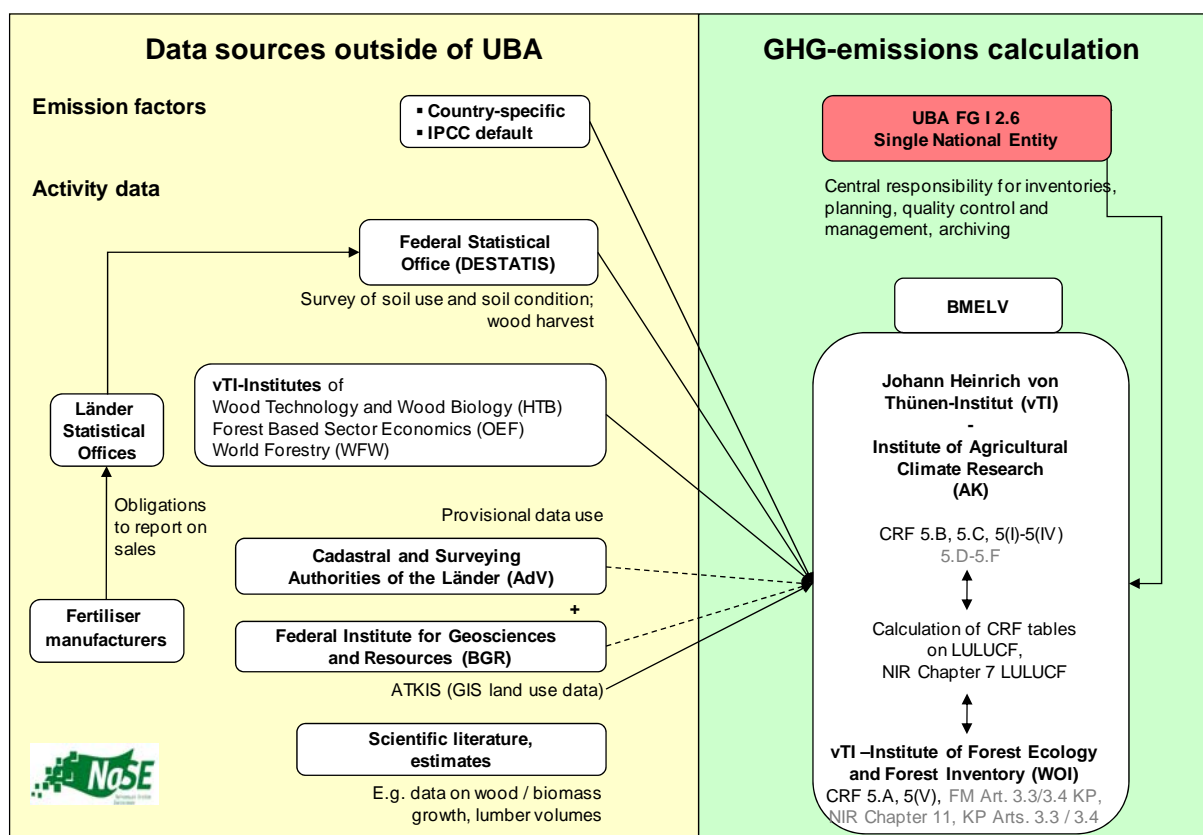
Figure 15:   Responsibilities and data flows for calculation of greenhouse-gas emissions from the area of land-use changes and forestry[15]

The changes in carbon stocks in forest biomass, and the activity data for forest and land-use changes (uses changed to and from forest), were derived for the first time for the 1990-2003 greenhouse-gas inventory. In that work, carried out on behalf of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) by the Forest Research Institute Baden-Württemberg (Forstliche Versuchs- und Forschungsanstalt; FVA), the changes were derived primarily from the data of Federal Forest Inventories (Bundeswaldinventuren; BWI), in keeping with provisions of the Good Practice Guidance Land-Use, Land-use Change and Forestry (GPG-LULUCF, IPCC, 2003). CO_2 emissions were determined via the stock-change method. The activity data are based on the Federal Forest Inventories and on information from the Datenspeicher Waldfonds forest database. When the results of the next Federal Forest Inventory (Bundeswaldinventur 3) become available, another recalculation will be carried out for the period 2003 to 2012. That recalculation is expected to provide finalised, high-quality emissions estimates. Recalculation will then also be carried out with regard to activity data for the same period. That work will also help to increase quality, and it will support uncertainties estimates. A nation-wide study on data collection for the 2008

---

[15] In 2008, data flows are being adjusted in accordance with restructuring of departmental research (the Federal Agricultural Research Institute (FAL) and the Federal Research Centre for Forestry and Forest Products (BFH), the latter of which is being renamed as the "Johann Heinrich von Thünen Institute").

commencement of the 2008-2012 commitment period has enhanced conclusions regarding trends during that commitment period. CO_2 emissions from forests have been redetermined for the period 2002 to 2008.

Reporting on forestry activities pursuant to Article 3 (4) of the Kyoto Protocol will thus be based primarily on statistical and spatial surveys using a regular grid. Samples will be taken at the grid's nodes. Each sampling site will be geo-referenced and will statistically represent a certain area.

Forests' function as carbon sinks, in terms of carbon stored in biomass, can be estimated for the period between 2002 and 2012 on the basis of the Federal Forest Inventory 2 (Bundeswaldinventur 2) and the Federal Forest Inventory 3 (Bundeswaldinventur 3; sample year 2012), which is currently in preparation.

Area surveys for determination of use changes in the areas of cropland, grassland, wetlands, settlements and other land are carried out with the help of a digital landscape model (B-DLM/ATKIS). That model divides the Federal Republic of Germany into defined areas, all of which are fully georeferenced. "Wall-to-wall" use of unique identification numbers for the areas eliminates the possibility of any double-counting. The system is continually updated by the surveying authorities of the Länder and the Federal Agency for Cartography and Geodesy (BKG). For purposes of the inventory, land-use changes are determined on an annual basis, with the help of a GIS.

Soil carbon stocks are estimated with the help of soil maps provided by the Federal Institute for Geosciences and Natural Resources (BGR), while use-change-related changes in these stocks are estimated using response functions (mathematical models that serve as emission factors) derived from the scientific literature.

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 data from the digital landscape model). 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 are underway for improving activity data and, especially, for determining country-specific emission factors for carbon and nitrogen – and CO_2, CH_4 and N_2O (such as the "Organic Soils" project and the Soil-condition Survey for the Agriculture Sector project ("Bodenzustandserhebung Landwirtschaft"), both of which have been underway since 2009). These projects will lead to high-quality estimates of emissions and removals for the land-use categories forest, cropland, grassland, wetlands, settlements and other land uses, as well as to considerable reductions in uncertainties. On the other hand, recalculation of results for the years 1990 - 1999 will not yield the same degree of quality improvements. The reasons for this are that German reunification has created a special historical situation and that data for the digital landscape model are available only as of the year 2000. Area-changes for this period are calculated on the basis of the data from the CORINE Landcover Programme (UBA, DLR), area-survey data and the data from the main survey on soil use (Bodennutzungshaupterhebung; administrated by the Federal Statistical Office), following application of mathematical procedures to bring the data in line with the ATKIS® (AdV) system.

1.4.1.1.6   *Waste and wastewater*
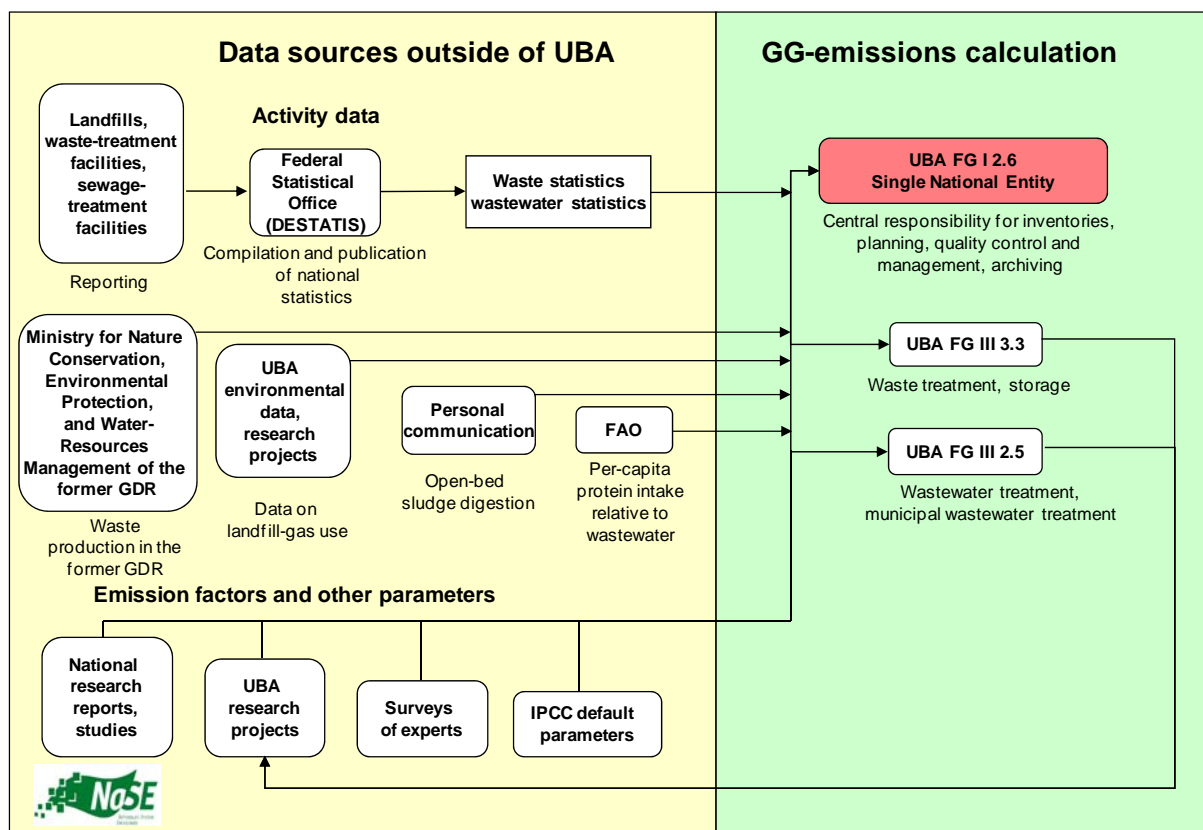
Figure 16:   Data flows for calculation of greenhouse-gas emissions from the area of waste and wastewater

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 on landfill-gas use are based on data from the publication "Daten zur Umwelt" (environmental data), which is published regularly by the Federal Environment Agency. For 2001, data were also taken from a current research project.

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.

No Federal Environment Agency section has yet been identified that would be responsible for selecting the methods, parameters and data for calculating emissions from the industrial wastewater handling sector (wastewater and sewage sludge) (6.B.1). The Federal Environment Agency's Section FG 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 have been taken from national studies and research reports and from 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 methods and calculations made, in the various source categories, with IPCC-prescribed calculation methods of varying degrees of detail (of varying "Tiers"*)*[16]. 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-source analysis" (cf. Chap. 1.5 in this regard).

For the present report, air-transport emissions have been calculated, for the first time, in accordance with IPCC-Tier 2a - i.e. they have been calculated separately for national and international air transports and separately for the flight phases LTO and Cruise. Further information regarding the procedure used is presented in Chapters 3.2.2.2 and 3.2.10.1.

Unlike emissions calculations for other modes of transport, and for mobile sources, calculation of greenhouse-gas emissions from road transports uses 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.

For industrial processes, in many areas detailed IPCC tiers are used for the greenhouse gases HFCs, PFCs and SF_6. This is possible, in particular, because emissions for these

---

16 *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.

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.

For agriculture, emissions were calculated primarily on the basis of the CORINAIR Guidebook, using IPCC default emission factors. Calculations for key sources 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, Chapter 7.2 and Annex Chapter 19.5.1.

1.5   Brief description of key sources

1.5.1   Greenhouse-gas inventory (with and without LULUCF)

The key sources were defined by applying two Tier 1 procedures, Level (for the base year, for 1990 and for 2008) and Trend (for 2008, as compared to the base year), to German greenhouse-gas emissions. In keeping with the pertinent IPCC specifications, analysis focussed both on emissions from sources and on storage 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 sources result from work in 2008 – they resulted either from level analysis for 2008 or from trend assessment.

For 2008, this approach identified 42 source categories, out of a total of 117 source and sink categories studied, as key sources. Only 28 of these were identified, by both trend and level analysis, as key sources. In addition, 9 source categories were identified as key sources solely by trend analysis, and 5 source categories were so identified solely by level analysis.

In critical discussion of the results, 6 of the aforementioned identified source categories were then removed from the group of key sources. Such removal always occurred in cases in which the key-source decision was based only on trend analysis, in which an extreme falling

trend was seen (over 60 %) and in which the 2008 emissions were considerably below the emissions level via which the last relevant sources had been identified via "level" analysis (for example, in 2008, emissions of the source that was the last source responsible for the exceeding of the 95 % emissions percentage amounted to 3,675 Gg equivalent emissions; the CO_2 emissions from 1.A.2.e *Food Processing* decreased by over 92 % between the base year and 2008, and in 2008 they were only 155 Gg – as a result of this comparison, this source category is no longer listed as a key source within the German inventory).

Ultimately, 36 key sources were defined. These are summarised in Table 5.

Table 5:   Number of source categories and key sources

Source categories			116	
				Key sources
by Level	Level & Trend	Trend		
5	28	3		**36**

Table 7 provides an overview of the results of key-source assessment. Annex 1 (Chapter 17) of this report presents detailed explanations of the key-source assessment carried out.

Only few changes have occurred with respect to the results obtained in the previous year. In definition of key sources in 2008, emissions from the source category *Sulphuric acid production* were removed from the "key source" group (the reason was that the source category's emissions were lower; emissions analysis, which is now carried out on the basis of information provided by producers, produced that result). New additions to the group include CH_4 and N_2O emissions from the source category 1.A.1a *Public electricity and heat production* and CO_2 emissions from the category 5.F *Other land*.

1.5.2   Inventory with KP-LULUCF reporting

This year, elements of KP-LULUCF reporting were included, for the first time, in key-source assessment. As a result of the analysis, as described in the previous chapter, of the UNFCCC inventory, CO_2 emissions/storage in the categories *Forest Land* (5.A), *Cropland* (5.B), *Grassland* (5.C), *Settlements* (5.E) and *Other Land* (5.F) proved to be key sources. For these categories, additional detailed analyses were carried out, in line with the methodological specifications set forth in the chapter "5.4 methodological choice – identification of key sources" 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 sources 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 196 in Chapter 17.1.3).

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

IPCC Source categories	Emissions / Sinks of	1990	2008	Key source assessment
5.A.1 Forest Land remaining Forest Land	CO_2	-65,644.1	-20,441.0	●
5.A.2 Land converted to Forest Land	CO_2	-49.7	-2615.2	●
5.B.1 Cropland remaining Cropland	CO_2	24,546.9	22,955.9	●
5.B.2 Land converted to Cropland	CO_2	480.6	6,329.5	●
5.C.1 Grassland remaining Grassland	CO_2	13,304.1	12,742.6	●
5.C.2 Land converted to Grassland	CO_2	-252.2	2,778.7	●
5.D.1 Wetlands remaining Wetlands	CO_2	2,145.7	1,983.8	
5.D.2 Land converted to Wetlands	CO_2	44.8	613.0	
5.E.1 Settlements remaining Settlements	CO_2	1,448.6	2,304.6	
5.E.2 Land converted to Settlements	CO_2	430.7	5,296.7	●
5.F.1 Other Land remaining Other Land	CO_2	0.0	-148.4	
5.F.2 Land converted to Other Land	CO_2	22.2	-5,079.4	●
5.G Other C emissions from lime application	CO_2	163.5	60.5	
5.B.2 Lands converted to Cropland	N_2O	56.5	740.1	

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

IPCC Source Categories	Activity	Emissions of	Level						Trend		Emission Base Year	Emission 2008
			Base Year	Base Year +sinks	LEVEL 1990	1990 +sinks	LEVEL 2008	2008 +sinks	2008	2008 +sinks		
1A1a Public electricity and Heat production	all fuels	N_2O	●								3610.0	3534.1
1A1a Public electricity and Heat production	all fuels	CO_2	●	●	●	●	●	●	●	●	335781.5	316924.2
1A1a Public electricity and Heat production	all fuels	CH_4							●	●	185.8	1778.8
1A1b Petroleum Refining	all fuels	CO_2	●	●	●	●	●	●	●	●	20005.9	21611.6
1A1c Manufacture of Solid Fuels and Other Energy Industries	all fuels	CO_2	●	●	●	●	●	●	●	●	59066.1	13310.8
1A2a Manufacturing Industries and Construction: Iron and Steel	all fuels	CO_2	●	●	●	●	●	●	●	●	12577.9	11377.5
1A2e Manufacturing Industries and Construction: Food Processing	all fuels	CO_2							●	●	1989.2	154.7
1A2f Manufacturing Industries and Construction: Other	all fuels	CO_2	●	●	●	●	●	●	●	●	138312.0	81299.9
1A3b Transport: Road Transportation	all fuels	CO_2	●	●	●	●	●	●	●	●	150358.3	144872.9
1A3c Transport: Railways	all fuels	CO_2							●	●	2879.3	1142.9
1A3d Transport: Navigation	Diesel Oil	CO_2							●	●	2049.8	401.5
1A3e Transport: Other Transportation	all fuels	CO_2	●	●	●	●	●	●			4302.3	3675.7
1A4a Other Sectors: Commercial/Institutional	all fuels	CO_2	●	●	●	●	●	●	●	●	63949.6	40136.9
1A4a Other Sectors: Commercial/Institutional	all fuels	CH_4							●		1216.1	57.2
1A4b Other Sectors: Residential	all fuels	CO_2	●	●	●	●	●	●	●	●	129474.0	104411.6
1A4c Other Sectors: Agriculture/Forestry/Fisheries	all fuels	CO_2	●	●	●	●	●	●	●	●	10917.1	6298.6
1A5 Other: Include Military fuel use under this category	all fuels	CO_2	●	●	●	●			●	●	11798.5	1305.5
1B1a Fugitive Emissions from Fuels: Coal Mining and Handling	Solid Fuels	CH_4	●	●	●	●	●	●	●	●	18415.2	3744.8
1B1c Fugitive Emissions from Fuels: Other (Abandoned Mines)	Solid Fuels	CH_4							●	●	1806.8	105.4
1B2b Fugitive Emissions from Fuels: Natural Gas	Gaseous Fuels	CH_4	●	●	●	●	●	●	●	●	6782.3	6896.5
2A1 Mineral Products: Cement Production	Clinker Production	CO_2	●	●	●	●	●	●	●	●	15145.8	13444.1
2A2 Mineral Products: Lime Production	Limestone and Dolomite	CO_2	●	●	●	●	●	●	●	●	6135.0	5660.9
2B1 Chemical Industry	Ammonia Production	CO_2	●	●	●	●	●	●			4292.0	4111.0
2B3 Chemical Industry	Adipic Acid Production	N_2O	●	●	●	●	●	●	●	●	18804.6	5502.3
2B5 Chemical Industry	Other	CO_2	●	●	●	●	●	●	●	●	6869.8	10299.5
2C1 Metal Production: Iron and Steel Production	Steel (integrated production)	CO_2	●	●	●	●	●	●	●	●	48326.0	43184.9
2C3 Aluminium Production		PFC							●	●	1551.7	247.2
2C4 SF6 Used in Aluminium and Magnesium Foundries		SF_6							●	●	C	C
2E Production of Halocarbons and SF6	Production of HCFC-22	HFC	●	●	●	●			●	●	C	C
2F Industrial Processes	Consumption of Halocarbons and SF6	SF_6	●	●	●	●			●	●	6413.8	3052.6

IPCC Source Categories	Activity	Emissions of	Level						Trend		Emission Base Year	Emission 2008
			Base Year	Base Year +sinks	LEVEL 1990	1990 +sinks	LEVEL 2008	2008 +sinks	2008	2008 +sinks		
2F Industrial Processes	Consumption of Halocarbons and SF6	HFC					●	●	●	●	2250.5	11024.4
4A1 Enteric Fermentation	Dairy Cattle	CH_4	●	●	●	●	●	●			13119.4	10080.2
4A1 Enteric Fermentation	Non-Dairy Cattle	CH_4	●	●	●	●	●	●	●	●	11747.1	8178.4
4D1 Agricultural Soils	Direct Soil Emissions	N_2O	●	●	●	●	●	●	●	●	33115.2	30409.9
4D1 Agricultural Soils	Indirect Emissions	N_2O	●	●	●	●	●	●			7491.3	6639.7
5A Forest Land		CO_2		●		●		●		●	65693.7	23056.2
5B Cropland		CO_2		●		●		●		●	27629.4	31252.6
5C Grassland		CO_2		●		●		●		●	13051.9	15521.3
5E Settlements		CO_2						●		●	1879.3	7601.4
5F Other Land		CO_2						●		●	22.2	5227.8
6A Solid Waste Disposal on Land	Managed Waste Disposal on Land	CH_4	●	●	●	●	●	●	●	●	35910.0	7518.0
6B Wastewater Handling	Domestic and Commercial Wastewater	CH_4							●	●	2226.2	100.1

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

As of the 2006 report, inventories are submitted using the CRF-Reporter software provided by the climate secretariat. Like previous versions, the current version contains a range of programming errors. The identified programming errors have been communicated to the UNFCCC. As a result of existing software errors, data-validity problems cannot be ruled out. In addition, the time and care required to carry out quality assurance for data entry exceed the relevant limits in light of the applicable deadlines. The German QSE cannot solve this problem with measures of its own; the FCCC Secretariat is requested to correct this situation.

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. That evaluation is then combined with evaluation of the results of the various review procedures of the UNFCCC and the EU Commission. 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 departments, 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 8. 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 8:   Inventory plan 2010

Planning for inventory improvement / required actions	Category (CRF code)
Check whether requirements of IPCC Good Practice Guidance pertaining to selection of calculation method and to procedures for applicable methods changes are fulfilled.	2.F.6
Check whether it was possible to take pointers from inventory reviews into account.	1, 2.C.2, 4.D, 5
Check whether there are any gaps in the available data for time series as of 1990.	1.A.3.c, 2.C.2, 4.A.(b), 4.B.(b), 4.D
Check whether uncertainties have been determined and are complete.	1.A.3.b+c+e.ii, 1.A.5.b, 2.A.5, 5, 6.B.2
Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	1.A.2.f, 1.B.2, 2.A.5+6, 4
Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.	1.A.1-2, 1.A.3.b+c+e, 1.A.4, 1.A.5.a+b, 1.B.1+2, 2.A.7(b), 2.C.2+3, 2.D.2, 5(III), 5.B-F, 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.).	2.A.6, 2.C.2-3, 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, 1.A.1-2, 1.A.3.a.ii, 1.A.3.b+c+e, 1.A.4, 1.A.5.a+b, 1.B.1+2, 1.C.1.b, 2.C.1-3, 2.D.1-2, 4.A.(a), 4.B.(a), 5, 6.A.1, 6.B.2, 6.D
Check whether the data source (s) used will be available throughout the long term.	4.A.(a), 4.B.(a), 6.D.(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.	1.A.1, 1.A.3, 1.A.4.cii, 1.A.5.b, 1.C.1.b, 4.A+B+D, 5(III), 5.A.(f), 5.B-F, 6.B.2
Various types of required action.	1.A.3.b+e.ii, 1.A.4.c.ii, 1.A.5.b, 1.B.1, 2.A.5, 3.A+B, 3.D.1+4+5, 5.B
Check whether pertinent responsibilities need to be updated.	1.A.2.d, 1.A.3.e.i, 1.B.1, 2.A.6, 2.B.5.Ger2, 2.D.1, 3.D.1+4, 6.B.2

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 the European Emissions Trading Scheme (ETS) 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 ETS CO_2 Emissions Trading Scheme.

Allocation rules have been developed with which data from verified emissions reports can be compared with that 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. 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.

1.6.2.2   Workshop on the National System

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 independent third parties.

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 emissions data and reporting methods used to date were reviewed and improved. The workshop contributed significantly to overall improvement of the data and of the quality of reporting.

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 rates, 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. That study was completed in mid-2009, and its results are now being successively implemented.

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*.

The Single National Entity is currently refining its concept for handling of confidential information and adjusting it to the relevant new circumstances (agreements with the *Federal Statistical Office*, associations and companies).

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 rates 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 rates, 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 assessment, pertinent figures are added from other sources (such as relevant technical literature), in the framework of a Tier 1 calculation.

1.7.1.1   Procedure for determining uncertainties pursuant to Tier 1 and Tier 2, Chapter 6 of the GPG

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 structural element 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 various pertinent time series are aggregated, using formula 6.3 of the IPCC Good Practice Guidance (additive combination of uncertainties), to form a total uncertainty for the sector. In the process, the uncertainties for the various activity rates, emission factors and determined emissions (U_i in Formula 6.3) are taken into account, together with the pertinent calculated or otherwise determined emissions (x_i in Formula 6.3). 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|).

Tier 2 uncertainties determination was carried out in keeping with the five-step procedure described in the GPG (IPCC, 2000, Chapter 6.4 "Tier 2 – Estimating Uncertainties by Source Category Using Monte Carlo Analysis"). The first step consists of assigning a value range and a distribution function, at the level of the basic data. The values for the 2008 report year, from the current time series in the CSE, are used as the basic data. The time series are considered to be consistent also with regard to uncertainties. Along with time series for activity rates and emission factors, time series for emissions not calculated as the product of AR and EF are taken into account.

The second step consists of computer-aided execution of Tier 2 calculation. Figures for mean value, upper and lower boundary (2.5 % and 97.5 % percentile) and distribution type are read out from the CSE. The uncertainties figures in the CSE are based primarily on experts' assessments. Where those figures are incomplete, they are supplemented with values from the relevant technical literature wherever possible. Where data have not yet been evaluated in this regard, and it has also not been possible to assign a literature value to them, the uncertainties underlying the "Conservativeness Factors" of the IPCC's adjustment procedure

(FCCC/SBSTA/2003/ 10/Add2) have been used as placeholders, and thus a complete set of uncertainties data is available for the inventory for purposes of uncertainties aggregation.

These starting data serve as the factors and sum elements of the emissions to be calculated, and they are referred to as "assumptions". The pertinent emissions then appear at the level of the individual source categories, and in the inventory's various aggregation levels. They should be understood as predictions.

In a third step, a random value is then generated, for each assumption, as a function of the relevant value range and type of distribution involved in the starting data. In the fourth step, the emissions (predictions) are calculated. In a fifth step, the results of this calculation step are saved. Steps three to five are repeated 20,000 times. Finally, the 95 % confidence interval and arithmetic mean are read out for each instance of emissions. In the GPG, a mean-value fluctuation range of less than +/-1 % is given as a criterion for terminating steps three to five. In a few source categories (categories with especially high uncertainties), that termination criterion is not achieved even with 20,000 iterations. In such cases, increasing the number of calculation runs to over 20,000 iterations led to termination of the calculation.

1.7.1.2 Results of uncertainties assessment

In general, uncertainties for activity rates can be assumed to be smaller than those for emission factors. In particular, the uncertainties are smaller for activity rates derived from fuel use and based on the Federal Energy Balance. On the other hand, uncertainties for activity rates 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 monitored in normal cases. 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 rates 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 rates for Coal mining (CRF 1.B.1) are also well-represented by production volumes. 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 the area of industrial processes (CRF 2). Activity rates 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 rates 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 rates 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) 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 uncertainties for the activity rates are also disproportionately high, since the underlying statistical data make use of non-standardised waste and recycling definitions. The general assumptions relative to the uncertainties of activity rates also apply to thermal treatment of waste.

Pursuant to Tier 1, the inventory's total uncertainty figures for 2008 are 3.8 % (level) and 4.1% (trend).

Tier 2 uncertainties determination yields uncertainty figures of +5.4% and -4.7% for the 2008 inventory as a whole.

With respect to the previous year, the total uncertainty has been significantly reduced, primarily via verification and revision of uncertainties for nitrous-oxide emissions from agricultural soils. Furthermore, in some other source categories high default uncertainties were replaced with new experts' assessments.

Nitrous oxide emissions account for a significant share of the total uncertainty. That share, while significantly reduced, is still defined markedly by nitrous oxide emissions from agricultural soils (4.D) and from the chemical industry (2.B). CO_2 sinks within the LULUCF sector also contribute significantly to the total uncertainty.

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 248 and Table 249). 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 the DEHSt's provision of data to the Single National Entity has been concluded in order to facilitate regular data exchanges. The regular checking process within the framework of source category responsibility is to be supported by adapting the QC system via checklists.

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 9 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 for reduction obligations under the Kyoto Protocol – 1,232,429.543 Gg CO_2 equivalent – has been defined in keeping with results of review[17] 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 %. Table 10 shows the annual progress achieved, with respect to 1990, for each pertinent year. With the exception of HFCs and of C_3F_8, 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 22.2 % compared to the aforementioned reference figure. With regard to the previous year, 2007, total emissions rose slightly, by 0.1 %. As to contributors to the overall result, a CO_2-emissions reduction of only 0.1 %, caused by a drop in energy consumption, and a 0.8 % reduction in methane emissions were offset by a 1.9 % increase in nitrous oxide emissions and + 5.5 % growth in emissions of F gases. The main factors contributing to the methane reductions include further increases in use of mine/pit gas and continuing decreases in waste-sector emissions.

Table 256 in the Annex shows the relevant emissions changes, in comparison to the previous year, for the period since 1990. For CO_2, 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 indoor heating, thereby having a major impact on annual trends in energy-related emissions.

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

All in all, extensive recalculations had to be carried out, especially for the years 2003 to 2007, to take account of now-available revised energy consumption data.

Table 9:   Emissions of direct and indirect greenhouse gases and SO_2 in Germany since 1990

Emissions change (Gg)	1990	1995	2000	2005	2006	2007	2008
Net CO_2 emissions / storage	1,016,438	903,407	864,733	887,701	897,128	871,887	862,488
CO_2 emissions (not including LULUCF)	1,036,716	925,413	886,900	853,540	861,339	833,926	833,092
CH_4	103,299	84,839	67,959	51,474	49,498	48,146	47,745
N_2O	79,989	75,749	57,572	57,775	56,654	59,028	60,166
HFCs (CO_2 equivalent)	4,369	6,469	6,483	9,990	10,527	11,141	11,469
PFCs (CO_2 equivalent)	2,708	1,750	781	707	569	528	531
SF_6 (CO_2 equivalent)	4,785	7,220	5,082	4,898	5,510	5,567	5,846
CO	12,178	6,582	5,039	3,829	3,807	3,763	3,741
NMVOC	3,736	2,076	1,580	1,328	1,295	1,273	1,267
NO_X	2,877	2,149	1,846	1,503	1,509	1,442	1,380
SO_2	5,311	1,713	637	524	532	506	498

---

[17] "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 10:   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 2007	Reference year until 2008	With regard to the previous year (2007 – 2008)
Net CO_2 emissions / storage	1990	-14.2	-15.1	-1.1
CO_2 emissions (not including LULUCF)	1990	-19.6	-19.6	-0.10
CH_4	1990	-53.4	-53.8	-0.8
N_2O	1990	-26.2	-24.8	+1.9
HFCs (CO_2 equivalent)	1995	+72.2	+77.3	+3.0
PFCs (CO_2 equivalent)	1995	-69.8	-69.7	+0.5
SF_6 (CO_2 equivalent)	1995	-22.9	-19.0	+5.0
Total emissions with respect to EU burden-sharing[18]	Defined base year	-22.2	-22.2	+0.05
CO	1990	-69.1	-69.3	-0.6
NMVOC	1990	-65.9	-66.1	-0.5
NO_X	1990	-49.9	-52.0	-4.3
SO_2	1990	-90.5	-90.6	-1.7

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

As of 2008, the above-described obligation to reduce greenhouse-gas emissions, in the framework of EU burden-sharing, was again fulfilled, via a reduction of 22.2 % (and the recalculations carried out showed that emissions in 2007 were also in this range). The individual greenhouse gases contributed to this development to varying degrees (cf. Table 1). This is hardly surprising when one considers that different greenhouse gases account for different proportions of total emissions in any given year. Emissions of the direct greenhouse gases that predominate by amount were considerably reduced; CO_2 emissions decreased by 19.6 % and CH_4 emissions were reduced by 53.8 %. In the main, the reasons for these reductions 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;
- Enhanced economic efficiency;
- Changes in animal-housing methods, and reductions of livestock populations;
- Continued expansion in use of renewable energies and of related substitutions of fossil fuels;
- Temperature effects (on the average, 2008 was a warm year; according to the Deutscher Wetterdienst (German meteorological service), it was the sixth-warmest on record);
- Extensive methodological changes, as discussed in detail in the relevant "recalculations chapters". The most important of these was a rollback of last-year's transition to methods of the 2006 IPCC Guidelines (a change that proved especially significant in the area of N_2O).

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 impacts at the end of 2008, has not yet had any emissions-reducing effect.

---

[18] Defined base-year emissions of 1,232,430 Gg CO_2 equivalent, without CO_2 from LULUCF; cf. Chapter 0.2

Release of carbon dioxide from stationary and mobile combustion processes is far and away the principal cause of emissions, accounting for 86.9 % 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 by 3 percentage points since 1990 (cf. Table 2). Emissions of methane, which are caused primarily by animal husbandry, fuel distribution and landfill emissions, accounted for a share of 5.0 % in 2008, as in the years before. Emissions of nitrous oxide, caused primarily by agriculture, industrial processes and combustion of fossil fuels, account for 6.3 % of greenhouse gas releases. The other relevant gases, the so-called "Kyoto" or "F" gases, together accounted for about 1.9 % of total greenhouse-gas emissions. This spectrum of distribution of greenhouse-gas emissions is typical for a highly developed and industrialised country.

2.2 Description and interpretation of emission trends, by greenhouse gases
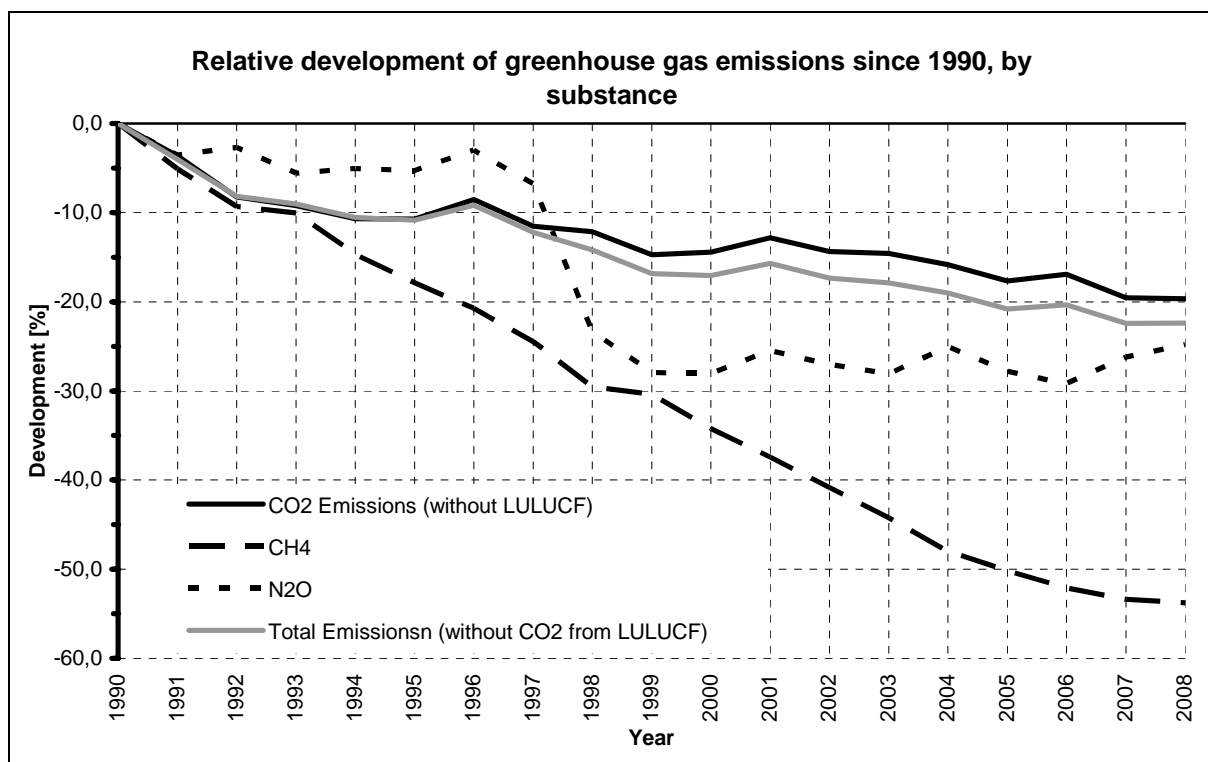
Figure 17:   Relative development of greenhouse gases in comparison to their levels in 1990

Figure 17 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 seen throughout the entire energy sector 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. This trend has 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 have decreased by 22.7 % with respect to their 1990 levels, and those from solid fuels have dropped by 40.6 %, emissions from combustion of gaseous fuels have increased by 44.3 %.

When these emissions trends are viewed at the source-category level, a highly consistent picture emerges. In comparison to 1990 levels, emissions in all source categories of energy-related emissions decreased by a total of 197 million t CO_2.

In the energy sector, emissions increased by a total of 3.5 million t in comparison to the previous year, with a significant reduction of nearly 21 million t in the power-station sector being offset by an emissions increase of 23.5 million t in the area of small combustion systems. The change in the power-station sector began with the situation in 2007, when the sector used an above-average quantity of coal, as a result of lower energy provision by nuclear power stations and of low prices for emissions allowances. That situation changed in 2008, as greater nuclear power-station capacities again became available and natural gas accounted for a large share of the fuels used in the sector. Other factors that tended to reduce emissions included further increases in energy efficiency, expansion in use of combined heat/power (CHP) systems and intensified use of renewable energies for electricity and heat production.

The slight emissions increases in the area of industrial combustion plants must be seen in light of the highly provisional nature of the available energy data and of data reallocations in the iron and steel industry.

Similar trends have occurred in the transport sector. In that sector, CO_2 emissions increased from 163 million t in 1990 to nearly 185 million t in 1999. Since then, they have fallen considerably below their outset level, to 152 million t, as a result of decreases in consumption, consumers' shifting of refuelling to other countries and fuel substitutions – use of diesel fuel instead of petrol, and use of biodiesel instead of petroleum-based diesel fuel. Over the 1990-2008 period, diesel fuel's share of total fuel consumption in road transports increased strongly. In 1990, nearly 2/3 of all road-traffic emissions were still being caused by petrol consumption. In 2008, the balance between petrol-related (44.5 %) and diesel-related emissions (55 %) reversed.

In the area of small residential combustion systems (+ 16 million t), and in the commercial and institutional sector (commerce, trade, services) (+ 6.5 million t), emissions increased considerably over the previous year, by a total of over 23 million t . Those areas again felt the impacts of the VAT increase that came into force at the end of 2006. In anticipation of the tax increase, all storage capacities for storable fuels were filled via early purchases. In 2007, that effect then led to considerable sales decreases – as much as 30 % in some cases. In 2008, sales increased again, but still failed to return to the level seen in 2006.

2.2.2   *Nitrous oxide (N_2O)*

Since 1990, N_2O emissions have decreased by nearly 25 %. The main emissions areas/sources include agriculture – use of nitrogen-containing fertilisers, and animal husbandry; the chemical industry; and combustion 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 the greatest influence on emissions reductions, especially in the area of adipic acid production. In this respect, in 1997 producers in Germany completed a

process of retrofitting their production systems with emissions-reduction equipment. This reduced emissions from the chemical industry by about 63 %, in relation to the corresponding level in 1990. Emissions trends since 1999 have been influenced strongly by economic trends in the chemical industry.

With regard to the emissions reported in the previous year, recalculations for the chemical industry, and surveys of emissions from agricultural soils, have produced some marked changes. Those changes are described in detail in the relevant sector chapters.

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; the role of energy-related and process-related emissions is almost negligible. Methane emissions have been decreased by 53.8 % since 1990. This trend has been the result of environmental protection measures ("green dot" on recyclable products, "yellow sacks" for recycling pickups, increased recycling overall and increasing energy recovery from waste) that have reduced amounts of waste for landfilling. A second key reason is that use of mine gas from coal mining, for energy recovery, has increased. Emissions in this area have decreased by over 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 introduction of vapour recovery in fuel distribution, have brought about further reductions of total emissions. In comparison to the previous year, emissions decreased slightly, by 0.8 %. This trend is due to further increases in use of mine gas for energy recovery, as well as to further decreases in landfill emissions.

Extensive recalculations had to be carried out for the entire relevant period, as a result of methodological changes in calculation of emissions from animal husbandry in agriculture and a change in the emission factor for biogas use.

2.2.4   F gases

Figure 18 shows emissions trends for so-called "F" gases for the period 1995-2008. 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 soundproof 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. The increase in total SF$_6$ emissions in recent years is due to use of pure SF$_6$ in aluminium production; in the 1990s, that gas was used

solely as an additive. Other reasons for the increase include growing disposal of soundproof windows and intensified use of SF_6 in production of solar cells.
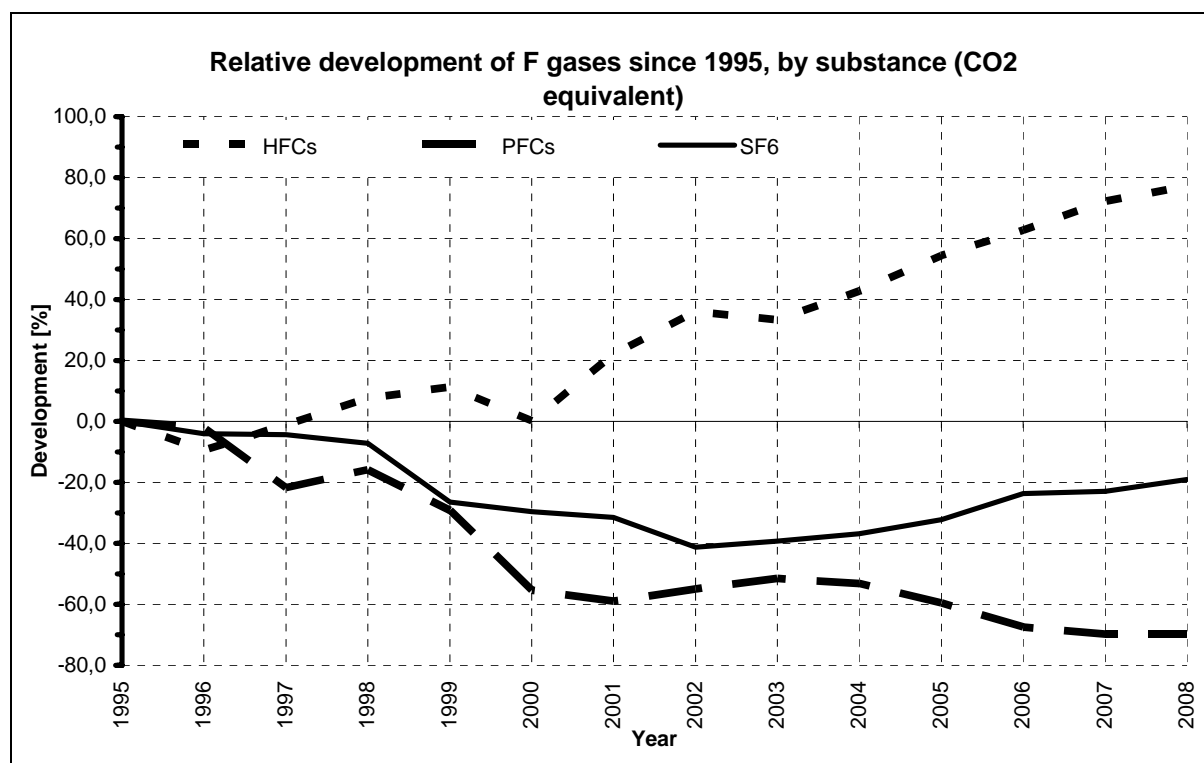
Figure 18:   Relative development of F gases in comparison to relevant 1995 levels

2.3   Description and interpretation of emissions trends, by source categories

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. This situation is reversed for energy-related 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 22 % since 1990. For combustion-related emissions, this has been achieved through fuel changeovers and higher energy and technical efficiencies, and through increasing use of zero-emissions energy sources, whereas for distribution emissions it has resulted from increased use of mine gas, modernisation of gas-distribution networks and introduction of vapour-recovery systems in fuel distribution.

In the area of emissions from industrial processes, carbon dioxide and nitrous oxide are the predominant pollutants. 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 decrease from the previous

year as production decreases, especially in the iron and steel industry, chemical industry and cement industry.

To date, a counter-trend has been achieved only in the case of N_2O emissions. It is the result of emissions-reduction measures by adipic acid producers, measures that took effect as of 1997. That trend is being increasingly offset by production increases, however. Overall, N_2O emissions have decreased by over 62 % since 1990. Changes occurred via changes in calculation methods for production of sulphuric acid.

Since 1990, emissions for the totality of all industrial processes and pollutants, in GG equivalents, have been reduced by about 14 %. In comparison to the previous year, the decrease amounted to over 3.7 %. The change with regard to the previous year is due primarily to changes in emissions from the chemical industry.

Also since 1990, emissions in the area of solvent and product use have decreased by over 38 %. 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 in 2008). Emissions from use of N_2O as an anaesthetic decreased by nearly 44 % since 1990. That finding was reached via preparation of a pertinent balance sheet for the years 1990 and 2001. The results were interpolated for the period between the two years, and then, due to a lack of later data, the same relevant figure was used regularly for the period after 2001. The next chapter discusses the relevant solvent emissions (NMVOC) themselves.

Methodological changes were carried out in the area of agriculture. In some cases, such as that of nitrous oxide emissions from soils, the changes were needed because an international review of the 2009 report concluded that the new 2006 IPCC Guidelines could not be used. That made it necessary, for the present report, to return to the methods used until 2008. For all reported years, the increases seen in agricultural emissions, in comparison to the relevant previous-year figures (cf. NIR 2009), are due primarily to the methods changes.

The decrease in agricultural emissions since 1990, amounting to over 15 %, is due primarily to reductions in livestock populations, although it is also due to reductions in emissions from agricultural soils and from fertiliser use.

The 41 % reduction in storage of greenhouse gases via land-use changes and forestry is due primarily to a reduction of sink function in the category "forestland remaining forestland".

The most significant emissions reduction, at 73.1 %, 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 over 79 %. Emissions from wastewater treatment, which also belong to this source category, are considerably lower, in terms of amounts, than landfill emissions. At the same time, they decreased by nearly 46 %.

Table 11:   Changes in 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
1. Energy	0.0	-11.7	-16.2	-19.5	-19.1	-22.2	-21.9
2. Industrial processes	0.0	2.0	-15.0	-15.8	-12.8	-7.8	-11.3
3. Solvent and other product use	0.0	-17.4	-31.0	-37.0	-38.0	-38.5	-38.5
4. Agriculture	0.0	-12.4	-12.0	-16.3	-17.9	-18.3	-15.2
5. Land use, land-use changes & forestry	0.0	8.6	9.4	-273.4	-280.8	-293.2	-249.7
CO_2 (net sink)	0.0	8.5	9.3	-268.5	-276.5	-287.2	-245.0
N_2O & CH_4	0.0	-6.3	-6.4	609.2	487.1	788.7	601.0
6. Waste	0.0	-15.3	-45.5	-67.6	-69.6	-71.4	-73.1

Emissions change, in each case with respect to the previous year; change in %	1990	1995	2000	2005	2006	2007	2008
1. Energy	0.0	-0.4	-0.4	-2.1	0.6	-3.9	0.4
2. Industrial processes	0.0	0.1	3.3	-3.0	3.5	5.7	-3.7
3. Solvent and other product use	0.0	0.8	-7.9	0.3	-1.7	-0.9	0.0
4. Agriculture	0.0	2.5	-0.3	-0.9	-2.0	-0.5	3.8
5. Land use, land-use changes & forestry	0.0	-0.1	-1.4	4.8	4.3	6.9	-22.5
CO_2 (net sink)	0.0	-0.1	-1.4	4.9	4.8	6.1	-22.6
N_2O & CH_4	0.0	-3.4	1.1	-0.1	-17.2	51.4	-21.1
6. Waste	0.0	-5.9	-8.6	-11.0	-6.2	-5.8	-6.1

The relevant detailed data are presented inTable 257 in Annex Chapter 22.3.

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 19 and in Table 10. Over this period, considerable reductions of emissions of these pollutants have been achieved. For example, emissions of SO_2 have been reduced by almost 91 %, those of CO by nearly 70 %, those of NMVOCs by over 66 % and those of NO_X by 52 %.

The vast majority of emissions of sulphur dioxide, nitrogen oxide and carbon monoxide are combustion-related. 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.
- 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 and market-economic regulations led to thriftier use of energy and raw materials.
- International legislation, particularly from the European Community, has had an emission-reducing effect (e.g. the NEC Directive).
- Increasing use of zero-emissions energy sources (electricity/heat from solar and wind systems, and heat 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.
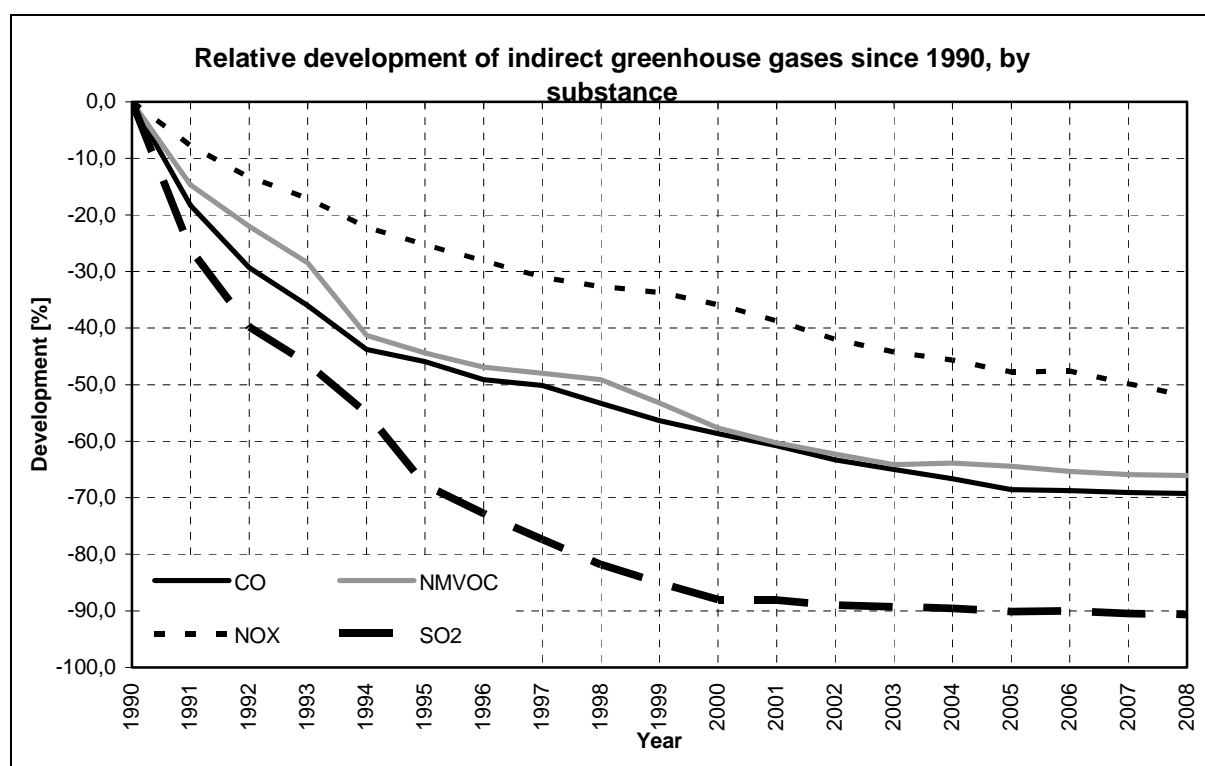
Figure 19:   Emissions trends for indirect greenhouse gases and SO_2

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 methane, nitrous oxide and carbon dioxide.

Under Article 3.3, it reports emissions of 13,778.4 Gg CO_2 equivalent. The emissions are composed of storage of CO_2 via forestation and reafforestation, amounting to 2,615.20 Gg CO_2 equivalent, and emissions from deforestation, amounting to 16,393.32 Gg CO_2

equivalent. Under Article 3.3, it reports CO_2 emissions of 13,778.18 Gg CO_2 equivalent and N_2O emissions of 0.26 Gg CO_2 equivalent.

Under Article 3.4, it reports storage of 20,331.81 Gg CO_2 equivalent. The relevant storage consists of CO_2 storage of 20,380.47 Gg CO_2 equivalent and emissions of 49.86 Gg CO_2 equivalent. Under Artikel 3.4, it reports CO_2 storage of 20,331.81 Gg CO_2 equivalent, N_2O emissions of 46.5 Gg CO_2 equivalent and CH_4 emissions of 3.36 Gg CO_2 equivalent.

Since the current year is the first inventory year under the Kyoto Protocol, it is not yet possible to describe any trend.

3   ENERGY (CRF SECTOR 1)

3.1   Overview (CRF Sector 1)

**Development of greenhouse gases in Germany, energy sector
(without CO_2 from LULUCF)**
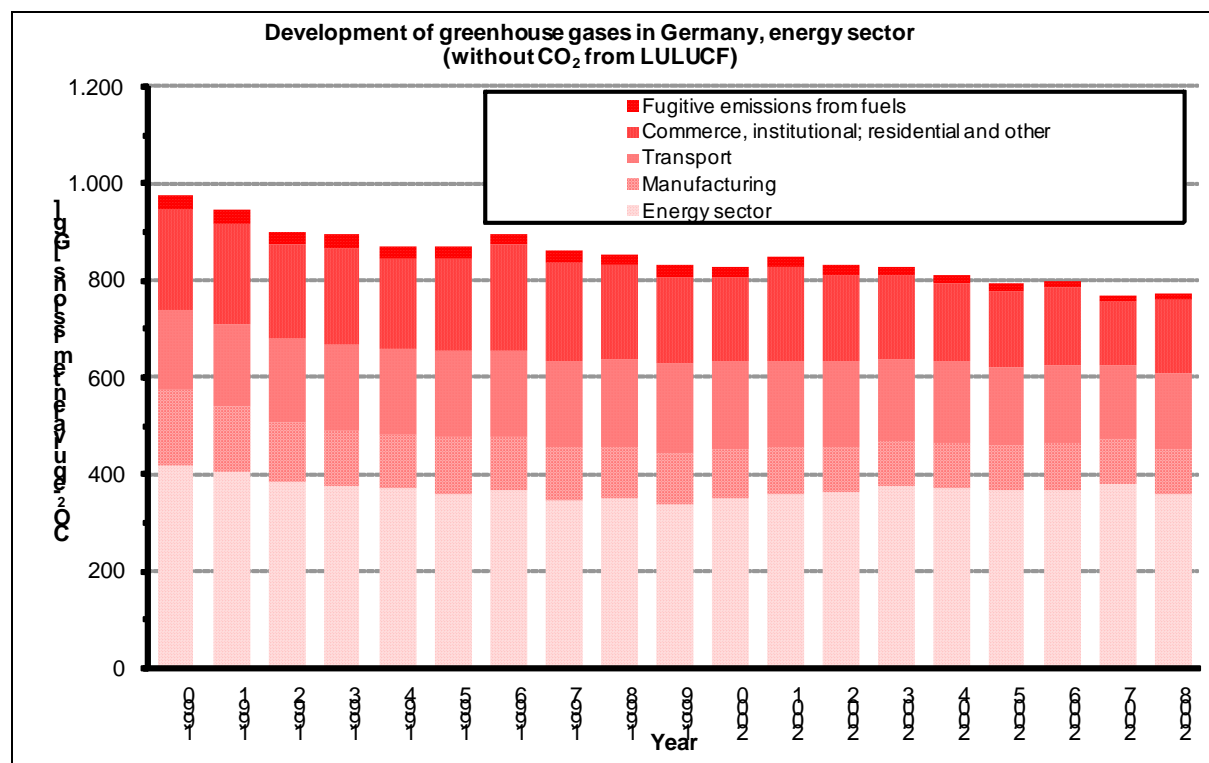
Figure 20:   Overview of greenhouse-gas emissions in CRF Sector 1

For determination of activity rates from combustion, different models are used for mobile and stationary sources. The model used for mobile sources is the "Transport Emission Estimation Model" (TREMOD), while the model used for stationary sources is the "Balance of Emissions Causes" ("Bilanz der Emissionsursachen" – BEU). 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 rates 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 Chapter 18.1.

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. In 2009, for the first time, 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.

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)

> **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.

> **Industrial thermal power stations** (line 12) comprise the following operator groups:
>> a) Power stations in hard coal mining,
>> b) Power stations in lignite mining,
>> c) Power stations in petroleum processing (refinery power stations),
>> d) 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)),
>> e) Industrial power stations (quarrying, other mining, manufacturing industry).

> **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.

> **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.

> **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.

> **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)

> 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. Until 1979, the Energy Balance showed fuel inputs for lignite drying together with other own consumption of lignite pits and briquette plants, in line 35 (energy consumption in the transformation sector). 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)

> **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.

> 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.

> 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 21 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 1st Ordinance on the Execution of the Federal Immission Control Act (13. BimSchV),   - Facilities under the 1st 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 21:   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, surveys of "classical" air pollutants have necessitated finer disaggregation.

Despite the conversion of the Energy Balance to the new 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.

Figure 21 and the following tables (Table 12 through Table 18) 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).*

Table 12:   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]	Calculation procedure
Public supply						
Electricity generation in large combustion systems of public power stations	11	13. BImSchV	DTKW	Public supply	S	OEKW13
Electricity generation in waste incineration systems of public power stations	11	17. BImSchV	DTKW	Public supply	S	OEKW17
Electricity generation in gas turbines (TA Luft) of public power stations	11	TA Luft	GTKW	Public supply	S	OEKWGTTA
Electricity generation in gas and steam turbine systems (TA Luft) of public power stations	11	TA Luft	GuD	Public supply	S	OEKWGUDT
Electricity generation in large combustion systems of gas turbines of public power stations	11	13. BImSchV	GTKW	Public supply	S	OEKWGT13
Electricity generation in large combustion systems of gas and steam turbine systems of public power stations	11	13. BImSchV	GuD	Public supply	S	OEKWGUD13
Electricity generation in gas engines of public power stations	11	TA Luft	GMA	Public supply	S	OEKWGM
Electricity generation in diesel engines of public power stations	11	TA Luft	DMA	Public supply	S	OEKWDM
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	HEKW13
Heat generation in large combustion systems of public crude-lignite-fired power stations	15	13. BImSchV	DTKW	Public supply	W	HEBKW13
Heat generation in waste-incineration systems of public power stations	15	17. BImSchV	DTKW	Public supply	W	HEKW17
Heat generation in gas turbines (TA Luft) of public power stations	15	TA Luft	GTKW	Public supply	W	HEKWGTTA
Heat generation in gas and steam turbine systems (TA Luft) of public power stations	15	TA Luft	GuD	Public supply	W	HEKWGuDTA
Heat generation in large combustion systems of gas turbines of public power stations	15	13. BImSchV	GTKW	Public supply	W	HEKWGT13
Heat generation in large combustion systems of gas and steam turbine systems of public power stations	15	13. BImSchV	GuD	Public supply	W	HEKWGUD13
Heat generation in gas engines of public power stations	15	TA Luft	GMA	Public supply	W	HEKWGM
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	FEHW13
Heat generation in waste-incineration systems of public district heating stations	16	17. BImSchV	FHW	Public supply	W	FEHW17
Heat generation in TA Luft systems of public district heating stations	16	TA Luft	FHW	Public supply	W	FEHWTA
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 13:   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]	Calculation procedure
Refineries						
Electricity generation in large combustion systems of refinery power stations	12	13. BImSchV	DTKW	Manufacture of refined petroleum products	S	UIKR13
Electricity generation in TA Luft systems of refinery power stations	12	TA-Luft	DTKW	Manufacture of refined petroleum products	S	UIKRTA
Electricity generation in gas turbines (TA Luft) of refinery power stations	12	TA Luft	GTKW	Manufacture of refined petroleum products	S	UIKRGTTA
Electricity generation in large combustion systems of gas turbine systems of refinery power stations	12	13. BImSchV	GTKW	Manufacture of refined petroleum products	S	UIKRGT13
Heat production in large combustion systems of refinery power stations	40	13. BImSchV	DTKW	Manufacture of refined petroleum products	W	UEKR13
Heat generation in TA Luft systems of refinery power stations	40	TA-Luft	DTKW	Manufacture of refined petroleum products	W	UEKRTA
Heat generation in gas turbines (TA Luft) of refinery power stations	40	TA Luft	GTKW	Manufacture of refined petroleum products	W	UEKRGTTA
Heat generation in large combustion systems of gas turbine systems of refinery power stations	40	13. BImSchV	GTKW	Manufacture of refined petroleum products	W	UEKRGT13
Heat generation in diesel engines of refinery power stations	40	TA Luft	DMA	Manufacture of refined petroleum products	W	UEKRDM
Refinery bottom-heating systems (large combustion systems)	40	13. BImSchV	PF	Manufacture of refined petroleum products	W	UEPFRG
Refinery bottom-heating systems (TA Luft installations)	40	TA Luft	PF	Manufacture of refined petroleum products	W	UEPFRT

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 engine 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 14:   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]	Calculation procedure
Coal mining						
Electricity generation in large combustion systems of power stations of the hard-coal-mining sector	12	13. BImSchV	DTKW	Coal mining	S	STKBKW 13
Electricity generation in TA-Luft systems of power stations of the hard-coal-mining sector	12	TA Luft	DTKW	Coal mining	S	STKBKWTA
Electricity generation in large combustion systems of mine power stations	12	13. BIMSchV	DTKW	Other coal mining	S	GRKW13
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	UEGK13
Heat generation in large combustion systems of power stations of the hard-coal-mining sector	40	13. BImSchV	DTKW	Coal mining	W	UESTKB13
Heat generation in gas engines of power stations of the hard-coal-mining sector	40	TA Luft	GMA	Coal mining	w	UESTKBTA
Direct drive via diesel engines of colliery and mine power stations	40	TA Luft	DMKW	Coal mining	K	UEKZDM
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	UEPFKO
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 engine 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 15:   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]	Calculation procedure
Other BEU structural elements						
Gas turbines (TA Luft) in natural-gas-compressor stations	40	TA Luft	GT	Gas industry	K	GVKOMPTA
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	INPFWA
Production of iron, steel and malleable cast iron (process combustion)	60	TA Luft	Foundries	Foundry industry	W	INPFGU
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	INPFNE
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	INKWZP
Source category 1.A.2.e						
Sugar manufacturing (process combustion)	60	TA Luft	Sugar refineries	Sugar production	W	INPFZU
Source category 1.A.2.f						
Lime production (process combustion)	60	TA Luft	Lime-burning furnaces	Lime production	W	INPFKA
Production of cement clinkers (process combustion)	60	TA Luft	Cement furnaces	Cement production	W	INPFZK
Glass production (process combustion)	60	TA Luft	Glass smelting furnaces	Glass production	W	INPFGL
Ceramics production (process combustion)	60	TA Luft	Kilns	Brick production	W	INPFZI
Other process combustion	60	TA Luft	Process combustion	Other mining and manufacturing	W	INUEPF

1)   GT = gas turbines, DTKW = steam turbine power stations

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

Table 16:   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]	Calculation procedure
Other industrial power stations						
Electricity generation in large combustion systems of DB power stations	12	13. BImSchV	DTKW	Deutsche Bahn AG (German Railways)	S	DBKW13
Electricity generation in large combustion systems of other industrial power stations	12	13. BImSchV	DTKW	Other mining and manufacturing (w/o VAW)	S	UIKW13
Electricity generation in waste incineration systems of other industrial power stations	12	17. BImSchV	DTKW	Other mining and manufacturing	S	UIKW17
Heat generation in TA Luft systems of other industrial power stations	12	TA Luft	DTKW	Other mining and manufacturing	S	UIKWTA
Electricity generation in gas turbines (TA Luft) of other industrial power stations	12	TA Luft	GTKW	Other mining and manufacturing	S	UIKWGT
Electricity generation in large combustion systems of gas turbines of other industrial power stations	12	13. BImSchV	GTKW	Other mining and manufacturing	S	UIKWGT13
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	UIKWGUDTA
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	UIKWGUD13
Electricity generation in gas engines of other industrial power stations	12	TA Luft	GMA	Other mining and manufacturing	S	UIKWGM
Electricity generation in diesel motors of other industrial power stations	12	TA Luft	DMA	Other mining and manufacturing	S	UIKWDM
Incineration of special waste		17. BImSchV	FA	Other mining and manufacturing	S	
Heat generation in diesel engines of the manufacturing 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 manufacturing and other mining sectors	60	13. BImSchV	DTKW	Other mining and manufacturing	W	INKW13
Heat generation in waste-incineration systems of industrial power stations of the manufacturing and other mining sectors	60	17. BImSchV	DTKW	Other mining and manufacturing	W	INKW17
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	INKWTA
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	INKWGT
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	INKWGT13
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	INKWGUDTA
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	INKWGUD13
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	INKWGM

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 – 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]	Calculation procedure
Source category 1.A.4.a						
Heat generation in TA Luft systems of other small consumers	67	TA Luft	Hot-water boilers	Commerce/trade/services	W	UEKVTA
Heat generation in small combustion systems of other small consumers	67	1. BImSchV	Hot-water boilers	Commerce/trade/services	W	UEKV01
Source category 1.A.4.b						
Heat generation in small combustion systems of households	66	1. BImSchV	Heat producing systems	Households	W	HAUS01
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	LAWITA
Heat generation in small combustion systems in agricultural and horticultural operations	67	1. BImSchV	Steam / hot-water production systems	Agriculture	W	LAWI01
Source category 1.A.5.a						
Heat generation in TA Luft systems of military agencies	67	TA Luft	Hot-water boilers	Military agencies	W	MILITA
Heat generation in small combustion systems of military agencies	67	1. BImSchV	Hot-water boilers	Military agencies	W	MILI01

Table 18:   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]	Calculation procedure
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   Comparison of the sectoral approach and the Reference Approach

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. 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 comparative approach, the Intergovernmental Panel on Climate Change (IPCC) has developed the *Reference Approach*, which is based on primary energy consumption (input of energy resources in a given country). This approach places less demanding requirements on the databases than does the source-category-specific approach.

The Reference Approach was carried out for all years in question. Currently, Energy Balances up to the year 2007 are available. For 2008, the relevant analysis was carried out on the basis of experts' detailed assessments of energy consumption. These are based on the promptly appearing evaluation tables, which offer aggregated energy input datasets.

The results of the Reference Approach are compiled in Table 19. In Figure 22 and Figure 23, they are compared with the various relevant data records. In an average for all years in question, the discrepancy between the results obtained with the Reference Approach and those obtained with the sectoral calculation approach is 1.2 %. The discrepancies vary throughout a range of 0.3 to + 2.8 %.

3.2.1.2   Quality assurance / control and verification (1.A)

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 Germany-relevant 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.

The comparison is carried out as a comparison of the calculation results with data:

- from an independent CO_2 calculation,
- from the IEA (source-category-specific procedure and Reference Approach),
- from the CO_2 calculations performed at *Länder* level.

Table 19 presents the results of the various CO_2 calculation approaches for comparison. For visualisation purposes, the data are also presented graphically, on a comparative basis over time, in Figure 22. This approach reveals the key development trends in all calculation approaches, including the Reference Approach, albeit at differing levels. In Figure 23, the relative deviations in the data records created by the varying calculations are depicted in order to illustrate these level differences.

On the whole, the comparisons show that the methods used for reporting and allocating CO_2 emissions in the iron and steel sector have made it more difficult to directly compare results for the detailed independent procedure with those for the Reference Approach. This also applies to comparisons with the results of the Länder. As a result of allocation of emissions

from coke inputs in the iron and steel industry to process emissions, in each of the pertinent years, between 5 and 6 % of CO_2 emissions from the energy sector are shifted to process emissions.

Nevertheless, on the whole, these comparisons confirm the CO_2 emissions calculated for Germany.

Table 19:   Comparison of CO_2 inventories with other independent national and international results for CO_2 emissions

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Results, discrepancy									[Millions of t] / [%]									
Ziesing (energy-related emissions)	948.2					840.6	866.9	831.4	824.4	801.3	800.2	822.7	808.1	821.8	819.1	798.9	799.4	774.3
Discrepancy between Ziesing and UBA (1.A)	0.0					0.0	0.0	0.0	-0.1	0.0	0.1	0.2	0.3	2.3	3.9	3.4	2.8	3.6
IEA statistics, SA (sectoral approach)	950.4	941.5	892.6	884.9	871.8	869.3	908.4	879.7	867.6	837.7	827.1	846.3	836.4	842.1	843.4	811.3	823.5	798.4
Discrepancy between IEA SA and UBA (1.A)	0.2	2.9	2.6	2.6	3.5	3.5	4.8	5.9	5.1	4.5	3.4	3.0	3.8	4.8	6.9	5.0	5.9	6.8
IEA statistics, RA (reference approach)	971.7	937.5	897.5	883.7	870.7	877.5	895.5	870.4	869.9	833.9	843.9	868.4	846.3	849	843.5	820.1	821.3	801.5
Discrepancy between IEA RA and UBA (1.A)	2.5	2.5	3.2	2.5	3.3	4.4	3.3	4.7	5.4	4.0	5.5	5.7	5.0	5.7	6.9	6.2	5.6	7.3
Discrepancy between IEA RA figures and UBA RA figures	2.2	2.0	2.3	1.2	2.1	4.1	2.9	3.7	4.5	3.2	4.5	4.9	3.9	3.3	4.3	3.3	3.1	5.0
Results of the Länder (energy)	981.7	963.3	917.1	912.6	890.5	893.7	914.6	890.5	887.7	862.7	863.1	887.6	864.5	859.5	847.4	835.3	838.6	826.8
Discrepancy between the Länder figures (energy) and UBA's figures	3.5	5.3	5.4	5.8	5.7	6.4	5.5	7.2	7.5	7.6	7.9	8.1	7.3	7.0	7.4	8.2	7.9	10.6
Reference Approach, UBA (RA)	950.9	918.9	877.1	873.2	852.5	842.6	870.3	839.4	832.3	808.4	807.2	827.8	814.6	821.5	808.6	793.6	796.9	763.4
Discrepancy between UBA RA figures and UBA's figures	0.3	0.4	0.8	1.3	1.2	0.3	0.4	1.0	0.8	0.8	0.9	0.8	1.1	2.3	2.5	2.8	2.5	2.2
Sectoral approach, UBA (1.A)	948.1	915.0	870.0	862.1	842.5	840.3	867.2	831.0	825.6	801.6	799.7	821.3	805.9	803.4	788.7	772.4	777.4	747.3
Reference approach, UBA (RA); allocation to iron and steel sector	45.9	43.9	40.7	38.6	41.7	41.7	38.5	43.3	41.8	38.9	43.2	41.4	41.6	41.0	42.0	40.3	42.5	43.8
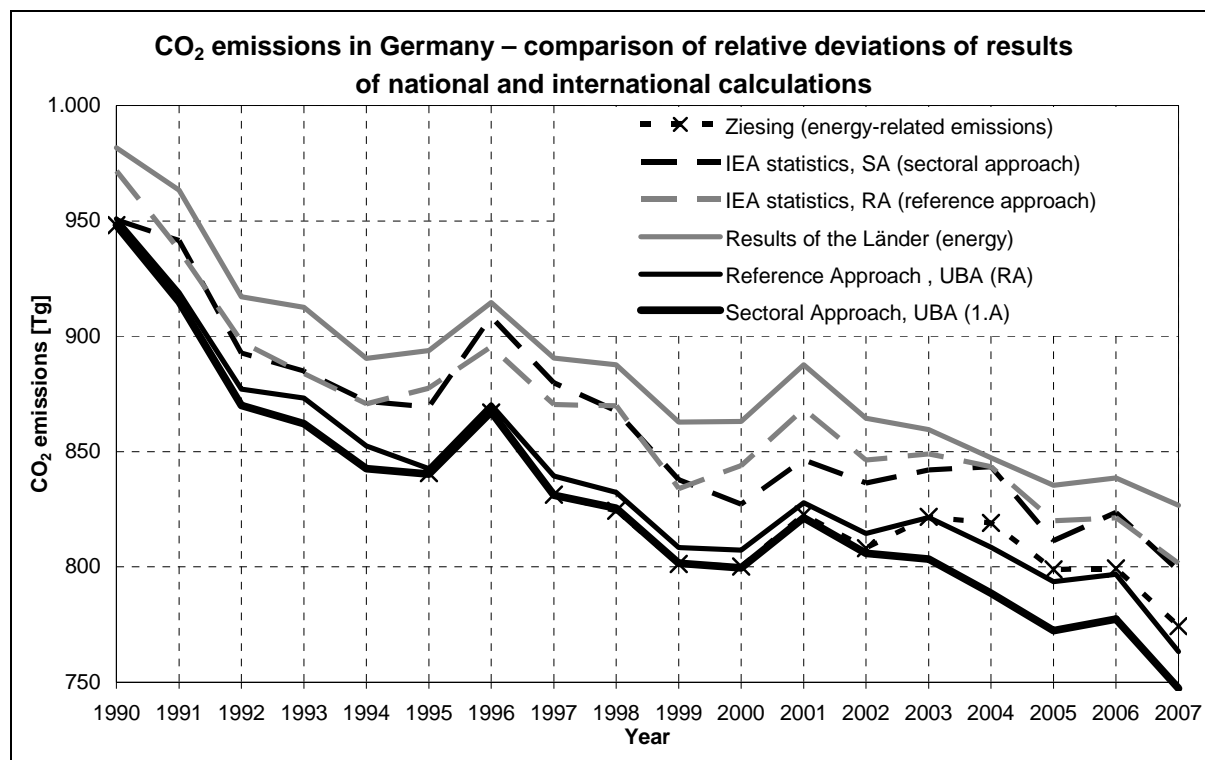
Figure 22: CO_2 emissions in Germany – comparison of results of national and international calculations
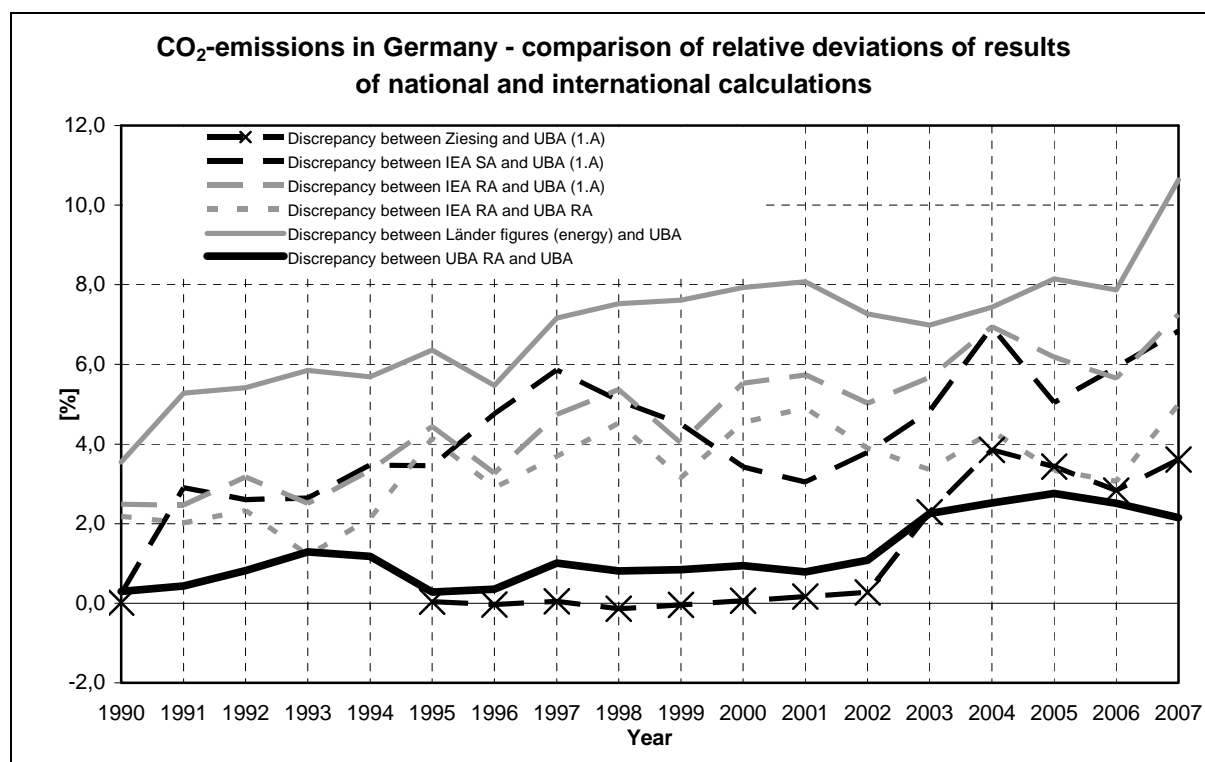
Figure 23: CO_2 emissions in Germany – comparison of relative deviations of national and international calculations

3.2.1.2.1   Comparison with independent calculations of CO_2 emissions

The data used in the comparison discussed below are taken from a publication of Dr. Hans Joachim Ziesing (2009). These results are included for the sake of completeness; in past

inventory reports, CO_2-emissions figures were often compared with data published by the German Institute for Economic Research (DIW). Such comparisons were made by the same author concerned in the present context.

The difference between the two calculation approaches is very small, with a mean deviation of 0.2 % for the years 1990 through 2002, and thus confirms the findings of the detailed emissions calculation, in terms of both results and trend. The only significant differences (2 to 4 %) are seen for the years since 2003. These differences result from first-time use of detailed and processed data from the published Energy Balances for the years 2004, 2005, 2006 and 2007, as well as of use of own estimates relative to detailed energy data for the year 2008. These changes led to recalculations in the detailed calculations of CO_2 emissions.

3.2.1.2.2   *Comparison with the IEA results*

Comparison with the IEA results was included here for reasons of completeness. Annually updated, internationally published data (most recently: OECD/IEA 2009) are available. The method of determining, processing and applying the basic data used for this purpose is not precisely comparable with the national procedure in Germany at present, due to a lack of the necessary further methodological information – particularly information with regard to the detailed data used.

However, results of the comparison confirm the data obtained via the national, detailed method (mean deviation over 18 years: 4.2 %; fluctuation since 1991 ranges between 2.6 and 6.8 %).

The results of the Reference Approach used by the IEA differ from those of the reference approach carried out in Germany by 3.4 %, over a 18-year average. The changes in methods have an effect in this context, since the national Reference Approach also takes account of allocation of some 40 million t of CO_2 emissions in the iron and steel sector as process-related emissions. The IEA Reference Approach does not use a comparable method. Taking account of shifting of emissions from the iron and steel industry, as carried out in the German inventory in both the sectoral approach and the Reference Approach, the discrepancies between the national results and IEA results would be on the order of 1 to 2 %.

For comparisons within the "old" structures, the reader is referred to the 2006 inventory report.

3.2.1.2.3   *Comparison with the data obtained for the individual Federal Länder*

The German Länder publish data on their own CO_2 emissions (cf.: http://www.lak-energiebilanzen.de/sixcms/detail.php?template=liste_cobilanzen). The relevant procedures, competent organisations and methods are described/listed at the corresponding location in the NIR 2009.

The following section presents a comparison, for energy-related CO_2 emissions, of a) 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, which is based on data for the years 1990 to 2007, is that pertinent information is not always available in the form of complete time series for the individual Länder for all relevant years. Suitable procedures for closing the resulting gaps, procedures based on interpolation and extrapolation, were used. The following section presents a compilation of the relevant data

and results used. For reasons tied to the manner in which the data were obtained, as explained above, the data and results should be seen only as an orientation.

Table 20:   Comparison of the results of CO_2 calculations of individual Länder with corresponding figures from the federal inventories

Land (state)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
									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	74,940	80,108	76,549	75,598	74,768	77,222	78,283	70,952
Bavaria	84,544	88,972	87,041	90,335	87,871	88,307	92,265	89,837	92,708	90,590	88,705	90,377	84,578	83,783	83,191	80,541	79,262	77,070
Berlin	26,941	27,957	25,234	26,643	25,531	24,445	24,726	23,560	22,876	23,693	23,661	24,068	21,281	21,249	20,184	19,998	19,915	19,763
Brandenburg	81,894	66,751	58,894	57,104	54,011	50,791	50,312	50,762	59,255	58,783	60,564	60,928	61,537	57,910	58,882	59,910	58,273	58,413
Bremen	13,433	13,586	12,903	12,517	13,341	13,239	14,256	14,170	13,857	12,793	14,079	14,137	14,031	14,667	13,057	12,222	12,704	12,308
Hamburg	12,743	14,226	13,116	13,813	13,361	13,467	14,572	13,940	13,651	13,362	13,073	12,784	12,495	12,206	11,589	11,343	11,451	11,323
Hesse	50,338	53,945	53,267	56,060	56,201	56,126	59,935	57,264	57,156	54,688	56,011	57,817	54,897	55,528	54,787	54,441	53,832	53,398
Mecklenburg – West Pomerania	15,539	10,757	9,360	9,473	9,510	10,233	11,636	10,654	10,413	10,627	10,256	10,718	10,908	10,451	10,961	10,216	10,308	9,842
Lower Saxony	77,138	82,276	80,915	79,553	78,192	78,334	78,475	79,440	80,405	77,316	74,228	73,145	72,061	71,040	70,019	70,025	70,032	70,038
North Rhine – Westphalia	299,028	309,888	306,287	300,041	295,874	303,349	312,345	307,064	304,784	294,014	293,987	299,969	295,293	295,885	291,555	282,533	287,140	289,557
Rhineland-Palatinate	27,394	29,448	28,914	30,248	30,274	31,490	31,463	31,646	31,167	30,311	28,853	29,574	27,793	26,787	26,432	26,399	27,110	25,596
Saarland	23,708	25,767	24,398	23,214	24,313	23,133	23,852	21,825	23,795	22,833	23,459	23,260	22,964	23,278	23,917	24,799	23,577	25,714
Saxony	91,465	77,105	64,059	66,046	62,988	61,349	56,223	51,036	37,167	35,116	41,552	48,842	49,038	49,625	48,476	47,019	48,295	46,854
Saxony-Anhalt	50,863	38,085	31,892	27,887	26,307	25,200	25,652	25,294	25,261	26,900	26,301	26,840	27,518	28,171	27,145	27,846	27,821	26,477
Schleswig-Holstein	24,200	23,826	24,082	24,590	24,191	22,940	23,517	22,654	22,426	21,868	21,378	22,737	21,455	21,401	20,592	19,356	19,339	18,509
Thuringia	28,098	22,071	18,687	16,334	13,992	13,240	13,641	12,806	12,713	12,438	12,059	12,339	12,066	11,924	11,812	11,450	11,283	10,986
Total	**981,699**	**963,249**	**917,084**	**912,531**	**890,493**	**893,716**	**914,629**	**890,521**	**887,713**	**862,711**	**863,106**	**887,643**	**864,465**	**859,503**	**847,366**	**835,320**	**838,624**	**826,799**
Result for the nation as a whole	**948,086**	**914,960**	**869,979**	**862,099**	**842,549**	**840,264**	**867,179**	**831,012**	**825,569**	**801,636**	**799,704**	**821,305**	**805,875**	**803,392**	**788,716**	**772,363**	**777,387**	**747,301**
Deviation (Gg)	33,613	48,289	47,105	50,432	47,944	53,453	47,450	59,509	62,144	61,075	63,402	66,338	58,589	56,111	58,650	62,957	61,236	79,498
Deviation (%)	3.5	5.3	5.4	5.8	5.7	6.4	5.5	7.2	7.5	7.6	7.9	8.1	7.3	7.0	7.4	8.2	7.9	10.6

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 18 years in question, the total CO_2 emissions for the Länder were about 6.9 % higher than the Federal result. The extremes of the deviations ranged from 3.5 % in 1990 to 10.6 % in 2007. If the annual shifts (for balance purposes) of the some 40 million t CO_2 that are now reported in the metal-production sector were taken into account, the discrepancies between the Länder results and the national results would decrease to about 1.5 to 2 %.

3.2.1.2.4   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 further concrete plans in this regard have been made, however.

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.

3.2.2   International bunker fuels

3.2.2.1   Emissions from international transports (1.BU.1/1.BU.2)

The area of international transports is divided into international civil air transports (1.BU.1) and international sea transports (1.BU.2), the latter of which also includes blue-water fisheries and maritime navigation.

3.2.2.2   Emissions from international air transports (1.BU.1)

3.2.2.2.1   Source category description (1.BU.1)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS				CS	CS	CS	CS	CS
EF uncertainties in %	±5	-57 +100				-70 +150				
Distribution of uncertainties	N	L				L				
EF-determination method	T2a	T2a				T2a				

Source category 1.BU.1 "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.

3.2.2.2.2   Methodological issues (1.BU.1)

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.

Currently, this breakdown is made in accordance with an annual split factor that refers to domestic air transports' share of total jet-kerosene consumption. For years as of 2003, that factor is provided directly by Eurocontrol (which calculates in accordance with Tier 3). With such factor values, along with other – uncertain – Eurocontrol figures for the years 1996 to 2001 and with a further supporting value for 1990, split factors for the interim years (i.e. 1991 through 2002) are determined via an exponential function.

International air transports' so-determined shares of the jet-kerosene consumption figures listed in the Energy Balance (AGEB, until 2007) and in the official mineral-oil data (Amtliche Mineralöldaten) of the Federal Office of Economics and Export Control (BAFA, 2008) (AGEB, 2008; BAFA, 2008), are as follows:

Table 21:   Development of international air transports' share since 1990

Year	1990	1995	2000	2005	2006	2007	2008
National share [%]	80.0	85.0	88.8	91.7	91.6	91.8	92.1

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 listed explicitly as such in the CSE.

3.2.2.2.3   *Uncertainties and time-series consistency (1.BU.1)*

Cf. National air transport, Chapter 3.2.10.1.3.

3.2.2.2.4   *Source-specific quality assurance / control (1.BU.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.

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

3.2.2.2.5   *Source-specific recalculations (1.BU.1)*

The total emissions from air transports were comprehensively recalculated to take account of the now-introduced (i.e. first-ever) breakdown of jet-kerosene consumption by the various flight phases, and of related complete revision of emission factors.

The international share of jet-turbine fuel (jet kerosene) sold has increased continuously, from 80 % in 1990 to 92.1 % in 2008. The pertinent emissions share has also increased as a result.

3.2.2.2.6   *Planned improvements (1.BU.1)*

Cf. National air transport, Chapter 3.2.10.1.6.

3.2.2.3   Emissions from international maritime transport / maritime navigation (1.BU.2)

3.2.2.3.1   Source category description (1.BU.2)

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	CS	D	--	--	--	D	D	D	D	D
EF uncertainties in %	±5	-57 +100	--	--	--	-70 +150				
Distribution of uncertainties	N	L	--	--	--	L				
EF-determination method	T1	T1	--	--	--	T1				

Source category 1.BU.2 "International maritime transport / maritime navigation", which is part of the relevant reported source category, is not included in key-source analysis.

International maritime transport includes international blue-water fisheries and marine navigation, categories which are also listed as such in the CSE.

Emissions from fuel consumption 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 petroleum prices, global increases in transports and increasing maritime use of diesel engines that can run on heavy oil.

The emissions fluctuations that occurred in the navigation sector in 1992 and 1996 were caused by trade and oil crises.

3.2.2.3.2   Methodological issues (1.BU.2)

Germany reports in keeping with the Tier 1 method. Emissions are calculated as the product of consumed fuels and country-specific emission factors for CO$_2$ and default EF for CH$_4$ and N$_2$O.

The **activity rates** for bunkering by ocean-going ships, until 2007, are taken from the Energy Balances of the Federal Republic of Germany. The reason why these rates are listed separately is that fuel purchased in ports is taxed differently.

Table 22:   Sources for AR in 1.BU.2

Fuel type	Energy Balance line	Area	Relevant years
Diesel fuel	6	High-seas bunkering	All years
Heavy fuel oil	6	High-seas bunkering	All years

For those years for which no Energy Balance is yet available (currently: 2008), certain data of the Federal Office of Economics and Export Control (BAFA) are used as a basis. These 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 6j: "Abgänge und Inlandsablieferungen von Mineralölprodukten" - "Exports and domestic deliveries of mineral-oil products") (BAFA, 2009).

For calculation of N$_2$O, CH$_4$, CO, NO$_X$ and NMVOC emissions, default **emission factors** from the Revised 1996 IPCC Guidelines (Reference Manual, 1996b: p.1.90 Table 1-48) are used.

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, we refer to the documentation in Annex 2, Chapter 18.7.

3.2.2.3.3　Uncertainties and time-series consistency (1.BU.2)

Since the emission factor for CO_2 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 %. The responsible Federal Environment Agency expert has estimated the uncertainties for the emission factors from the MARION model as amounting to ±10 %. The MARION research project was carried out in 1995/1997. Its aim was to calculate the emissions balances for individual ships, for maritime transports involving German ports.

The data input into the programme included the sum total of all shipping routes, ship-specific consumption data and specific ship characteristics. The resulting transport terms and emissions terms were used to determine the total emissions for the various relevant ship types, as a function of size class. Oily residues of consumed heavy fuel oil, from operation of ships' main engines, were estimated as amounting to 2 %. Ships' main engines were assumed to run at 85 % of full power, and auxiliary engines were assumed to run at 30 %. It is not possible to carry out separate calculations for heavy fuel oil and marine diesel oil.

3.2.2.3.4　Source-specific quality assurance / control and verification (1.BU.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.

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.BU.2)

Minor recalculations were carried out to take account of use of updated data from the Energy Balances of the Federal Republic of Germany and from the Federal Office of Economics and Export Control (BAFA) for all relevant years.

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 procedure. 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; three pilot systems are in place.

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.1.a					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	27.26 %	33.05 %	rising
All fuels	l / -	N_2O	0.29 %	0.37 %	rising
All fuels	- / t	CH4	0.02 %	0.19 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	< 3	+/-50	-	-	-	+/-50				
Distribution of uncertainties	T	U	-	-	-	U				
EF-determination method	CS	Tier 2	-	-	-	Tier 2				

Remark: See the "Declaration regarding introductory information tables", at the beginning of the NIR, for further information about these tables.

The source category "*Public electricity and heat production"* is a key source of CO_2 emissions in terms of level and trend. For N_2O emissions, it is a key source only in terms of level, and for CH_4 emissions, it is a key source 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 100 GW of net bottleneck capacity were in place in the public electricity generating sector in 2008. Of this amount, about 67 GW were operated with fossil fuels or with transformation products of fossil fuels. As a group, all fossil-driven plants generated some 338 TWh of electrical work. This corresponds to about 65 % of all public electricity generation (about 523 TWh). About 263 TWh of electricity were generated solely with lignite and hard coal (STATISTISCHES BUNDESAMT, 2008a).

In 2008, thermal power stations contributed net electricity production of 49 TWh, and net heat production of 111 TWh, to the public energy supply. The district-heat supply is supplemented with heat from heat-only boiler stations that are normally run in peak-load operation.

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 rates.

For the 2006 report, the activity rates 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 Systems 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). In the interest of including relevant fuel inputs as completely as possible, the relevant fuel inputs in the Energy Balance were supplemented with the pertinent difference between the Energy Balance and the waste statistics. As of 2005, energy statistics show a considerable increase in waste inputs. In 2006, then, the waste quantities shown in the Energy Balance increased to a degree that made it possible to discontinue use of additional data from waste statistics. Significantly improved data, with substantially enhanced differentiation of fuel inputs, made it possible to subtract biogenic gases, sewage sludge and waste heat. In addition, it became possible to list co-incineration of waste and sewage sludge separately. Revision of fuel inputs for waste incineration has not yet been completed. In a next step, allocation of fuels to the public energy production and industry sectors will be carefully reviewed. Suitable, differentiated, sector-specific waste-statistics data for that purpose are already available and await close evaluation.

As of the NIR 2006, the fossil and biogenic fractions of household / municipal waste are listed separately, in a ratio of 1/1.

The activity rates 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.

Emission factors (except for CO_2-emission factors)

The underlying data for the emission factors used are 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 - 2008 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 and 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. This process consists primarily of analysing and characterising the relevant emitter structures, and the pertinent emission factors, for the year 1995, and then of updating the data for the years 2000 and 2010. This procedure systematically determines emission factors for the substances SO_2, NO_X, CO, NMVOC, dust and N_2O. The process 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 under the TA Luft that are subject to licensing requirements. Annex 3 (Chapter 19.1.2)

As part of a research project, completed in February 2007, for updating the National Programme in the framework of Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants ("NEC Directive), individual emission factors for the components SO_2, NO_X and dust were revised in keeping with recent findings. No changes were made in the climate-relevant components N_2O and CH_4, however (research project "Measures for compliance with the emission ceilings of the NEC Directive", FKZ 205 42 221; final report of the sub-project "Reference scenario 2000 – 2020 for emissions under the NEC Directive (SO_2, NO_X, NMVOC, NH_3)" of October 2006).

For this 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 23. These factors were used as a basis for calculating the source-category-specific emission factors for the CSE.

Table 23:   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 24, 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 24:   Technological emission factors for nitrous oxide from systems < 50 MW furnace thermal output

Fuel	Technology		Output	Länder	N_2O-E factor / median [kg/TJ]			
Hard coal		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	- 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 rates 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.

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.

Other aspects relative to time-series consistency of activity rates are explained in Chapter 18.5 and Chapter 18.6.

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 19.1.2.1and in Annex 3, Chapter.

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, and 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 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 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 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$_2$O.

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$_2$O were determined for 1995 (reference year) and then extrapolated, 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 2008. The N$_2$O 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$_2$O emissions in the CRF area under consideration.

The time series for N$_2$O between 1995 and 2008 were reviewed in this light and assessed as consistent overall. The time series of CH$_4$ emission factors for 1995 to 2008 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, in turn, 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)

General quality control (in accordance with Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, has 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 Energy Balances. In addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[19].

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, regular exchanges and discussions are carried out with the members of the AGEB for 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 41). Their results were reported in the NIR 2005.

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

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables. For inputs of household waste / municipal waste as fuel, recalculations for the period 1995 – 2007 had to be carried out to take account of improved pertinent data.

Revision of CH_4 emission factors for gas engines led to large recalculations for methane, throughout the entire time series. In addition, biogas fuel, which has been accounting for a growing share of electricity production, is covered for the first time in the present report. Together, these two effects have led to very large recalculations; as of 2007, the recalculations have increased to nearly 1.5 million t CO_2 equivalents.

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

In the framework of a major research project launched at the end of 2008, we have begun updating the database for emission factors (apart from those for CO_2) that is described in Chapter 3.2.6.2. Current plans call for the pertinent results to enter into the 2012 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.

In addition, plans call for further improvement of the methods for calculating activity data for waste incineration.

---

[19] 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)

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

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

CRF 1.A.1.b

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
All fuels	l / t	CO_2	1.62 %	2.25 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	< 1	+/- 50	-	-	-	+/- 50				
Distribution of uncertainties	U	U	-	-	-	U				
EF-determination method	CS	Tier 2	-	-	-	Tier 2				

The source category "*petroleum refining*" is a key source of CO_2 emissions in terms of both 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 117.8 Mt in 2008. In that period, 108 Mt of crude oil, along with 13 Mt of intermediate products, were input for processing. Production of petroleum products totalled 118 Mt, of which about 60 Mt consisted of fuels, about 29 Mt consisted of heating oils, about 8.6 Mt consisted of naphtha and about 21.7 Mt consisted of other products. (MWV, 2009).

The refineries operate power stations with electrical output of about 0.9 GW. In 2007, these power stations generated 5.8 TWh of electrical work and yielded process heat for production purposes. (STATISTISCHES BUNDESAMT, 2006d).

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".

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

Activity rates

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 rates for electricity production, energy inputs for heat production (EB line 38) and for used-oil processing (EB line 39) 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 rates 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 CO_2-emission factors)

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 rates 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 rates of stationary combustion systems" (Chapter 13.6 of the NIR 2007).

3.2.7.3.1   Result for N_2O

The values for the relative uncertainty are on the order of about 0.6. The pertinent comments 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.b)

General quality control (in accordance with Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out.

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 for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables.

The results of Chapter 3.2.6.5 apply mutatis mutandis.

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

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

The planned new research project described in Chapter 3.2.6.6, aimed at updating **emission factors** (except for those for CO_2) will also cover power stations and bottom-heating systems in petroleum refineries.

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.1c					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
All Fuels	l / t	CO_2	4.80 %	1.39 %	falling

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	< 5	+/-50	-	-	-	+/- 50				
Distribution of uncertainties	U	U	-	-	-	U				
EF-determination method	CS	Tier 2	-	-	-	Tier 2				

The source category "*Manufacture of solid fuels and other energy industries*" is a key source, in terms of both emissions level and trend, of CO_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 2008, the German hard-coal mining sector extracted 17.1 Mt of usable hard coal (STATISTIK DER KOHLEWIRTSCHAFT 2009: for the year 2008, Übersicht (Overview) 1, and www.kohlenstatistik.de). Coke production in 2008 amounted to 8.3 Mt (STATISTIK DER KOHLENWIRTSCHAFT 2009). Production of hard coal briquettes and other coal products combined amounted to less than 1 Mt.

In 2008, 175.3 Mt of crude lignite was produced in Germany (www.kohlenstatistik.de). Combined production of lignite briquettes and other lignite products amounted to about 5.9

Mt (www.kohlenstatistik.de). 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 2008, German production of petroleum totalled 3.05 Mt (MWV, 2009), while production of natural gas totalled about 15,515 Mm³ (H_u = 31,736 kJ/m³) (AGEB, 2009). The fuel input needed for operation of the plants is included in the Balance of Emission Causes (BEU).

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).

3.2.8.2   Methodological issues (1.A.1.c)

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, 2006d). In the relevant calculation, the fuel-input fraction for electricity production in CHP plants is added to the fuel input in electricity-only plants. The fuel-input fraction for electricity production in CHP plants is equivalent to the relationship between electricity production in CHP plants and heat/electricity production in CHP plants. The activity rates 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 2008) 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 remaining transformation sector is obtained by combining the energy consumption figures in Energy Balance lines 33 to 39 (total energy

consumption in the transformation sector). These figures include mines' own consumption; facilities for petroleum and natural gas production and for processing of old oil; plants that produce coal products; plants for production and processing of fissile and fertile materials; and wastewater-treatment facilities' own consumption.

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

Emission factors (except for CO_2-emission factors)

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.

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.

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

Uncertainties for the activity rates 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 the relative uncertainty of the emission factors are on the order of about 0.6. The pertinent comments made in Chapter 3.2.6.3.2 also 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.1.c)

Quality control and quality assurance (for EF, pursuant to Tier 1; for AR, pursuant to Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The results of Chapter 3.2.6.4 apply mutatis mutandis.

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

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances and of updating of evaluation tables. Recalculations as of 1995 had to be carried out for the area of the coking plants, to take account of changes in the relevant calculation method.

New CH_4 emission factors were determined for pit gas. This led to a considerable increase in CH_4 emissions for 1990-2007.

The results of Chapter 3.2.6.5 apply mutatis mutandis.

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

The new research project described in Chapter 3.2.6.6, for updating of emission factors (except for those for CO_2), also covers power stations and other combustion systems in the mining sector.

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 rates" (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 rates was carried out solely for process combustion.

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 13. BImSchV).

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

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); *FEDERAL STATISTICAL OFFICE*, 2008c).

A change in Statistics 067 (op. cit.) of the Federal Statistical Office has led to a jump in the activity rates 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 rates" ("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.

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

CRF 1.A.2.a

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
All fuels	l / t	CO_2	1.02 %	1.19 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties	N									
EF-determination method	T2									

The source category "*Manufacturing industries and construction – iron and steel*" is a key source, 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.2.a)

It comprises the production areas of pig iron (blast furnaces), sinter, rolled steel, iron and steel casting and Siemens-Martin steel.

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.

3.2.9.1.2   Methodological issues (1.A.2.a)

In the interest of more standardised, consistent and transparent description of calculation algorithms for activity rates, in the Balance of Emissions Causes (BEU), the pertinent model in the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) was revised, and the relevant calculation algorithms were described in detail.

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). Allocation of the various fuels, within the production areas pig iron (blast furnaces), sinter, rolled steel and iron and steel casting, is to be reviewed again.

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.2.a)

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 have been updated for the activity rates in the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and included in the relevant final report.

Reallocation of CO_2 emissions from a) use of reducing agents in blast furnaces and b) top-gas combustion from source categories 1.A.1 and 1.A.2 to source category 2.C.1 leads to some trend inconsistencies with regard to the pertinent production data. For this reason, the procedure is to be further improved.

3.2.9.1.4   Source-specific quality assurance / control and verification (1.A.2.a)

Quality control and quality assurance (pursuant to Tier 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 comparing and evaluating data.

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

3.2.9.1.5   *Source-specific recalculations (1.A.2.a)*

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables.

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.2.b)

CRF 1.A.2.b

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
	- / -				

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category "Non-ferrous metals" is not a key source.

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; *FEDERAL STATISTICAL OFFICE*, 2008b) (Melde-Nr. (reporting number) 27.43, Erzeugung und erste Bearbeitung von Blei, Zink und Zinn (production and initial processing of lead, zinc and tin) and 27.44, 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, 2008c).

Descriptions of calculation algorithms for activity rates 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 rates" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

The 1990 activity rates 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 rates 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 carry out quality control and quality assurance (i.e. for it to be 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.

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)

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables.

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					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
All fuels	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

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
	- / -				

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	CS	NE	NO	NO	NO	NE	NE	NE	NE	NE
EF uncertainties in %	-50 / +90									
Distribution of uncertainties	N									
EF-determination method	T2									

The source category "*Pulp, paper and print*" is not a key source.

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.

Table 25:   Inputs of secondary fuels in the pulp and paper industry: CO$_2$ emission factors and their biogenic components

Secondary fuel (designation in the CSE)	CO$_2$ emission factor [kg/ TJ]	Biogenic mass fraction [%]
Spent liquors from pulp production	74,046	100
Bark	80,611	100
Fibre/de-inking residues	54,871	100
Paper-industry residues	86,222	95

Remark: The listed biogenic fractions include no data on inorganic carbon fractions (TIC, such as carbonates); the emission factor has been derived from the organic fraction (TOC). Since in EU emissions trading both TIC and TOC are to be taken into account, these figures have little suitability for comparisons and for use in calculations for individual plants.

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 carry out quality control and quality assurance (i.e. for it to be 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.

The data on inputs of substitute fuels in the paper industry were provided by the German Pulp and Paper Association (VDP) and subjected to intensive quality checks in the framework of a research project (UBA 2005b, FKZ 204 42 203/02). In the process, the relevant physical flow quantities were checked for consistency with overall energy consumption in paper production. In addition, CO_2 emissions from use of regular and substitute fuels were determined, as a means of checking the quality of the underlying data.

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)

No recalculations were carried out for this source category this year.

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					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
All fuels	- / t	CO_2	0.16 %	0.02 %	falling

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category "*Sugar production*" is not a key source.

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; these 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 rates 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, 2008b) and Statistik 067 (STATISTISCHES BUNDESAMT, 2008c) list all of the fuels required for calculation of the pertinent activity rates 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 rates" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

Additional review is expected to show whether shifting seen in relevant coal use has resulted from allocation to the *lime industry*.

3.2.9.5.3   Uncertainties and time-series consistency (1.A.2.e)

For 2004, the uncertainties for all activity rates 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 carry out quality control and quality assurance (i.e. for it to be 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.

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)

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables.

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

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
All fuels	l / t	CO_2	11.23 %	8.48 %	falling

The source category "*Manufacturing industries and construction – Other*" (1.A.2.f), 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) (cf. Figure1).

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.

3.2.9.7 Manufacturing industries and construction – Cement production (1.A.2.f, Cement)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	NE	NO	NO	NO	NE	NE	NE	NE	NE
EF uncertainties in %	-30 / +30									
Distribution of uncertainties	N									
EF-determination method	T2									

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; this 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)

Descriptions of calculation algorithms for activity rates in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

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, Cement production). The source for pertinent differentiation from heat and electricity production is Statistik 067 (STATISTISCHES BUNDESAMT, 2008c).

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 (production of cement, lime and burnt plaster) can be used as a basis.

To permit differentiation, individual data items available until 2001 for manufacturing of cement (Meldenummer (reporting number) 26.51), manufacturing of lime (Melde-Nr. (reporting number) 26.52 and manufacturing of plaster (Melde-Nr. (reporting number) 26.53) were suitably 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) 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, 2008c) 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 rates" ("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).

Table 26:   Inputs of secondary fuels in the cement industry: emission factors and their biogenic components

Secondary fuel (designation in the CSE)	CO_2 emission factor [kg/ TJ]	Biogenic mass fraction [%]
Used tyres*	97,319	27
Used oil	78,689	0
Commercial waste - paper	64,881	91
Commercial waste - plastic	83,075	0
Commercial waste - packaging	56,854	40
Textile waste	63,294	70
Commercial waste - other	68,129	52.33
Animal meals and fats	74,867	100
Processed municipal waste	59,846	55
Waste wood (wood scraps)	95,056	100
Solvents (waste)	71,133	0
Carpet waste	80,425	36.50
Bleaching clay	82,260	0
Sewage sludge	95,110	100
Oil sludge	84,024	0

*   The emission factor for used tyres in the ETS context, in Germany, is 88,000 kg CO_2/TJ. The suitability of this figure with regard to the emissions inventories will be reviewed in the next report.

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 substitute 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 have been updated for the activity rates in the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and included in the relevant final report.

The activity rates 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, Chapter 19.1.2.1.

3.2.9.7.4   *Source-specific quality assurance / control and verification (1.A.2.f, Cement)*

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.

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)*

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables.

Allocation of the substitute fuel *used oil* to the category *other petroleum products*, which is already listed in the Energy Balance, leads to recalculations for the period as of 1995.

3.2.9.7.6   *Planned improvements (source-specific) (1.A.2.f, Cement)*

At present, only review of the emission factor for use of used tyres is planned (cf. Table 26).

3.2.9.8   Manufacturing industries and construction – Ceramics (1.A.2.f, Ceramics)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS					CS				

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; this 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 fuels inputs for process combustion are calculated 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.) 26.40, Ziegelei (brickworks), production of other construction certamics), and, for differentiation from heat and electricity production, Statistik 067 (STATISTISCHES BUNDESAMT, 2008c).

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity rates" ("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 rates, 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 (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 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)*

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables.

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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS					CS				

3.2.9.9.1   *Source category description (1.A.2.f, Glass)*

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; this 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)*

Descriptions of calculation algorithms for activity rates in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

The source for fuel inputs is Statistik des produzierenden Gewerbes (manufacturing-sector statistics; Melde-Nr. (reporting number) 26.1, Production of glass and glassware). The source for pertinent differentiation from heat and electricity production is Statistik 067 (STATISTISCHES BUNDESAMT, 2008c).

The relevant calculation algorithms are described in detail in the final report for the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten") (FKZ 204 41 132).

3.2.9.9.3   *Uncertainties and time-series consistency (1.A.2.f, Glass)*

Since 1995, when official statistics were converted to the economic-sector classification system (Klassifikation der Wirtschaftszweige; *FEDERAL STATISTICAL OFFICE*, 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 have been updated for the activity rates in the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and included in the relevant final report.

Uncertainties were determined for all activity rates, 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)*

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 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)*

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables.

3.2.9.9.6   *Planned improvements (source-specific) (1.A.2.f, Glass)*

No improvements are planned at present.

3.2.9.10   Manufacturing industries and construction – Lime (1.A.2.f, Lime production)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS									

3.2.9.10.1   *Source category description (1.A.2.f, Lime)*

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)*

Descriptions of calculation algorithms for activity rates in the Balance of Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

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).

Pursuant to Statistik 067 (STATISTISCHES BUNDESAMT, 2008c), 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, 2008b) is used.

Additional review is expected to show whether 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 rates" ("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 (op. cit.).

Table 27:   Inputs of substitute fuels in the lime industry: emission factors and their biogenic components

Secondary fuel (designation in the CSE)	CO_2 emission factor [kg/ TJ]	Biogenic mass fraction [%]
Used oil	78,689	0
Animal meals and fats	74,867	100
Commercial waste - other	68,129	52.33

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; *FEDERAL STATISTICAL OFFICE*, 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 have been updated for the activity rates in the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and 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 substitute 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 rates 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, Chapter 19.1.2.1.

3.2.9.10.4   Source-specific quality assurance / control and verification (1.A.2.f, Lime)

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.

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 this end, 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. On the other hand, 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.

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)

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables.

Allocation of the substitute fuel *used oil* to the category *other petroleum products*, which is already listed in the Energy Balance, leads to recalculations for the period as of 1995.

3.2.9.10.6   Planned improvements (source-specific) (1.A.2.f, Lime)

No improvements are planned at present.

3.2.9.11   Manufacturing industries and construction – Other energy production (1.A.2.f, Other)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %	NE	NE				NE				
Distribution of uncertainties										
EF-determination method	CS	CS				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.

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 rates" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132).

Emission factors (except for CO_2-emission factors)

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.

3.2.9.11.3   Uncertainties and time-series consistency (1.A.2.f Other)

Activity rates

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 have been updated for the activity rates in the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) and 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 (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 further information on quality assurance, cf. CRF 1.A.1.a (Chapter 3.2.6.4).

Activity rates

The quality of the data was reviewed in the research project "Substantiation of the data quality of activity rates" ("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 rates

Recalculations for the years 2003 to 2007 were carried out to take account of fundamental methodological revision of the Energy Balances as of 2003 and of updating of evaluation tables.

Emission factors:

The results of Chapter 3.2.6.5 apply mutatis mutandis.

Determination of new CH_4 emission factors for use of gaseous fuels in combustion-engine systems led to an increase of CH_4 emissions throughout the entire time series.

3.2.9.11.6   *Planned improvements (source-specific) (1.A.2.f Other)*

Activity rates:

No improvements are planned at present.

Emission factors:

The new research project described in Chapter 3.2.6.6, for updating of emission factors (except for those for CO_2), will also cover power stations and other combustion systems in the area of "manufacturing - other energy production".

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.3					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	--	--	--	CS	CS	CS	CS	CS
EF uncertainties in %	±5	-57 / +100				-70 / +150				
Distribution of uncertainties	N	L				L				
EF-determination method	T2a	T2a	--	--	--	T2a				

The source category *"Civil aviation"* is not a key source.

Air transports differ significantly from land and water transports with respect to emissions production. In air transports, fuels are burned under atmospheric conditions that a) differ markedly from those prevailing at ground level and b) can vary widely. 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 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), HC (hydrocarbons), dust (total suspended particles; TSP) and ammonia (NH_3).

3.2.10.1.2   *Methodological issues (1.A.3.a)*

In its emissions reporting, Germany plans to serve as a pilot user of data and models of Eurocontrol, the European Organisation for the Safety of Air Navigation. Eurocontrol has detailed, suitably processed data on aircraft movements in all partner countries. On the basis of such data, Eurocontrol implements two methods for calculating emissions from air transports: ANCAT 3 and the Advanced Emission Model 3 (AEM 3). ANCAT 3 corresponds to

the Tier 3a method described in the IPCC Guidelines 2006, while AEM 3 corresponds to the Tier 3b method (IPCC 2006a, p 3.61). Both methods calculate emissions on the basis of individual aircraft movements, without cross-checking fuel consumption against national energy balances.

The only data available to date are data for 2003 to 2006 that were provided by Eurocontrol for a workshop held in 2007 that was organised by Norway and the European Environment Agency (EEA) (ETC/ACC 2007). These data were used only for calculation of the ratio between jet-kerosene consumption in national air transports and total jet-kerosene consumption. All emissions are calculated in keeping with the Tier 2a method (IPCC 2006a, p. 3.58, IPCC 2006b), i.e. with separate consideration of the flight phases "landing/take-off (LTO) cycle" (i.e. phases of flight up to an altitude of 3,000 feet / about 915 m) and "cruise". The pertinent emissions are determined by multiplying fuel consumption, for the various flight phases, by the relevant emission factors.

CO_2, H_2O 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, HC, 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. NO_x, CO and HC are taken into account in the AEM 3 model developed by Eurocontrol. As soon as the data in that model become available, the German emissions inventory will be suitably adapted. A pertinent model for calculation is already available.

Since 2007, figures for the relevant gasoline consumed (aviation gasoline) 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. Significantly, 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 turbine fuel consumed in Germany, pursuant to the national Energy Balance (the latest version, covering the period until 2007) and to the official mineral-oil data provided by the Federal Office of Economics and Export Control (for 2008) (AGEB, 2009; BAFA, 2009). Eurocontrol data cannot be used directly, since the air transports covered by Eurocontrol do not completely accord with the air transports subject to inventory reporting obligations. Such direct use is also precluded by the need to ensure consistency with national statistics.

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. Until 2007, this breakdown was carried out using a constant value of 20 %, in keeping with a pertinent study of the TÜV Technical Inspection Association from 1989 (UBA, 2001a). That percentage is based on statistics on numbers of national/international passengers. Since those statistics have changed sharply since 1989, and since the IPCC Guidelines 2006a calls for such a

breakdown to be made in keeping with actual aircraft fuel consumption, the assumption in question has been completely revised (ÖKO-INSTITUT, 2007).

For the years 2003 to 2008, fuel-consumption data for national and international flights, calculated by Eurocontrol with ANCAT 3, are available for emissions-reporting purposes. For those years, the breakdown is made in keeping with the national/international ratio for fuel consumption as given by Eurocontrol. For earlier years, the breakdown is taken from an exponential function that begins in 1990, with a value of 20 %. The exponential function is based on Eurocontrol data for the years 1996 to 2001, data which are subject to a higher level of uncertainty and thus are not directly incorporated into the inventory.

Table 28:   Development of the national share of fuel consumption since 1990

Year	1990	1995	2000	2002	2003	2004	2005	2006	2007	2008
National share [%]	20.0	15.0	11.2	10.0	9.5	8.6	8.3	8.4	8.2	7.9

Kerosene consumption is broken down, in accordance with the two flight phases *LTO* and *cruise*, with the help of statistics on numbers of flights. Such statistics, which are collected by the Federal Statistical Office, have now been made available for the first time. The relevant figures are based on numbers of commercial domestic departing flights (i.e. flights within Germany), from all airports, as well as on numbers of departing international flights, from selected airports only. This selection covers over 99 % of all commercial international flights and thus is considered sufficiently precise. One uncertainty results in that kerosene-powered aircraft operating on non-commercial flights are not included. Those flights are not included in the Federal Statistical Office's statistics. Since average kerosene-consumption figures are used in pertinent calculations, inclusion of departures of such aircraft, which tend to be smaller (such as helicopters), would probably distort the overall result, however. The following procedure is used in order to ensure that only the numbers of departures of kerosene-powered aircraft in commercial flight operations are taken into account: on the basis of data of the Federal Statistical Office, the total number of national-flight departures is reduced to a level of 75 %, and the total number of international-flight departures is reduced to a level of 90 % (cf. ÖKO-INSTITUT, 2009).

For purposes of breaking down national and international kerosene consumption by flight phases, it is assumed that the number of flights is the same as the number of LTO cycles, since each such cycle includes both a take-off phase and a landing phase. On the basis of the IPCC Guidelines 2006b, an average consumption of 850 kg of kerosene is assumed for each LTO cycle in national flight operations. Multiplication of that figure by the total number of flight operations yields the kerosene consumption for the LTO cycle. Consumption for the *cruise* flight phase is thus obtained as the difference between total consumption and LTO-cycle consumption.

A similar calculation is carried out for international flight operations. Since larger aircraft tend to be used in such flights, on average, a higher LTO consumption is assumed, however. In addition, a figure of 1,675 kg kerosene / LTO is used. The manner in which that figure is derived is described in the explanations for the relevant emission factors. For international flights, those emissions must be determined that result from flights departing from Germany, i.e. flights with take-offs in Germany and landings in other countries. The pertinent emissions are thus calculated in exactly the same way in which emissions from national flights are calculated.

For those years in which kerosene-consumption data from Eurocontrol are available, broken down by LTO-cycle and cruising consumption, the relevant percentage figures are applied to national and international kerosene consumption.

Avgas

The relevant consumption data accord with the figures for aviation fuel consumed in Germany, pursuant to the national Energy Balance (the latest version, covering the period until 2007) and to the official mineral-oil data provided by the Federal Office of Economics and Export Control (for 2008) (AGEB, 2009; BAFA, 2009). 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.

Emission factors:

Aviation turbine fuel / jet kerosene

For the 2010 report, and for the first time ever, the emissions calculation for jet kerosene is carried out pursuant to Tier 2a, i.e. separately for LTO-cycle and cruising-flight phases. This has required a complete revision of emission factors, since each such factor – i.e. each factor for a single pollutant – can differ considerably by flight phases.

The emission factor for **carbon dioxide** was derived on the basis of the carbon content of kerosene. This approach is required in light of the average composition of kerosene: Kerosene consists of alkanes (about 35 % by volume), cycloalkanes (about 45 % by volume), aromates (about 17 % by volume) and alkenes (about 1 % by volume). As a rule, the fuel's composition varies widely by region. Among the lengths of the hydrocarbon chains involved, the fraction with 11 to 12 carbon atoms predominates by amount. Taking into account kerosene's average hydrogen content, and its average mol-weight of 167 g/mol, kerosene can be simply described via the sum formula $C_{12}H_{23}$. In complete combustion, in strict stoichiometric terms, one kg of kerosene produces 1.24 kg of water and 3.15 kg of carbon dioxide. The average **emission factor for carbon dioxide from kerosene** is thus **3,150 g/kg**. That value 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. In the mid-1990s, data were published for nitrous oxide (and methane) that had been obtained in a study of a Pratt & Whitney engine (PW 305) and a Rolls Royce engine (RB211), and measured with infrared spectroscopy under various flight conditions (Wiesen et al, 1994 and 1996). Those studies yielded an average emission factor of 0.15 g/kg for N_2O. 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 29) The emissions per LTO cycle are recalculated using the listed 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 jet kerosene / LTO cycle is assumed. The latter figure is the mean value of the figures for the two aircraft classes listed in IPCC 2006b for international flights, 850 and 2,500 kg kerosene / LTO cycle. That figure is somewhat higher than the value given in Table 8.2 of the Corinair

Guidelines 2006. That source proposes values of 825 kg for national LTO cycles and 1,617 kg for international flights (in each case, for the average fleet involved). In the present case, the more conservative approach, assuming a fleet with somewhat larger aircraft, is used.

Table 29: CH_4, N_2O and SO_2 emission factors from the IPCC emission-factor database

Gas	Average fleet				
	national		international		
	LTO	Cruise	LTO		Cruise
	850 kg		850 kg	2500 kg	
	[kg/LTO]	[kg/ t]	[kg/LTO]		[kg/ t]
CH_4	0.30	0.00	0.30	1.50	0.00
N_2O	0.10	0.10	0.10	0.20	0.10
SO_2	0.80	1.00	0.80	2.50	1.00

Source: IPCC 2006b

Emissions of **sulphur dioxide** depend directly on the sulphur content of the relevant jet kerosene. 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 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 (cf. Table 29), which, at 1 kg SO_2/t jet kerosene, are of an order similar to the old inventory values, are based on a sulphur content of 0.05 mass percentage. According to current information of the Fachausschuss für Mineralöl- und Brennstoff-Normung[20] (FAM; technical committee for petroleum and fuels standardisation), kerosene in Germany typically has a total sulphur content of about 0.01 mass percentage, i.e. one-fifth of the content given by the IPCC. The 2009 inventory report uses a sulphur-content figure of 0.021 mass percentage 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 keeping with the above-described stoichiometric considerations, an EF of 1.24 kg H_2O/kg jet kerosene still results. In the interest of limiting the number of emission-factor sources, the Corinair figure (2006) is used. Since this emission factor is solely fuel-specific, it is also applied to both flight phases, for both national and international air transports.

NO_X, CO and HC emissions can be calculated with the help of emission factors. As of 2003, another option is available: Eurocontrol figures can be used as a basis. Such use produces a methodological discontinuity, however. In such use, the Eurocontrol data are not used directly; they are first converted via a scaling factor that corresponds to the ratio between jet-

---

[20]Personal e-mail communication with Dr. Feuerhelm, FAM Hamburg, 9 June 2009

kerosene consumption pursuant to Eurocontrol and jet-kerosene consumption pursuant to the Energy Balance.

It is difficult to select suitable average emission factors for **nitrogen oxides**, since such emissions depend strongly on external conditions. They are highly technology-specific, and they increase with increasing combustion-chamber pressures and temperatures. In recent years, profound changes have occurred in connection with such emissions, since efforts to make aircraft engines more fuel-efficient have led to increases in average emission factors. At the same time, the role of cruising flight in this context has tended to be overestimated, however. Determining the emission factor for nitrogen dioxide has thus proven to be difficult (DÖPELHEUER, 2002; RAND, 2003; UBA, 2001a). In addition, at this juncture, it would be more correct to speak first of nitrogen oxides in general – i.e. of the sum of nitrogen monoxide and nitrogen dioxide: in an aircraft engine, primarily nitrogen monoxide is produced; this substance, after leaving the engine, is then converted into nitrogen dioxide. For this reason, the emission factor listed below refers to the sum of all nitrogen oxides, even where complete oxidation to nitrogen dioxide effectively occurs.

The main source for required nitrogen, in addition to the surrounding air, is fuel, which contains nitrogen in organically bound form. Consequently, formation of nitrogen oxides depends on the combustion-chamber intake temperature and pressure, the amount of time that hot gases remain in the combustion chamber and the local equivalence ratio of the fuel/air mixture. In keeping with the different technologies currently used, for these purposes aircraft engines can be divided into three different groups (high, medium and low emissions levels; see below) (RAND, 2003).

At present, reliable values are available only from the ICAO database (ICAO, 2009). These values refer only to the LTO cycle, however. The cycle is used to determine, via measurement, whether engines comply with binding standards under international law (to date, standards have been defined for nitrogen oxides, carbon monoxide, hydrocarbons and soot). The standards are certification standards, covering individual flight phases of specified duration and with specified thrust. Derivation of cruising-flight emission factors from LTO-cycle emission factors requires correlation methods, such as the p^3-T^3 method that is used by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt e.V. – DLR) and that is oriented to temperatures and pressures at the combustion-chamber intake. Engines with higher bypass ratios have slightly lower specific nitrogen-oxide emissions (DLR, 1999).

Aircraft with comparatively high NO_X emissions were found to have average NO_X emissions of about 14.5 g/kg, while those with medium NO_X emissions have emissions of about 13.5 g/kg and engines using technologies that provide low specific nitrogen-oxide emissions have emissions of about 11 g/kg (refers to values in the ICAO database, i.e. applies only to the LTO cycle) (RAND, 2003). IPCC (1999) contains emission-factor figures for NO_X, HC and CO that are based on various sources, and that represent average values for all flight phases (cf. Table 30.

It must be remembered that the average emission factor for NO_X has risen as a result of the increases, over the past few decades, in combustion-chamber pressures and temperatures. The values determined in the DLR and ANCAT scenarios are likely to have been affected by the assumption that a large percentage of engines in 2015 will have lower specific nitrogen oxide emissions, i.e. by the assumption that the zenith for the emission factor EF (NO_X) has already been passed.

Table 30:   Emission factors for NO_x, CO and HC, from IPCC 1999

Gas	EF [g/kg kerosene] 1992	EF [g/kg kerosene] 2015	Source
NO_x	12.60	13.70	NASA
NO_x	14.00	12.40	ANCAT
NO_x	14.20	12.60	DLR
CO	11.30	7.10	NASA
HC	2.30	1.00	NASA

Source: IPCC 1999: "Aviation and the Global Atmosphere", Chapter 9: Aircraft Emissions

At present, the percentage of aircraft engines that have lower specific nitrogen oxide emissions still seems to be very low. For this reason, NASA's pertinent assumptions are used as a basis for the time series for emissions of NO_x, as well as for emissions of CO and HC. For 1990 to 1991, the value for 1992 is used; for years as of 2015, the value for 2015 is used. Linear interpolation is carried out for the years in between.

These values are average values for both flight phases. The relevant relationships in IPCC 2006b are used to convert them into emission factors for the two relevant flight phases. The same relationships are also used for differentiation by national/international (ÖKO-INSTITUT, 2009).

Unburned **hydrocarbons**, along with carbon monoxide, are among the most important products resulting from incomplete combustion of jet kerosene. They are emitted primarily at low load levels. As engine efficiencies have improved, a process that has involved increases in combustion-chamber temperatures and pressures, the specific emission factor for unburned hydrocarbons has decreased. For example, the EF (HC) for global airline transports in 1986, for all flight phases, is given as 1.34 g/kg, while that for 1989 is 1.25 g/kg and that for 1992 is 1.12 g/kg (DLR, 1999). Studies of emitted hydrocarbons have shown that the length of hydrocarbon chains in the hydrocarbon fractions formed in jet-kerosene combustion decreases with increasing engine load. At an 80 % load level, primarily C1 and C2 fractions form, while at 7 % and 30 % thrust the pertinent maximum involves emissions of molecules with C2 and C3 fractions. On the other hand, at lower thrust levels, larger numbers of considerably longer hydrocarbon fractions occur. The emission factor varies considerably from thrust level to thrust level. For example, in a test run with the TF-39-1C engine, it was 18.9 g/kg at 7 % thrust and only 0.04 g/kg at 80 % thrust. The higher the load level, the higher the ratio of alkanes to alkenes; aromates range between 3 and 9 %, while oxygen-containing hydrocarbons account for about 25 % (DÖPELHEUER, 2002).

IPCC 1999, on a basis of NASA data, lists different emission factors (for all flight phases) for different years (cf. Table 30). The values refer to all air traffic worldwide, except for military air traffic. Fuel efficiency tends to improve continuously, i.e. without sudden jumps, and changes in EF levels (HC) are inversely proportional to such improvement. For these reasons, in an approach similar to that used with NO_x emissions, a time series with continuously decreasing emission factors was developed (ÖKO-INSTITUT, 2009). That series does not include different emission factors for the two different flight phases, however. At the same time, in addition to the larger hydrocarbon fractions, it does include the C1-body fraction. If the species in question is not a radical one, and a pure hydrocarbon is involved, this group also includes methane.

Carbon monoxide results from incomplete carbon oxidation in combustion of jet kerosene. While the first sub-reaction involved, oxidation of carbon to carbon monoxide, is fast, the second sub-reaction, oxidation to carbon dioxide, determines the rate of the overall reaction. In combustion, part of the carbon monoxide is not completely converted. Since a somewhat linear continuous decrease is apparent here as well, the time series for the emission factors are prepared on the basis of the values in IPCC 1999, in a manner similar to that used for NO_x emissions, and separately for the different flight phases (ÖKO-INSTITUT, 2009).

Ammonia emissions are calculated, for both flight phases, with an emission factor of **0.173 g/kg jet kerosene** (UBA, 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 dust emissions from jet kerosene (Total Suspended Particulate matter (TSP); $PM_{2.5}$; PM_{10}). For this reason, the emission factors for **dust** (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 kerosene; for international flights, 0.15 kg TSP/LTO and 0.2 kg TSP/t jet kerosene. According to that table, 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.

Table 31:　　　Emission factors used for kerosene

Gases [kg/t kerosene]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
National LTO																			
CO_2	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
CH_4	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
N_2O	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
SO_2	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
NO_X	13.46	13.42	13.41	13.47	13.51	13.56	13.60	13.63	13.66	13.72	13.76	13.79	13.81	13.86	13.87	13.96	14.04	14.10	14.15
NMVOC	1.9	1.9	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.1	1.0
CO	14.19	14.02	14.00	13.80	13.55	13.29	13.05	12.73	12.46	12.25	12.01	11.72	11.41	11.17	10.83	10.74	10.59	10.41	10.16
National, Cruise																			
CO_2	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
CH_4	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
N_2O	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
SO_2	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
NO_X	12.34	12.3	12.3	12.3	12.4	12.4	12.5	12.5	12.5	12.6	12.6	12.6	12.7	12.7	12.7	12.8	12.9	12.9	13.0
NMVOC	2.3	2.3	2.3	2.2	2.2	2.1	2.1	2.0	2.0	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.4
CO	10.4	10.3	10.3	10.1	9.9	9.8	9.6	9.3	9.2	9.0	8.8	8.6	8.4	8.2	8.0	7.9	7.8	7.6	7.5
International, LTO																			
CO_2	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
CH_4	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
N_2O	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
SO_2	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
NO_X	15.9	15.9	15.9	15.9	16.0	16.0	16.1	16.1	16.2	16.2	16.3	16.3	16.3	16.4	16.4	16.5	16.6	16.7	16.7
NMVOC	2.2	2.2	2.2	2.1	2.1	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.5	1.5	1.4	1.4	1.3	1.3
CO	22.0	21.7	21.7	21.4	21.0	20.6	20.2	19.7	19.3	19.0	18.6	18.2	17.7	17.3	16.8	16.6	16.4	16.1	15.7
International, Cruise																			
CO_2	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
CH_4	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
N_2O	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
SO_2	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
NO_X	15.7	15.7	15.6	15.7	15.8	15.8	15.9	15.9	15.9	16.0	16.1	16.1	16.1	16.2	16.2	16.3	16.4	16.5	16.5
NMVOC	2.3	2.3	2.3	2.2	2.2	2.1	2.1	2.0	2.0	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.5	1.5	1.4
CO	18.8	18.6	18.6	18.3	18.0	17.7	17.3	16.9	16.5	16.3	15.9	15.6	15.1	14.8	14.4	14.3	14.1	13.8	13.5

Source:　　Öko-Institut (2009)

The relevant emission factors were converted from [kg emissions / kg of burned fuel] to [kg emissions / TJ converted energy]; the conversion factor used for this was the pertinent net calorific value, 43,000 kJ/kg.

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**, **nitrous oxide** and **nitrogen 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 2008).

As to fuel properties, there are no fundamental differences between avgas and automobile petrol[21]. 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 mass percentage, which is one-tenth of the figure given for jet kerosene. As a result, the emission factor used for SO_2 from jet kerosene has been reduced by 90 %.

The different mixtures of avgas in use differ in terms of their **lead content**. No precise data on the various mixtures' shares of total use are available. The most commonly used mixture is AvGas 100 LL (low lead), which has a maximum lead concentration of 0.56 g/l. That value is somewhat lower than the standard value of 0.6 g/l proposed by the Corinair Guidebook 2007. For calculation of lead emissions, the value determined for AvGas 100 LL is used in the present context and, with a density figure of 0.75 kg/l, converted to an emission factor of about **0.75 g lead/kg avgas**.

The emission factor for **dust** (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 32 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** and **CO**, pertinent values are given in the **Revised IPCC Guidelines 1996** (pages I 42 and 40); those values are used here. The emission factor for **hydrocarbons** is obtained via addition of the emission factors for NMVOC and methane. (For EF, cf. Table 31).

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 kerosene emission factors (national, cruise).

All emission factors are listed in Table 32.

---

[21]E-mail communication with Mr Winkler of the Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry, 8 June 2009

Table 32:   Emission factors for avgas (1990-2008)

Gas	Emission factor [g/kg]	Remarks regarding the source or calculation
CO_2	3,070.00	from IPCC Guidelines 2006, Table 3.6.4
CH_4	0.36	same as EF jet kerosene, LTO/national/2008
N_2O	0.10	same as EF jet kerosene, cruise/national/2008
SO_2	0.02	equivalent to 1/10 of EF jet kerosene, cruise/national/2008
H_2O	1,274.00	same as EF jet kerosene, cruise/national/2008
NOx	13.36	same as EF jet kerosene, cruise/national/2008
HC	13.65	obtained via addition of EF for NMVOC and CH_4
NMVOC	13.29	from Revised IPCC Guidelines 1996, p. I.42
CO	665.00	from Revised IPCC Guidelines 1996, p. I.40
TSP	1.20	calculated from lead content of AvGas 100 LL
Pb	0.75	calculated from max. lead content of AvGas 100 L

Source: Öko-Institut (2009)

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.

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 IPCC (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 Table 33. 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 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 relevant fleet divisions (in national flight operations, an average consumption of 850 kg kerosene per LTO cycle is applied, in keeping with the IPCC's assumptions). The total uncertainty for 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 splitting of national and international flights is given as an average throughout the time series. A study carried out by the Öko-Institut (2007) confirmed the figure of 20 % as the national share of total kerosene consumption in the base year. For the years 1991 to 2002, that share is calculated via an exponential function whose uncertainty cannot

yet be quantified, because the necessary data for such quantification are lacking. For the years 2003 to 2008, 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).

Table 33:   Total and partial uncertainties of the activity data end the emission factors (CRF 1.A.3.a)

Relevant uncertainties — Individual components		Partial uncertainties %		Kerosene and avgas consumption		LTO/cruise split		Kerosene consumption for LTO / cruise		CO_2 emissions for LTO and cruise		CH_4 emissions for LTO and cruise		N_2O emissions for LTO and cruise		SO_2 emissions for LTO and cruise		H_2O emissions for LTO and cruise		Remaining emissions for LTO + cruise		Source / reason for assumptions
				Total	nat / int	nat	int	nat	int	nat	int	nat	int	nat	int	nat	int	nat	int	nat	int	
Energy Balance		-5	5	x	x																	Öko-Institut / DIW 2007
BAFA data		-1	3																			Öko-Institut / DIW 2007 – here, the uncertainty from the mineral-oil statistics was used (those statistics are based on BAFA). The assumption is thus a conservative one.
Split		-15	15		x																	Assumption. See text.
Kerosene consumption	nat/int	-16	16					x	x													Calculated
Number of flight operations	nat	-5	5			x																Figures of the Federal Statistical Office, less an estimated share of motor-driven aircraft types.
	int	-2	2				x															Figures of the Federal Statistical Office, less an estimated share of motor-driven aircraft types.
Fleet split	nat	-3	3			x																The LTO figure pursuant to IPCC is based on the assumption that aircraft with 850 kg kerosene / LTO are used.
	int	-5	5				x															An average value between 850 and 2,500 kg kerosene/LTO (basic figures from IPCC 2006b)
LTO/cruise split	nat	-6	6					x														Calculated
LTO/cruise split, international	int	-5	5						x													Calculated
Kerosene consumption for LTO / cruise	nat	-17	17							x		x		x		x		x		x		Calculated
	int	-17	17								x		x		x		x		x		x	Calculated
Emission factors	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							IPCC 2006, p.3.69; depends on technology and is thus subject to large uncertainty in combination via the Tier 1 approach
	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 emission factors	nat	-50	50																	x		Assumption
	int	-50	50																		x	Assumption
Total uncertainty above	%			+5	+16	+6	+5	+17	+17	+18	+18	+101	+101	+150	+150	+20	+20	+18	+18	+53	+53	
Total uncertainty below	%			-5	-16	+6	-5	-17	-17	-18	-18	- 59	-59	-72	-72	-20	-20	-18	-18	-53	-53	

Source: Öko-Institut (2009)

3.2.10.1.4   Source-specific quality assurance / control and verification (1.A.3.a)

Quality control and quality assurance (pursuant to Tier 1 & 2), 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.

For determination of emissions from air transports, emission factors used to date had to be revised and adjusted to take account of recent information, technological progress in aircraft engines and a new calculation method. Since – as explained above – combustion differs as flight altitude varies, and can depend strongly on the type of aircraft engine involved, generation of emission factors is sometimes problematic.

Apart from the emission factors for sulphur dioxide, international standard values were used. These were taken from the IPCC emission-factor database or the Corinair Guidebook (2006) or are based on the NASA figures in the IPCC 1999 publication "Aviation and the Global Atmosphere". Discussions of the various individual values are presented in the "Methodological Aspects" chapters of the presentations of the various emission factors.

3.2.10.1.5   Source-specific recalculations (1.A.3.a)

The total emissions from air transports were recalculated to take account of the emissions recalculations as a result of the first-ever breakdown of jet-kerosene consumption by the various flight phases, and of related complete revision of emission factors.

The national share of jet-turbine fuel (jet kerosene) sold has decreased continuously, from 20 % in 1990 to 7.9 % in 2008. The pertinent emissions share has also decreased as a result.

3.2.10.1.6   Planned improvements (source-specific) (1.A.3.a)

The Federal Environment Agency continues to seek an agreement with Eurocontrol regarding the provision of original Eurocontrol data.

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.

If it proves impossible to obtain such data, the Federal Environment Agency will work to expand relevant calculations pursuant to Tier 2b, i.e. with consideration of the various aircraft types, and the various flight-departure locations and destinations, involved.

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				
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	12,21 %	15,11 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS/M	-	-	-	CS/M	CS/M	CS/M	CS/M	CS/M
EF uncertainties in %	±7	-72 +110	-	-	-	-76 +181				
Distribution of uncertainties	N	L/N	-	-	-	L/N				
EF-determination method	T2	T3	-	-	-	T3				

The source category "*Road transport*" is a key source of CO_2 emissions in terms of both 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 this 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 autobahn).

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 gasoline 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. For this reason, the decreasing trend in N_2O emissions that has been observed since 2000 can be expected to continue.

CO_2 emissions depend directly on fuel consumption. From 1990-1999, these emissions increased, since growth in miles 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 2008, fossil-fuel emissions were 26.4 million t lower than they were in 2000. The likely reasons for this trend include reductions in specific fuel consumption, a 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 34:   Emissions from road transports

	CO$_2$ fossil	CO$_2$ bio*	CH$_4$	N$_2$O	NO$_X$	CO	NMVOC**	SO$_2$
				[Gg]				
1990	150,358.32	0.00	58.37	1.96	1,341.45	6,527.26	1,408.97	90.20
1995	165,104.05	106.48	30.34	4.63	1,146.56	3,822.97	593.00	69.31
2000	171,229.50	869.14	15.68	4.82	1,002.94	2,452.83	278.59	19.67
2005	151,603.57	5,573.72	8.79	3.76	686.07	1,541.65	153.72	0.81
2006	147,747.23	10,179.93	8.16	3.56	682.90	1,416.11	142.74	0.82
2007	144,955.50	11,030.25	7.30	3.37	631.34	1,299.64	129.81	0.81
2008	144,872.86	8,952.70	6.63	3.11	572.53	1,210.74	119.07	0.81

*) 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, 2009)[22]. 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.

---

22 To permit derivation and evaluation of reduction measures, TREMOD is also used to calculate the energy consumption and CO_2 emissions of the individual vehicle categories. The values are subsequently aligned with total consumption and total emissions of CO_2.

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:

Table 35:   Differentiation of emissions-control categories in road transports

	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, buses, heavy duty vehicles, motorcycles	Before Euro 1 standard	As of Euro1 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.

Motor-vehicle-fleet data:

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, for the reference years 2001 through 2003, are obtained from 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. The fleet figures for the years 2004 through 2008 were calculated in TREMOD with the help of a fleet-shifting module that extrapolates past fleet-growth trends.

Emission factors:

All emission factors are listed in the "Emission-factor manual for road transports 2.1" ("Handbuch für Emissionsfaktoren des Straßenverkehrs 1.2") (INFRAS, 2004), 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 have included fundamental surveys for the reference years 1989/1990. In those surveys, 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 2.1 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 2.1". The emissions reduction achieved via the introduction of sulphur-free fuels was estimated by the Federal Environment Agency.

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 and quality assurance (pursuant to Tier 1 & 2), 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 energy balances. In

addition, documentation on revision of Energy Balances as of 2003 has been published in the Internet[23].

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 5.03 (IFEU, 2009). Changes with respect to the 2009 report year include an adjustment of activity rates (fuel consumption figures), for the years 2000 through 2007, to the latest figures from the Energy Balances, official mineral-oil data of the Federal Office of Economics and Export Control (BAFA) and data of the Association of the German Petroleum Industry (MWV) (cf. Annex Table 224).

For the first time, use of natural gas, and the pertinent emissions, have been taken account of in this context. Pursuant to the revised Energy Balances as of 2003, petroleum is no longer used in this area. Starting immediately, consumption of that fuel, and the resulting emissions, will thus be reported only for the period through 2002.

3.2.10.2.6   *Planned improvements (source-specific) (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					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
All fuels	- / t	CO_2	0.23 %	0.12 %	falling

Gas	CO_2	CH_4	HFCHFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	--	--	--	CS				
EF uncertainties in %	±7	±34	--	--	--	-42.5 +75				
Distribution of uncertainties	N	N	--	--	--	L				
EF-determination method	T2	T2	--	--	--	T2				

The "*Railways*" source category is a key source of CO_2 emissions in terms of trend.

---

[23] 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)

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[24]. 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. Since pertinent reliable figures have been available only since 2009, the present inventory includes a first consideration of biodiesel consumption and the resulting emissions.

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.

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.

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 rate:

As a result, energy consumption data (currently, for the period from 1990 to 2007) are taken from the official Energy Balances of the Federal Republic of Germany (AGEB, 2009). In particular, the fuel data have been taken from the following Energy Balance lines, for the following periods:

Table 36:   Sources for AR 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	74	through 1994
	61	since 1995
Hard-coal coke	61	since 1995

For those years for which no Energy Balance is yet available (currently: 2008, sales data of the Association of the German Petroleum Industry (MWV) are used as a basis. These data are published in the annual report "Petroleum Data" ("Mineralöl-Zahlen"; in the present

---

[24] from Energiewirtschaftliche Tagesfragen, 54th year (Jahrgang; 2004), issue 3, p. 185

instance: page 52, Table "Sectoral consumption of diesel fuel" ("Sektoraler Verbrauch von Dieselkraftstoff") (MWV, 2009)).

In the 2010 report, use of biogenic fuels (biodiesel) is taken account of for the first time. Because the pertinent figures in the Energy Balances (2004 to 2007) and in the sales figures of the Association of the German Petroleum Industry (MWV; 2008) are incomplete, the annual-consumption figures for the present report were calculated on the basis of the official mixing quotas. As soon as consistent data become available within the official statistics, those sources will be used.

Emission factors:

The emission factors are based, for each specific gas, on the results of various Federal Environment Agency research projects and expert opinions:

- For CO_2, we refer to the documentation in Annex 2, Chapter CO_2 emission factors.
- The CH_4 EF for solid fuels are based on the Federal Environment Agency study "Luftreinhaltung '88" ("Air Quality Control '88", UBA, 1989b). These country-specific factors can be compared with the IPCC default values: for coal, the EF used are higher than those 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 ("Transport Emission Estimation Model"; IFEU, 2009.) 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, via a chronological progression, of engine-based measures to improve the emissions behaviour of railway vehicles (1995: 2.4 kg/TJ; 2008: 1.5 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).

Table 37:   Comparison of current EF for railway transports with the corresponding default emission factors

Gas	EF used [kg/ TJ]		Default EF [kg/ TJ]	
CH₄	Diesel & biodiesel	1.5 - 3.2		
	Hard coal	15.0	Oil	5.0
	Lignite briquettes	15.0	Coal	10.0
	Raw lignite	15.0		
	Hard-coal coke	0.5		
N₂O	Diesel & biodiesel	1.0		
	Hard coal	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 and quality assurance (pursuant to Tier 1 & 2), 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).

3.2.10.3.5   Source-specific recalculations (1.A.3.c)

Recalculations were carried out to take account of use of updated figures from the Energy Balances (2000 to 2007) and of first-time inclusion of data for biogenic fuels (as of 2004).

3.2.10.3.6   Planned improvements (source-specific) (1.A.3.c)

No improvements are planned at present.

---

[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   Transport – Navigation (1.A.3.d)

3.2.10.4.1   Source category description (1.A.3.d)

CRF 1.A.3.d				
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Diesel oil	- / t	CO_2	0.17 %	0.04 %	falling

Gas	CO_2	CH_4	HFCHFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	--	--	--	CS				
EF uncertainties in %	±7	±34	--	--	--	-42.5 +75				
Distribution of uncertainties	N	N	--	--	--	L				
EF-determination method	T1	T1	--	--	--	T1				

The "*Navigation*" source category is a key source of CO_2 emissions in terms of trend.

Navigation is broken down into the categories "coastal and inland navigation" and "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.3.d Navigation, the CSE includes coastal and inland fishing and coastal and inland shipping.

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 IPCC 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:

As a rule, energy consumption data (currently, for the period from 1990 to 2007) are taken from the official Energy Balances of the Federal Republic of Germany (AGEB, 2009). In particular, the fuel data have been taken from the following Energy Balance lines, for the following periods:

Table 38:   Sources for AR in 1.A.3.d

Fuel type	Energy Balance line	Area	Relevant years
Diesel fuel	77	domestic	until 1994
	64	domestic	as of 1995

For those years for which no Energy Balance is yet available (currently: 2008), certain data of the Federal Office of Economics and Export Control (BAFA) are used as a basis. These 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, 2009).

In both cases, the relevant activity rates are broken down by the categories "domestic" and "international", taking account of sales – as listed in different Energy Balance lines – of different ship fuels subject to different taxation rates. By combining the pertinent fuel quantities with the various relevant EF, one can calculate and report domestic and international emissions separately. Since no data is available on ship movements, the IPCC-GPG criteria for separating domestic and international emissions (2000: Table 2.8) cannot be used.

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.

In the 2010 report, use of biogenic fuels (biodiesel) is taken account of for the first time. Because the pertinent figures in the Energy Balances (2004 to 2007) and in the data of BAFA (2008) are incomplete, the annual-consumption figures for the present report were calculated on the basis of the official mixing quotas. As soon as pertinent consistent data become available within the official statistics, those sources will be used.

Data on use of diesel fuel and heavy fuel oil in international maritime transports are provided in the Chapter Internationaler Seeverkehr (1.BU.2).

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 of 74,000 kg/TJ, we refer to the documentation in Annex 2, Chapter "CO_2 emission factors".
- 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 2.4 to 2.8 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, 1997, 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, 1997: Table 1-8).

Data on use of diesel fuel and heavy fuel oil in international maritime transports are provided in Chapter 3.2.2.3 International maritime transports (1.BU.2).

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 statistical conversion as of 1994/1995; 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 and quality assurance (pursuant to Tier 1 & 2), 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[26].

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).

3.2.10.4.5 Source-specific recalculations (1.A.3.d)

Recalculations were carried out to take account of use of updated figures from the Energy Balances (2000 to 2007) and of first-time inclusion of data for biogenic fuels (as of 2004).

3.2.10.4.6 Planned improvements (source-specific) (1.A.3.d)

Currently, the greenhouse-gas inventory for the area of maritime transports is being extensively revised. The future impacts of findings and results from this work will include impacts on source category 1.A.3.d.

---

[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)

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

Key source nach Level 8l) / Trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
All fuels	l / -	CO_2	0.35 %	0.38 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	--	--	--	CS	--	--	--	--
EF uncertainties in %	±3	±34	--	--	--	-42.5 +75				
Distribution of uncertainties	N	N	--	--	--	L				
EF-determination method	T1	T1	--	--	--	T1				

The source category "*Other transport*" is a key source 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 rates:

The area **construction-sector transports** accounts for the majority of energy inputs in this source category. The diesel 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 transports are significant to this category's status as a key source, 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. The activity data used for the years 1995 until 2002 have been taken from the Energy Balances of the Federal Republic of Germany. Natural-gas-consumption data have been provided in a revised form since the 2007 report. The relevant values, along with those for natural gas inputs in coking plants and local gas works, are listed in the Energy Balance in the line "Transformation inputs of coking plants" (EB line 33). The relevant input figures for coking plants and natural gas compressor stations were provided to the Federal Environment Agency via a special evaluation of the Working Group on Energy Balances (AGEB). For the years 1998 to 2002, natural gas inputs of natural gas compressor stations are listed as such in the Energy Balance, EB line 33. Since this area is an insignificant sub-emissions area of the source category in question, the above-described Tier 1 method was used.

For the years 1990 to 1994, natural gas inputs in compressors were determined via the factor 0.005, which is linked with domestic natural gas consumption. The same method was used for the period as of 2003. The factor 0.005 has been obtained as the average of the ratios between a) the statistically documented input quantities in natural gas compressor stations for the years 1995 to 2002 and b) the relevant primary energy consumption figures.

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:

- For CO_2, we refer to the documentation in Annex 2, Chapter "CO_2 emission factors".
- The country-specific CH_4 emission factors are based, for the period 1990 to 1994, on the Federal Environment Agency study "Air Quality Control '88" ("Luftreinhaltung '88"; UBA 1989b). For the period as of 1995, updated emission factors from a Federal Environment Agency study on emissions of mobile machinery are being used (IFEU, 2004). These factors reflect the emissions standards that have been phased in gradually, since the mid-1990s, for construction-sector machinery. For 2008, the relevant value for diesel fuel is 1.8 kg/TJ (1995: 4.4 kg/TJ), while for petrol it is 26.3 kg/TJ (1995: 28.4 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"). 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:

- For CO_2, we refer to the documentation in Annex 2, 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 rates 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 rates of stationary combustion plants", of the NIR 2007.

As a result of statistical conversions in 1994/1995, the EF time series for CH_4 (for all fuels) and the EF time series for N_2O (for gasoline, construction industry) contain inconsistencies that cannot be eliminated. 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 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)*

General quality control (in accordance with Tier 1), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out. The relevant involved technical experts were unable to carry out quality assurance. The national co-ordinating agency (Single National Entity) carried out quality assurance.

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[27].

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 <u>construction-sector transports</u> were compared with those of other countries. Due to this source category's highly heterogeneous composition, however, such comparisons are extremely difficult to carry out for methane and nitrous oxide.

<u>Natural gas compressor stations</u>: The results of Chapter 3.2.6.4 apply mutatis mutandis.

3.2.10.5.5   *Source-specific recalculations (1.A.3.e)*

<u>Construction-sector transport</u>:

Changes, to both the figures taken from the eastern Energy Balances (Energy Balance line 67) and to the BAFA activity data used for military transports (see above: methodological aspects – activity rates), made it necessary to recalculate the consumption data for construction-sector transports for all years as of 1995.

<u>Natural-gas-compressor stations</u>:

The results of Chapter 3.2.6.5 apply mutatis mutandis.

Recalculations were carried out to take account of extensive methodological revision of the Energy Balances for the years 2003 to 2007.

---

[27] 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)

3.2.10.5.6   *Planned improvements (source-specific) (1.A.3.e)*

The database for calculating emissions from <u>construction-sector transports</u> is comprehensively updated within the framework of an ongoing research project.

<u>Natural-gas-compressor stations</u>: The new research project described in Chapter 3.2.6.2, aimed at updating emission factors (except for those for CO_2), will also cover gas turbines in natural gas compressor stations.

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

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
CRF 1.A.4.a (Commercial/institutional)					
All fuels	l / t	CO_2	5.19 %	4.19 %	falling
All fuels	- / t	CH_4	0.10 %	0.01 %	falling
CRF 1.A.4.b (Residential)					
All Fuels	l / t	CO_2	10.51 %	10.89 %	rising
CRF 1.A.4.c (Agriculture, forestry and fisheries)					
All Fuels	l / t	CO_2	0.89 %	0.66 %	falling

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	CS	CS	CS	CS	CS
CRF 1.A.4.a (Commercial, institutional),										
EF uncertainties in % - liquid fuels		-70 +100	-	-	-	-70 +100				
EF uncertainties in % - gaseous fuels		-70 +100	-	-	-	-40 +60				
EF uncertainties in % - solid fuels		-70 +100	-	-	-	-50 +80				
CRF 1.A.4.b Residential										
EF uncertainties in % - liquid fuels		-30 +50	-	-	-	-30 +50				
EF uncertainties in % - gaseous fuels		-15 +23	-	-	-	-45 +70				
EF uncertainties in % - solid fuels		-60 +90	-	-	-	-15-60 +23-85				
CRF 1.A.4.c Agriculture and forestry										
EF uncertainties in % - liquid fuels		-70 +100	-	-	-	-70 +100				
EF uncertainties in % - gaseous fuels		-70 +100	-	-	-	-40 +60				
EF uncertainties in % - solid fuels		-70 +100	-	-	-	-40-60 +60-100				
Distribution of uncertainties		L	-	-	-	L				
EF-determination method		Tier 2	-	-	-	Tier 2				

All of the uncertainties given in the Table should be understood solely as guideline values. The uncertainties based on the emissions database have been determined separately for each fuel. The uncertainties as used in calculation of the inventory uncertainty are more highly detailed.

The source category 1.A.4 *Other* is a key source 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 source of CH_4 emissions, in terms of trend.

Source category 1.A.4 comprises combustion systems in the areas Residential, Commercial and Institutional (commerce/trade/services) 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. Such emissions cannot be reported in 1.A.4, due to differences, in this area, in the breakdown of basic energy statistics. Such emissions are included instead in transport emissions (1.A.3).

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/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. Firewood consumption in the source categories commercial and institutional is determined via experts' assessments that are based on various publications of the German Institute for Economic Research (DIW; their "Wochenberichte"), studies of the Forsa institute and individual publications. 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") is currently underway with the aim of facilitating more precise future determination of wood-fuel activity rates in the commercial and institutional sector. 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)

The **activity rates** 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.

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, 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 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 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 (IPPC 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. These 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 39 shows the sectoral emission factors determined.

Table 39:   Sectoral emission factors for combustion systems in the residential and commercial/institutional sectors for reference year 2005

Households	**CH$_4$ [kg/TJ]**	**N$_2$O [kg/TJ]**
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
Commercial and institutional, residential (commerce/trade/services - small consumers)		
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 40:   Sectoral emission factors for mobile sources of the residential and agricultural sectors

Mobile sources of households (residential)	CH$_4$ [kg/TJ]	N$_2$O [kg/TJ]
Diesel fuel	-	-
Petrol	37.0	3.7
Agricultural transport		
Diesel fuel	5.0	1.0
Petrol	37.0	3.7

3.2.11.3   Uncertainties and time-series consistency (1.A.4)

Calculating reliable emission factors in this installation sector is possible only via a complex procedure. Apart from emission figures, it is also necessary to obtain other information; for example, it is necessary to 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 the furnace design) the researchers only had recourse to a few results from individual measurements on selected installations. Gaps in the data were closed via transfer 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 experts' assessment 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 estimate for N_2O and CH_4:

- 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/stop emissions. During start-up/shutdown procedures, some partly unburned CH_4 is emitted from natural gas. These 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.

Annex 2, Chapter 13.6 in the NIR 2007 describes the method used to determine the uncertainties for the **activity rates**.

To date, default uncertainties pursuant to IPCC have been used for *mobile residential sources* and *agricultural transports*.

3.2.11.4   Source-specific quality assurance / control and verification (1.A.4)

General quality control (for stationary EF, in accordance with Tier 1; for all others, in accordance with Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, has 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[28].

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 41.

---

[28] 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 41:   Emissions calculation with country-specific Tier 2/3 emission factors and with the Tier 1 default emission factors pursuant to (IPCC 2006)

	CH4 [t]				N2O [t]			
	Residential		Commercial/ institutional		Residential		Commercial/ institutional	
Emission factors	Tier 1 default	Strusch-ka 2008	Tier 1 default	Strusch-ka 2008	Tier 1 default	Strusch-ka 2008	Tier 1 default	Strusch-ka 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)

Recalculation of the CH_4 and N_2O emission factors for *stationary combustion systems* was carried out last year. Those emission factors were then adopted, without change, for the 2009 report.

The **activity data** as of 2003 had to be recalculated to take account of revision of the Energy Balances. That, in turn, led to considerable recalculations, especially for natural gas:

Year	2003	2004	2005	2006
Recalculation	-7.7 million t CO_2	-12.9 million t CO_2	+0.07 million t CO_2	- 5 million t CO_2

The recalculations in 2007, amounting to 0.2 million t CO_2, reflect the provisional nature of the evaluation tables used for the last report. Updating of net calorific values for liquid and solid fuels led to minor recalculations as of 2000.

In the area of *mobile residential sources*, recalculations were confined to the year 2007, for which activity data were taken from line 66 of latest available Energy Balance. In the area of *agricultural transports*, activity data were adjusted for all years as of 1995, to take account of last year's adjustment of the consumption data, listed in Energy Balance line 67, for diesel fuel and petrol, and to take account of the now-available Energy Balance 2007.

3.2.11.6   Planned improvements (source-specific) (1.A.4)

No improvements are planned at present.

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

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
All fuels	l / t	CO_2	0.96 %	0.14 %	falling

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	NMVOC	VOC	SO_2
Emission factor (EF)	NO	CS	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties gaseous fuels in %		-70 / +100				-30 / +50				
EF uncertainties liquid fuels in %	± 5%	-30 / +50				-30 / +50				
EF uncertainties solid fuels in %		-70 / +100				-70 / +100				
Distribution of uncertainties	N	L				L				
EF-determination method	CS	CS				CS				

The source category "*Other*" is a key source of CO_2 emissions in terms of both emissions level and trend.

3.2.12.2   Methodological issues (1.A.5)

Activity rates

The Energy Balance of the Federal Republic of Germany (AGEB) provides the basis for the activity rates used. Since the Energy Balance does not provide separate listings of military agencies' final energy consumption as of 1995 – and includes this consumption 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, 2009), which has reported the "Energy input for heat production in the German Federal Armed Forces", by fuels and for 2000-2008, to the Federal Environment Agency. These 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 is being reported for the first time.

Until 1994, military fuel-consumption (diesel fuel and petrol) and aircraft-fuel-consumption (jet kerosene) 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 Statistics for the Federal Republic of Germany, published by the Federal Office of Economics and Export Control (BAFA), are used (BAFA, 2009). 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.

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 that described for source category 1.A.4. Table 42 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**, we refer to the documentation in Annex Chapter 18.7 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.

Table 42:   Sectoral emission factors for the military sector

Military	CH₄	N₂O
	[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
Heavy-grade turbine fuel (jet kerosene)	0.5	2.0
Avgas	8.2	2.3

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 rates were determined.

3.2.12.4   Source-specific quality assurance / control and verification (1.A.5)

General quality control (for stationary AR, in accordance with Tier 1; for all others, in accordance with Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out. Only for the stationary activity rates were the relevant involved technical experts unable to carry out complete quality assurance. The national co-ordinating agency (Single National Entity) carried out quality assurance.

3.2.12.5   Source-specific recalculations (1.A.5)

In the **stationary sector (1.A.5.a "Stationary")**, recalculations of the activity rates for solid, gaseous and liquid fuels were carried out to take account of updated Energy Balances of the AGEB as of 2003. The emission factors for the years 2005 through 2007, from the aforementioned research project (Struschka, 2008), were used for the first time in the present report. Previously, emission factors were reported that had been determined for the base year 1995. The factors for the time series between the base years 1995 and 2005 were obtained via linear interpolation. The net calorific values as of 2000 were recalculated using the relevant values of the Working Group on Energy Balances (AGEB).

For the **military transport sector (1.A.5.b "Mobile")**, recalculations were carried out to take account of individual-year corrections in jet-kerosene consumption data and of first-time inclusion of avgas consumption and of the resulting emissions.

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, 2008).

In the CSE, source category 1.A.5 includes, under stationary sources, heat production of military agences; 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 nitrous oxide.

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 43 presents the scheme for source category allocation and the relevant calculation methods (Table 44).

Table 43:   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 rate covers 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 an activity rate 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 44 presents calculated values for 2008 activity data, along with information regarding the origin of the data.

Table 44:   Calculation of methane emissions from coal mining for 2008

			Activity data [Mt]	CH$_4$ emissions [Gg]
1.B.1.a. Coal mining			**192.37** (= 1.B.1.a.i + 1.B.1.a.ii)	(= 1.B.1.a.i + 1.B.1.a.ii) = 176.34+1.93 **= 178.27**
	i.	**Underground mining**	**17.077**[29] Hard-coal production 1)	**= mining and follow-up mining-related activities** = 166.50 + 9.84 **= 176.34**
		Mining activities		= AR * EF = 17.077 * 9.75 **= 166.50**
		Follow-up mining activities		**= 9.84**
	ii.	**Open-pit mining**	**175.3** Lignite mining 1)	**= mining activities** **= 1.93**
		Mining activities		= AR * EF = 175.3 * 0.011 **= 1.93**
		Follow-up mining activities		(included in 1.B.1.a.ii) IE
1.B.1.b. Coal transformation – processing			**14.18** Total for processed products 2) 1)	$AR_{H\text{-coal production}} * EF_{H\text{-coal production}} + AR_{lignite\ production} * EF_{lignite\ production}$ = 8.25 * 0.049 + 5.93 * 0 **= 0.40**
1.B.1.c. Other				**= Decommissioned coal mines** **= 4.8**
		Decommissioned coal mines	**NO**	Potential emissions, minus gas usage **= 4.8**

1)   pursuant to STATISTIK DER KOHLENWIRTSCHAFT (2008)

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   Allgemeine Source category description Kohlenbergbau (1.B.1.a)

CRF 1.B.1.a					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Solid fuels	l / t	CH$_4$	1.49 %	0.39 %	falling

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	NO	CS	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %		-								
Distribution of uncertainties		-								
EF-determination method		T2								

The source category "Coal mining and handling" is a key source of CH$_4$ emissions in terms of both 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

---

[29] Not including small mines

decomissioned hard-coal mines (coal-mine methane, CMM) are listed in source category 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 7 mines (all closed-pit), while lignite is mined in 4 coal fields, primarily with the open-pit method (12 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.

Hard-coal production in 2008 amounted to some 17 million t of marketable production. Lignite production in 2007 totalled 175 million t (STATISTIK DER KOHLENWIRTSCHAFT, 2008). As a result, hard-coal production decreased by about 19 % from the previous year, while lignite production decreased by about 2.8 %.

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, 2008). Expert review is carried out by the competent state supervisory authority (the mining authority – Bergamt).

An implied emission factor (IEF) of 9.75 kg/t (2008) 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. The emission factor of 0.576 kg/t has been taken from an FHG ISI study (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 rate (crude lignite) has been taken from the STATISTIK DER KOHLENWIRTSCHAFT (2008). According to the DEBRIV German lignite-industry association (Deutscher Braunkohlen-Industrie-Verein e.V; DEBRIV 2004), an average emission factor of 0.015 m³ 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 m³ 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 rate 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, 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 rates, 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 carry out quality control and quality assurance (i.e. for it to be 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.

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 45. 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 45:   Emission factors for CH_4 from coal mining, for 2008

Emission factors	Hard coal		Lignite	
	EF m^3 CH$_4$/t	EF kg/t	EF m^3 CH$_4$/t	EF kg/t
CH$_4$ from extraction	22.23	14.89	0.016	0.011
CH$_4$ from extraction, minus pit gas used	14.55	9.75	-	-
CH$_4$ from storage	0.87	0.58	-	-
CH$_4$ from mining (extraction and storage, minus pit-gas used)	15.42	10.33	0.016	0.011

The IPCC Reference Manual (1996b) does not recommend any specific emission-factor levels for open-pit lignite mining.

General quality control and source-specific quality control (Tier 1 and Tier 2) in conformance with the requirements of the QSE handbook and its associated applicable documents, have not been carried out completely.

In the framework of verification for the 2005 report, various data sources for activity rates 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)*

Recalculations of decimal-place figures (i.e. for numbers after the decimal point) were carried out.

3.3.1.1.6   *Planned improvements (source-specific) (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.b)*

CRF 1.B.1.b

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
	- / -				

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NO	CS	NO	NO	NO	NO	NO	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method		CS								

The source category "*Solid fuel transformation*" is not a key source.

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 rates from the STATISTIK DER KOHLENWIRTSCHAFT (2008) 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.

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:

Emissions [Gg CH_4] =

EF [m^3 CH_4 /t] * $AR_{processing\ product}$ * conversion factor [Gg/$10^6 m^3$]

The activity rate for hard-coal-coke production has been taken from the STATISTIK DER KOHLENWIRTSCHAFT (2008).

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)*

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has not been carried out completely.

In consideration of emission factors, the IPCC conversion factor of 0.67 Gg/10^6m³ at 20°C and 1 atmosphere (IPCC et al; 1997, 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 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 rates, 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 carry out quality control and quality assurance (i.e. for it to be 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.

In consideration of emission factors, the IPCC conversion factor of 0.67 Gg/10^6m³ at 20°C and 1 atmosphere (IPCC et al; 1997, 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 Nm³ into m³.

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 Nm³/m³**

3.3.1.2.5   *Source-specific recalculations (1.B.1.b)*

No recalculations are required.

3.3.1.2.6   *Planned improvements (source-specific) (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)

CRF 1.B.1.c

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
Solid Fuels	- / t	CH_4	0.15 %	0.01 %	falling

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NO	CS	NO	NO	NO	NO	NO	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method		CS								

The source category "*Other*" is a key source of CH_4 emissions in terms of trend.

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 $AR_{CMM\ collection}$ increased from 1.429 million m³ in 1998 to 298 million m³ in 2008. The reason for the increase in pit-gas use, over the previous year, is that the added gas quantity in 2007 has been allocated primarily to the decommissioned-mine sector.

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.

Pit gas (CH$_4$) emitted and used as fuel
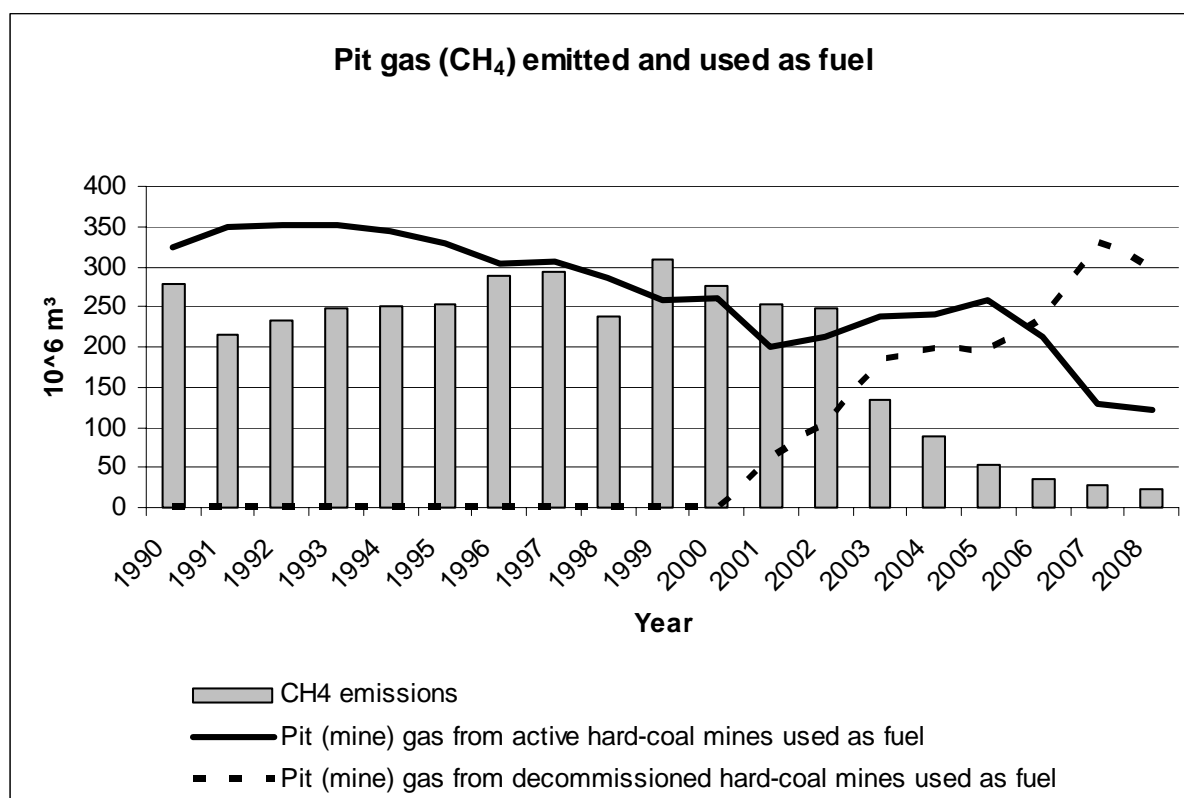
Figure 24: Comparison of quantities of pit-gas CH$_4$ that are emitted with those that are used as fuel

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 offset).

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, 1997, 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 amounts 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 quantities of methane used both originate from reliable sources and are consistent throughout.

3.3.1.3.4   *Source-specific quality assurance / control and verification (1.B.1.c)*

Due to a lack of relevant specialised staff, it has not yet been possible to carry out quality control and quality assurance (i.e. for it to be 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.

In consideration of emissions, it must be noted that the IPCC conversion factor is 0.67 Gg/10^6 m^3 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 Nm³ into m³.

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). Partial use of by-product methane has been in progress since 1998. Such use led to a considerable reduction of methane emissions in source category 1.B.1.c by 2008.

The listed emissions quantity consists of a highly uncertain estimate of total emissions from decommissioned mines (experts' assessment: $\pm$ 50 %, source: Deutsche Montan Technologie GmbH, DMT 2005), minus the quantity of methane used.

3.3.1.3.6   *Planned improvements (source-specific) (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 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.

3.3.2   *Oil and natural gas (1.B.2)*

The overarching category 1.B.2 comprises a total of 13 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.

In efforts to improve the emission factors in source categories 1.B.2.a.i, 1.B.2.a.ii, 1B.2.b.iv, 1.B.2.c.ii and 1.B.2.c.iii, both quantitatively and qualitatively, a research project of Müller-BBM[30] , conducted in 2009 (FKZ 360 16 012), showed that use of emission factors of other reporting countries (which use had previously been considered) "could by no means be recommended" – since, so the project, such factors are not applicable to the circumstances prevailing in Germany. For this reason, the default values from the IPCC Guidelines are used.

3.3.2.1   Recalculations and time-series consistency (1.B.2 all)

Numerous recalculations have been carried out, to take account of extensive improvements, updating and corrections, as the following tables show:

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.

Table 46:   Recalculations for CO_2 in CRF 1.B.2

CO2 emissions						
CO_2 emissions						
	Units	**1990**	**1995**	**2000**	**2005**	**2007**
1.B.2.a.i						
2009 submission	[Gg]	0.001140	0.001140	0.001140	0.002185	0.001045
2010 submission	[Gg]	0.000006	0.000006	0.000006	0.000011	0.000005
Difference	**[Gg]**	**0.001134**	**0.001134**	**0.001134**	**0.002174**	**0.001040**
Reason	Units error in conversion of the EF					
1.B.2.a.ii						
2009 submission	[Gg]	NE	NE	NE	NE	NE
2010 submission	[Gg]	1.129	0.927	0.978	1.119	1.070
Difference	**[Gg]**	**1.129**	**0.927**	**0.978**	**1.119**	**1.070**
Reason	Direct emissions from petroleum extraction are now taken into account					
1.B.2.b.ii						
2009 submission	[Gg]	0.0029	0.0036	0.0038	0.0037	0.0037
2010 submission	[Gg]	1,422.4	1,782.1	1,872.6	1,753.6	1,586.8
Difference	**[Gg]**	**1,422.42**	**1,782.08**	**1,872.57**	**1,753.59**	**1,586.83**
Reason	Direct emissions from acid-gas processing are now taken into account					
1.B.2.c						
2009 submission	[Gg]	NE	NE	NE	NE	NE
2010 submission	[Gg]	18.930	23.421	24.581	23.092	20.912
Difference	**[Gg]**	**18.930**	**23.421**	**24.581**	**23.092**	**20.912**
Reason	New EF for flaring					
1.B.2 (total)						
2009 submission	[Gg]	0.06	0.06	0.06	0.07	0.07
2010 submission	[Gg]	1,442.53	1,806.48	1,898.19	1,777.87	1,608.87
Difference	**[Gg]**	**1,442.48**	**1,806.42**	**1,898.13**	**1,777.80**	**1,608.81**

Table 47:   Recalculations for CH_4 in CRF 1.B.2

	Units	1990	1995	2000	2005	2007
CH_4 emissions						
1.B.2.a.i						
2009 submission	[Gg]	NE	NE	NE	NE	NE
2010 submission	[Gg]	0.000768	0.000768	0.000768	0.001472	0.000704
Difference	**[Gg]**	**0.000768**	**0.000768**	**0.000768**	**0.001472**	**0.000704**
Reason	New EF					
1.B.2.a.ii						
2009 submission	[Gg]	4.40	3.23	3.44	3.93	3.76
2010 submission	[Gg]	10.25	8.04	8.51	9.73	9.30
Difference	**[Gg]**	**5.86**	**4.80**	**5.07**	**5.80**	**5.55**
Reason	Direct emissions from petroleum extraction are now taken into account					
1.B.2.a.iv						
2009 submission	[Gg]	6.39	3.59	2.71	2.27	2.21
2010 submission	[Gg]	8.00	5.26	4.52	4.12	4.11
Difference	**[Gg]**	**1.61**	**1.68**	**1.81**	**1.85**	**1.90**
Reason	Change in calculation of activity data					
1.B.2.b.ii						
2009 submission	[Gg]	57.43	54.32	56.75	53.14	48.09
2010 submission	[Gg]	57.47	54.37	56.80	53.19	48.13
Difference	**[Gg]**	**0.04**	**0.05**	**0.05**	**0.05**	**0.04**
Reason	Direct emissions from natural gas extraction are now taken into account					
1.B.2.b.iii						
2009 submission	[Gg]	29.56	35.72	37.76	40.05	40.05
2010 submission	[Gg]	29.56	35.78	37.67	41.30	40.39
Difference	**[Gg]**	**0.00**	**0.06**	**-0.09**	**1.25**	**0.34**
Reason	Change in calculation of activity data					
1.B.2.b.iv						
2009 submission	[Gg]	199.57	208.47	191.34	165.87	158.30
2010 submission	[Gg]	199.57	204.31	192.28	190.90	190.13
Difference	**[Gg]**	**0.00**	**-4.16**	**0.94**	**25.04**	**31.83**
Reason	Change in calculation of activity data					
1.B.2.b.v						
2009 submission	[Gg]	36.37	53.74	58.46	66.95	66.95
2010 submission	[Gg]	36.37	53.74	58.47	56.92	53.25
Difference	**[Gg]**	**0.00**	**0.00**	**0.01**	**-10.03**	**-13.69**
Reason	Change in calculation of activity data					
1.B.2.c						
2009 submission	[Gg]	NE	NE	NE	NE	NE
2010 submission	[Gg]	0.014	0.017	0.017	0.016	0.015
Difference	**[Gg]**	**0.014**	**0.017**	**0.017**	**0.016**	**0.015**
Reason	New EF for flaring					
1.B.2 (total)						
2009 submission	[Gg]	356.28	367.29	355.07	335.35	322.26
2010 submission	[Gg]	363.80	369.73	362.88	359.33	348.25
Difference	**[Gg]**	**7.52**	**2.44**	**7.81**	**23.98**	**25.99**

3.3.2.2   Planned improvements (1.B.2, all)

The results produced by a research project of Müller-BBM (2009) 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.

An effort is to be made to calculate emissions for the other relevant source categories in accordance with Tier 2.

3.3.2.3   Oil (1.B.2.a)

CRF 1.B.2.a.i					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

3.3.2.3.1   Oil, exploration (1.B.2.a.i)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	D	D	NO	NO	NO	NO	NO	NO	CS	NO
EF uncertainties in %	20	20								
Distribution of uncertainties	N	N								
EF-determination method										

The source category "*Oil, exploration*" is not a key source.

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 2008, 12 successful drilling operations, with a total drilling distance of 57,480 m, were carried out. (WEG, 2008: Table p. 57, summary of drilling success). 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 from strikes (successful drilling operations) reported in the annual report of the Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V. (WEG) German oil and gas industry association are calculated on the basis of the default factor from the IPCC Guidance (1996) for CO_2, 0.48 kg / drilling operation, and the default factor for methane, 64 kg / drilling operation.

3.3.2.3.1.3   Uncertainties and time-series consistency (1.B.2.a.i)

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, + 25 % to + 50 % (IPCC GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.3.2.3.1.4   Source-specific quality assurance / control and verification (1.B.2.a.i)

Quality control and quality assurance (pursuant to Tier 1 & 2), 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. Only the UK has used existing data to develop country-specific emission factors that are not comparable to the default factors.

3.3.2.3.1.5   Source-specific recalculations (1.B.2.a.i)

On the basis of a pertinent research report (Inventory improvement 2008; FKZ 360 16 012), it was possible to show that the default factors may be used for Germany. As a result, the notation keys used to date have been replaced with values.

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.

3.3.2.3.1.6   Planned improvements (source-specific) (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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	NO	NO	NO	NO	NO	NO	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

Pursuant to the classification for the aggregated source category 1.B.2.a "*Oil*", the source category 1.B.2.a.ii "*Oil, production*" is not a key source.

The emissions of this source category are determined in accordance with the Tier 2 method.

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, 2008), German petroleum extraction in 2008 amounted to some 3.054 million tonnes.

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 WEG report (2008) (CO_2, about 100 kg/t; CH_4, about 0.14 kg/t) include both emissions from external energy production and actual emissions from extraction. Emissions from external energy production are not part of the defined focus of reporting in this source category.

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)

The Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry association (WEG) does not break down emissions by energy production and extraction. As

a result, for this source category the default emission factors for CO_2 (0.313 kg/t) and CH_4 (1.624 kg/t) from the 1996 IPCC Guidelines are used.

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 rate is given as 5 to 10 %. The figures are based on estimates of WEG experts and national experts.

The default emission factors have an uncertainty of + 25 % to + 50 % (IPCC-GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.3.2.3.2.4   *Source-specific quality assurance / control and verification (1.B.2.a.ii)*

Quality control and quality assurance (pursuant to Tier 1 & 2), 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.

Analysis of the inventories of other countries (Müller-BBM, 2009a) has shown that, because certain information is lacking and there are overly large discrepancies in the values for the relevant criteria, the inventories' figures neither are comparable to those of the German inventory not can be adopted for the German inventory.

3.3.2.3.2.5   *Source-specific recalculations (1.B.2.a.ii)*

Recalculations had to be carried out as a result of a transfer error in the area of CO_2 emissions. The notation key "NE" was then replaced with values at the relevant locations.

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.

3.3.2.3.2.6   *Planned improvements (source-specific) (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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	D	D	NO	NO	NO	NO	NO	NO	CS	NO
EF uncertainties in %	20	20								
Distribution of uncertainties	N	N								
EF-determination method										

Pursuant to the classification for the aggregated source category 1.B.2.a "*Oil*", the source category 1.B.2.a.iii "*Oil, transport*" is not a key source.

The emissions of this source category are determined in accordance with the Tier 1 method.

3.3.2.3.3.1   *Source category description (1.B.2.a.iii)*

This source category's emissions are produced in activities of logistics companies and of operators of pipelines and pipeline networks, including pertinent facilities for storage of relevant materials – i.e. crude oil and intermediate petroleum products. 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 2008, the Federal Republic of Germany's network of long-distance pipelines for crude-oil imports had a total length of 1,861 km and a throughput of about 104 million tonnes of crude oil (MWV, 2009, 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).

The NIR 2008 provides a list of long-distance pipelines in Germany.

Only about 0.1 % of all transported crude oil is transported by tanker ships on inland waterways (190,400 t in 2008, cf. *FEDERAL STATISTICAL OFFICE* Fachserie 8, Reihe 4, 06/2009). As a result, this area of crude-oil logistics would seem to play a negligible role.

3.3.2.3.3.2   *Methodological issues (1.B.2.a.iii)*

Due to a lack of country-specific emission factors in the area of pipeline oil transports, the default emission factors from the IPCC Good Practice Guidance (2000: p 2.87) will initially be used for the Tier 1 approach:

EF CH_4 – 0.00675 kg/t
EF CO_2 – 0.000613 kg/t

Experts have estimated the emission factor for NMVOC to be 0.06075 kg/t.

General information relative to fulfillment of good inventory practice, pursuant to the Guidelines, is provided in the section for 1.B.2 (cf. NIR 2008, Chapter 3.2.2.1, p. 205 ff).

3.3.2.3.3.3   *Uncertainties and time-series consistency (1.B.2.a.iii)*

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, + 25 % to + 50 % (IPCC GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.3.2.3.3.4   *Source-specific quality assurance / control and verification (1.B.2.a.iii)*

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Analysis of the inventories of other countries (Müller-BBM, 2009a) has shown that, because certain information is lacking and there are overly large discrepancies in the values for the relevant criteria, the inventories' figures neither are comparable to those of the German inventory not can be adopted for the German inventory.

3.3.2.3.3.5   *Source-specific recalculations (1.B.2.a.iii)*

No recalculations are required.

3.3.2.3.3.6   *Planned improvements (source-specific) (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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	-	CS	-	-	-	-	NO	NO	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category "*Oil, refining and storage*" is not a key source.

For certain areas of the CSE database, emissions of source category 1.B.2.a.iv "*Oil, refining and storage*" are determined via the Tier-1 or Tier-3 methods.

3.3.2.3.4.1   *Source category description (1.B.2.a.iv)*

Processing

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. To some extent, intermediate petroleum products undergo further processing outside of refineries, in processing networks. Such processing takes place in state-of-the-art plants. In 2008, 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 120.4 million t in 2008. (MWV, 2009: p. 48).

Storage

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 pertinent emissions come primarily from transport and sealing systems in refineries and in non-refinery tank storage systems.

With regard to tank storage systems in refineries, interim results can be taken from the research project[31] "Aufbereitung von Daten der Emissionserklärungen gemäß 11. BimSchV; Bereich Lageranlagen" ("Processing of data from emissions declarations pursuant to the 11th Ordinance on the Execution of the Federal Immission Control Act; the area of storage systems"; Müller-BBM, FKZ 3707 42 103/01, 2009).

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

---

[31] 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", Bericht Nr. (report number) M74 244/7, UBA FKZ 3707 42 103/01, 31 p.

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)*

Processing

With regard to emissions of NMVOC and CH_4 in the area of processing, the activity rate is taken from the "Petroleum Data" ("Jahresbericht Mineralöl-Zahlen" 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 are calculated as the product of the activity rate (quantity of sulphur produced by refineries) and the estimated emission factor (IZT, 2003).

Storage

Pursuant to Müller-BBM (sub-project on storage facilities, 2009b), crude-oil-distillation capacity (in 2008, about 118 million t) is used as the activity rate 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 2008, this leads to NMVOC emissions of 16,992 t and CH_4 emissions of 1,888 t (ratio of 9:1).

General information relative to fulfillment of good inventory practice, pursuant to the Guidelines, is provided for the NIR 2008 as a whole in the section for 1.B.2 (cf. NIR 2008, Chapter 3.2.2.1).

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 %. 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, + 25 % to + 50 % (IPCC GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.3.2.3.4.4   *Source-specific quality assurance / control and verification (1.B.2.a.iv)*

Quality control and quality assurance (pursuant to Tier 1 & 2), 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 (loc. cit.: 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. No further verification results are available at present.

A research project is to be commissioned for the purpose of verifying the estimated emission factor for NMVOC.

3.3.2.3.4.5   Source-specific recalculations (1.B.2.a.iv)

Recalculations were carried out in the area of CH_4 and NMVOC emissions to take account of the emissions from storage previously reported under 1.B.2.a.vi and of new findings from the research project in accordance with Müller-BBM (sub-project on storage facilities, 2009b).

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.

3.3.2.3.4.6   Planned improvements (source-specific) (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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	-	CS	-	-	-	-	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

Pursuant to the classification for the aggregated source category 1.B.2.a "*Oil*", the source category 1.B.2.a.v "*Oil, distribution of oil products*" is not a key source.

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.

Emissions of the source category are determined, in the emissions database, pursuant to the Tier-2 or Tier-3 method (cf. source category 1.B.2.a.iii, Chapter 3.3.2.3.3.1).

3.3.2.3.5.1   Source category description (1.B.2.a.v)

Distribution

Petroleum products are transported via ships, product pipelines, railway tank cars and tanker trucks, and they are transferred from tanks to other tanks. Germany's domestic sales of petroleum products totalled 114,043,000 t in 2008 (MWV, 2009, p. 51)) . Domestic sales of gasoline, pursuant to MWV (op. cit.), amounted to 20,561,000 t in 2008.

Total NMVOC emissions from gasoline distribution (1.B.2.a.v) amount to about 21,000 t (in 2000, they amounted to 41,000 t) (cf. CSE and UBA text 2004b[32] p.1). They come primarily from fugitive emissions released during transfer (filling/unloading) and from losses from tanks (tank breathing losses). The decrease in fugitive emissions is the result of implementation of the *Technical Instructions on Air Quality Control* (TA-Luft 2002) and of the 20th and 21st Ordinance on the Execution of the Federal Immission Control Act (20. and 21. BImSchV), involving introduction of vapour recovery systems. It is also the result of reduced petrol consumption.

---

[32] UBA 2004b: "VOC-Minderungspotential beim Transport und Umschlag von Mineralölprodukten mittels Kesselwagen" (VOC-reduction potential in connection with transport and transfer of petroleum products via tank cars", UBA-Forschungsbericht (UBA research report) 202 44 372, UBA text 12/04, UBA-FB 000581

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 t NMVOC and 4 t CH_4 per year (a total of 40 t/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.

3.3.2.3.5.2   Methodological issues (1.B.2.a.v)

Distribution

Currently, the inventory covers emissions relative to distribution of one petroleum product (petrol).

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 rates for NMVOC and methane emissions.

The CH_4 emission factor, 0.105 kg/t, and the NMVOC emission factor, 1.050 kg/t, were derived from a VOC emission factor (the CH_4 emission factor is equivalent to 10 % of the emission factor for VOC) and continually updated in keeping with improvements in emissions control technology. The original emission factor for VOC is not sufficiently well substantiated.

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 tanker trucks.

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 tanker trucks – 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 m³ 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/m³, exhaust concentration levels can be reduced by 99.5 %, to less than 5 g/m³. 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).

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, + 25 % to + 50 % (IPCC GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.3.2.3.5.4   Source-specific quality assurance / control and verification (1.B.2.a.v)

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The results of quality assurance are taken into account in determination and documentation of emissions.

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)

Recalculations were carried out in the area of NMVOC emissions to take account of the emissions from storage previously reported under 1.B.2.a.vi and of new findings from the research project in accordance with Müller-BBM (sub-project on storage facilities, 2009b).

3.3.2.3.5.6   Planned improvements (source-specific) (1.B.2.a.v)

A research project will be carried out for the purpose of updating the database on cleaning of railway tank cars (UBA 2004b), expanding it to include other cleaning areas, in keeping with the logistics approach (cf. NIR 2008) and determining the emissions in the pertinent added areas.

3.3.2.3.6   Oil, other (1.B.2.a.vi)

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	-	CS	-	-	-	-	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

Pursuant to the classification for the aggregated source category 1.B.2.a "*Oil*", the source category 1.B.2.a.vi "*Oil, other*" is not a key source.

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.

Emissions from cleaning of equipment for transporting petroleum products, which previously were reported in this source category, have been allocated to source category 1.B.2.a.v (distribution).

3.3.2.3.6.1   Source category description (1.B.2.a.vi)

Residual emissions from hydrocarbon vapour recovery systems (VRS system) have to be assigned to this source category. (Müller-BBM, 2009a)

3.3.2.3.6.2   Methodological issues (1.B.2.a.vi)

No significant interim results are available with regard to this source category.

3.3.2.3.6.3   Uncertainties and time-series consistency (1.B.2.a.vi)

No significant interim results are available with regard to this source category.

3.3.2.3.6.4   Source-specific quality assurance / control and verification (1.B.2.a.vi)

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

No significant interim results are available with regard to this source category.

3.3.2.3.6.5   Source-specific recalculations (1.B.2.a.vi)

No significant interim results are available with regard to this source category. Emissions from cleaning of equipment for transporting petroleum products, which were previously reported in this source category, have been assigned to source category 1.B.2.a.v., while emissions from storage have been assigned to source category 1.B.2.a.iv..

3.3.2.3.6.6   Planned improvements (source-specific) (1.B.2.a.vi)

For emissions determination, plant-specific considerations have to be applied. In some cases, additional estimations may be required for purposes of extrapolation. Such considerations and possible estimations will be the subject of an additional research project.

See 1.B.2 (Chapter 0) regarding additional planned improvements.

3.3.2.4   Natural gas (1.B.2.b)

CRF 1.B.2.b					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Natural gas	l / t	CH_4	0.55 %	0.72 %	rising

The source category *Natural gas* is a key source of CH_4 emissions from natural gas in terms of both emissions level and trend.

3.3.2.4.1   Natural gas, exploration (1.B.2.b.i)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	IE	IE	-	-	-	-	NO	NO	IE	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category *Natural gas, exploration* is a key source 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*.

Source category 1.B.2.b.i is processed 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.

3.3.2.4.1.1   Source category description (1.B.2.b.i)

For a description of the source category, see 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)

See 1.B.2.a.i for an explanation of source-specific quality assurance / control and verification.

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.4.1.5   Source-specific recalculations (1.B.2.b.i)

No recalculations are required.

3.3.2.4.1.6   Planned improvements (source-specific) (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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	-	-	-	-	NO	CS	CS	CS
EF uncertainties in %	20	20								
Distribution of uncertainties	N	N								
EF-determination method	CS	CS								

The source category *Natural gas, production and processing* is a key source 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).

The emissions of this source category are currently determined in accordance with the Tier-2 method.

3.3.2.4.2.1   Source category description (1.B.2.b.ii)

The emissions in this source category consist of emissions from the following activities: extraction, pre-treatment and processing. In 2008, a total of 15.5 billion m³ of natural gas were extracted in Germany (WEG 2008, p. 44, 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[33], 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

---

[33] WEG 2008a: Erdgas-Erdöl, Entstehung-Suche-Förderung, Hannover, 34 p.

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 amounts to about 1.03 million tonnes per year in Germany (WEG, 2008, p. 51).

3.3.2.4.2.2   Methodological issues (1.B.2.b.ii)

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, and they have been continually used.

For 1.B.2.b.ii, an emission factor of 62 kg/TJ is used. The IPCC Guidelines (1996b) give a default value for the emission factor of 58 to 111 kg/TJ (cf. also SCHNEIDER-FRESENIUS et al., 1989); that value applies for the entire source category, however. A comparison with the summed German emission factors converted using the lower net calorific value of natural gas (35.7 MJ/Nm³) shows good agreement. The country-specific determination produced an overall emission factor that lies within the lower range of the spread for the IPCC default value.

The country-specific emission factor of 27 kg/TJ for natural-gas extraction has not been adequately substantiated to date.

For purposes of determination of CO_2 and CH_4 emissions from natural gas extraction, the relevant default emission factors are used: 0.0026 t/m³ for CH_4 and 0.000095 t/m³ for CO_2.

The emission factors given by the Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry association (WEG) (cf. NIR 2009: Chapter 3.2.2.3.2., Table 42) seem unsuited, because they cover the relevant complete processes (energy production, extraction, etc.).

For calculation of CO_2 and CH_4 emissions from acid-gas processing, a split factor of 0.4 is applied to the activity rate (total natural gas extraction = 15.5 billion m³). These figures are based on the WEG report on acid-gas processing (WEG, 2008b).

The CO_2 emission factor used with regard to acid-gas processing, 0.000233 Gg / 1,000 m³, has been obtained by averaging emission factors from Austria.

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 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, + 25 % to + 50 % (IPCC GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.3.2.4.2.4   Source-specific quality assurance / control and verification (1.B.2.b.ii)

Quality control and quality assurance (pursuant to Tier 1 & 2), 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.

3.3.2.4.2.5   Source-specific recalculations (1.B.2.b.ii)

Recalculations were carried out to take account of recent findings concerning the composition of natural gas and of resulting recalculation of emissions.

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.

3.3.2.4.2.6   Planned improvements (source-specific) (1.B.2.b.ii)

See 1.B.2 (Chapter 3.3.2.2) regarding planned improvements.

3.3.2.4.3   Natural gas, transmission (1.B.2.b.iii)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	-	CS	-	-	-	-	NO	CS	NO	NO
EF uncertainties in %		20								
Distribution of uncertainties		N								
EF-determination method		CS								

The source category *Natural gas, transmission* is a key source 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).

The emissions of this source category are currently determined in accordance with the Tier-2 method.

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.

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* oil and gas industry association (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, tanker trucks on roads 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 amounts 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 beginning of 2000, Germany's underground gas-storage reservoirs had a working-gas volume of over 16 billion m³. Further expansions are currently in progress (cf. WEG, 2000: p. 18).

3.3.2.4.3.2   Methodological issues (1.B.2.b.iii)

The approach used in the calculation procedures is largely equivalent to that used for source category 1.B.2.a.v. See that section (Chapter 3.3.2.3.5) for further information.

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)

See 1.B.2 for an explanation of source-specific quality assurance / control and verification.

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.4.3.5   Source-specific recalculations (1.B.2.b.iii)

Recalculations were carried out to take account of the pipeline-length recalculation carried out in the research project of Müller-BBM in 2009 (FKZ 360 16 012).

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.

3.3.2.4.3.6   Planned improvements (source-specific) (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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	-	CS	-	-	-	-	NO	CS	NO	NO
EF uncertainties in %		20								
Distribution of uncertainties		N								
EF-determination method		CS								

The source category *Natural gas, distribution* is a key source 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*.

The emissions of this source category are determined in accordance with the Tier-3 method.

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 75 % 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). The main framework data relative to such measures are summarised in the following table.

Table 48:   Gas-distribution network and emissions from it

Parameter	1990	1995	2000	2005	2008
Total length of pipeline network [km]	245,852	320,878	369,390	411,954	437,953
Total methane emissions [t]	199,567	204,309	192,281	190,904	190,878
Implied emission factor [kg/km]	811.7	636.7	520.5	463.4	435.8
Change in the emission factor with respect to the base year	0 %	22 %	36 %	43 %	46 %

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 areas. 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 network-composition trends and of relevant emission factors. 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 290 %.

Table 49:   Structure of the gas-distribution network

Gas-distribution network		Length of the distribution network			Emission factors [kg/km]		
Pressure level	**Material**	**1990 [km]**	**2008 [km]**	**Change [%]**	**1990 (city gas)**	**1990 (natural gas)**	**2008 (natural gas)**
Low pressure	Grey cast iron	17,260	1,619	91	1,480	7,990	5820
	Plastic	23,894	41,017	72	18	70	70
	Steel and ductile cast iron	119,761	159,921	34	20	643	643
Medium pressure	Plastic	43,307	169,043	290	35	67	67
	Steel and ductile cast iron	41,622	66,353	59	250	971	971
Total		**245,844**	**437,953**	**78**			

Distribution via containers

Gas in containers (small tanks, flasks) is distributed via filling plants. Filled tanks are transported via inland ships, railway tank cars and tanker trucks. Gas in containers (flasks) is also transported by customers, prior to being used (it is not transported on a unit-load basis, however). 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.

No further significant intermediate results from this year's changeover of calculation procedures are yet available for this source category (see 1.B.2).

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)

The approach used in the calculation procedures is largely equivalent to that used for source category 1.B.2.a.v. See that section for further information (Chapter 3.3.2.3.5).

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)

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.4.4.5   Source-specific recalculations (1.B.2.b.iv)

Recalculations were carried out to take account of the pipeline-length recalculation carried out in the research project of Müller-BBM in 2009 (FKZ 360 16 012).

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.

3.3.2.4.4.6   Planned improvements (source-specific) (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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	-	CS	-	-	-	-	NO	CS	NO	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category *Natural gas, other leaks* is a key source 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 2005a: Group 5: Extraction & distribution of fossil fuels and geothermal energy).

CO_2 emissions are not determined, even though the CRF-Reporter software and the CRF list that gas, since the Guidelines do not list that gas for this source category.

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 residential and commercial/institutional areas.

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 activity rates are based on results of work carried out by the Working Group on Energy Balances (AGEB). The emission factors are country-specific.

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 %. 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, + 25 % to + 50 % (IPCC GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.3.2.4.5.4   *Source-specific quality assurance / control and verification (1.B.2.b.v)*

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

3.3.2.4.5.5   *Source-specific recalculations (1.B.2.b.v)*

Recalculations for the period as of 2000 had to be carried out to take account of changes in the Energy Balance.

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.

3.3.2.4.5.6   *Planned improvements (source-specific) (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.i

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
	- / -				

The source category *Venting and flaring* is not a key source.

The source categories in the overarching group of fugitive emissions from 1.B.2.c "Venting and flaring" cover emissions either vented and flared directly into the atmosphere.

3.3.2.4.7   *Venting and flaring, oil (1.B.2.c.i)*

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	CS	-	-	-	-	-	-	CS	-
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

Pursuant to the classification of the aggregated source category 1.B.2.c "*Venting and flaring*", the source category *Venting and flaring, oil* is not a key source.

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 (1.B.2.a.iv) 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, 99 % of hydrocarbons 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 "Status of and trends in greenhouse-gas emissions in upstream processes for oil and natural gas" ("Stand und Entwicklung von Treibhausgasemissionen in den Vorketten für Erdöl und Erdgas"; Öko-Institut e.V. 2006). The emissions include flaring losses of onshore installations. Venting emissions are taken into account in 1.B.2.a.iv.

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 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, + 25 % to + 50 % (IPCC GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.3.2.4.7.4   Source-specific quality assurance / control and verification (1.B.2.c.i)

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The results of quality control were taken into account in determination and documentation of emissions.

See 1.B.2 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)

New findings made it possible to replace notation keys with emissions figures.

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   Planned improvements (source-specific) (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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	D	D	-	-	-	-	-	-	D	CS
EF uncertainties in %	25	25								
Distribution of uncertainties	N	N								
EF-determination method										

Pursuant to the classification of the aggregated source category 1.B.2.c "*Venting and flaring*", the source category *Venting and flaring, gas* is not a key source.

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 rate of 13,541,000 m³ of flared natural gas (WEG 2008, p. 49) and an emission factor of 0.140 kg / 1,000 m³, a factor which takes account of an average H_2S content of 5 volume percent.

Emissions of CO_2, CH_4 and NMVOC are determined with the help of the relevant default factors listed in the 2006 IPCC Guidelines.

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 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, + 25 % to + 50 % (IPCC GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.3.2.4.8.4   *Source-specific quality assurance / control and verification (1.B.2.c.ii)*

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out. The results of quality control were taken into account in determination and documentation of emissions.

See 1.B.2 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)*

New findings made it possible to replace notation keys with emissions figures.

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.

3.3.2.4.8.6   Planned improvements (source-specific) (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 source.

Geothermal energy is a renewable resource. Basically, it comprises two types of energy production: direct use, in which the thermal energy stored in the ground is used for heating / water heating (heat pumps transport the energy to consumers); and indirect use, in which the energy is used to produce electricity (with such applications including heat/power cogeneration (CHP) systems).

In 2008, a total of two geothermal power stations were in operation in Germany – the Landau power station, which was connected to the grid in the last third of 2007, and the Neustadt Glewe power station, which has been in operation since 1994. In all likelihood, numerous additional geothermal power stations will be commissioned in the coming years.

Significantly, operation of geothermal power stations in Germany produces no greenhouse-gas emissions. Greenhouse-gas emissions occur only in related uses, such as use of electricity – generated with natural gas, oil or coal – for the installations' thermal water pumps or peak-load units. The total quantities of electricity required by the installations' pumps are not yet known.

Thermal water circulation, which takes place both underground and above-ground, is sealed off from the air, and thus no emissions would be expected to occur during normal operation. For this reasons, the emissions are reported as "NO". On the other hand, operational disruptions, or system inspections, could enable the thermal medium to come into contact with the air, thereby enabling gases dissolved in the medium – especially H_2, CH_4, CO_2 and H_2S – to escape. Because such dissolved gases would be diluted upon coming into contact with the air, such incidents would not be expected to produce any hazardous pollutant concentrations in the environment (cf. "Environmental effects of geothermal electricity production; analysis and assessment of the small-scale and large-scale environmental effects of geothermal electricity production" ("Umwelteffekte einer geothermischen Stromerzeugung, Analyse und Bewertung der klein- und großräumigen Umwelteffekte einer geothermischen Stromerzeugung"); FKZ 205 42 110, Chapter A.2.3.5).

According to the studies carried out by the GeoForschungsZentrum Potsdam ("The Neustadt-Glewe geothermal heat plant: state and substance parameters, process models, operational experience and emissions balances; emissions balance of the Neustadt-Glewe geothermal heat plant for the 1996 operational year"), the plant's emissions of NO_x, CO and SO_2 may be assumed to be of the order of several hundreds of kilograms (middle-hundreds range), while its CO_2 emissions reach the upper-hundreds range (also kilograms). More precise studies are not yet available to the Federal Environment Agency.

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 et al, 1996b: p. 1.132f)

No **emission factors** for 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. From a geoscientific standpoint, 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). In many cases, and especially in drilling for tapping of geothermal energy near the surface, such emissions would be expected to be very low. "Blow-out preventers", which are safety devices that guard against gas releases, are now used in connection with all deep drilling. In addition, specially modified drilling fluids are used that force gases that are released into the well back into the penetrated rock layers.

To date, no **activity rates** are available to the Federal Environment Agency. The Landau power station has been fully connected to the grid only since December 2007 (Unterhaching has been connected to the district heat network since October 2007 and to the electric grid since May 2008); for this reason, data for those power stations are not yet available. Furthermore, neither the durations of operational disruptions, nor the total quantities of electricity required by pumps, are known for all power stations. For this reason, the relevant operationally related emissions cannot be calculated.

3.3.2.5.3   *Uncertainties and time-series consistency (1.B.2.d)*

Due to a lack of activity rates, no uncertainties can be determined for this source category.

No explainations of uncertainties and time-series consistency are required.

3.3.2.5.4   *Source-specific quality assurance / control und –Verifizierung (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)*

Plans call for determination of activity rates for the source category.

4   INDUSTRIAL PROCESSES (CRF SECTOR 2)

4.1   Overview (CRF Secktor 2)
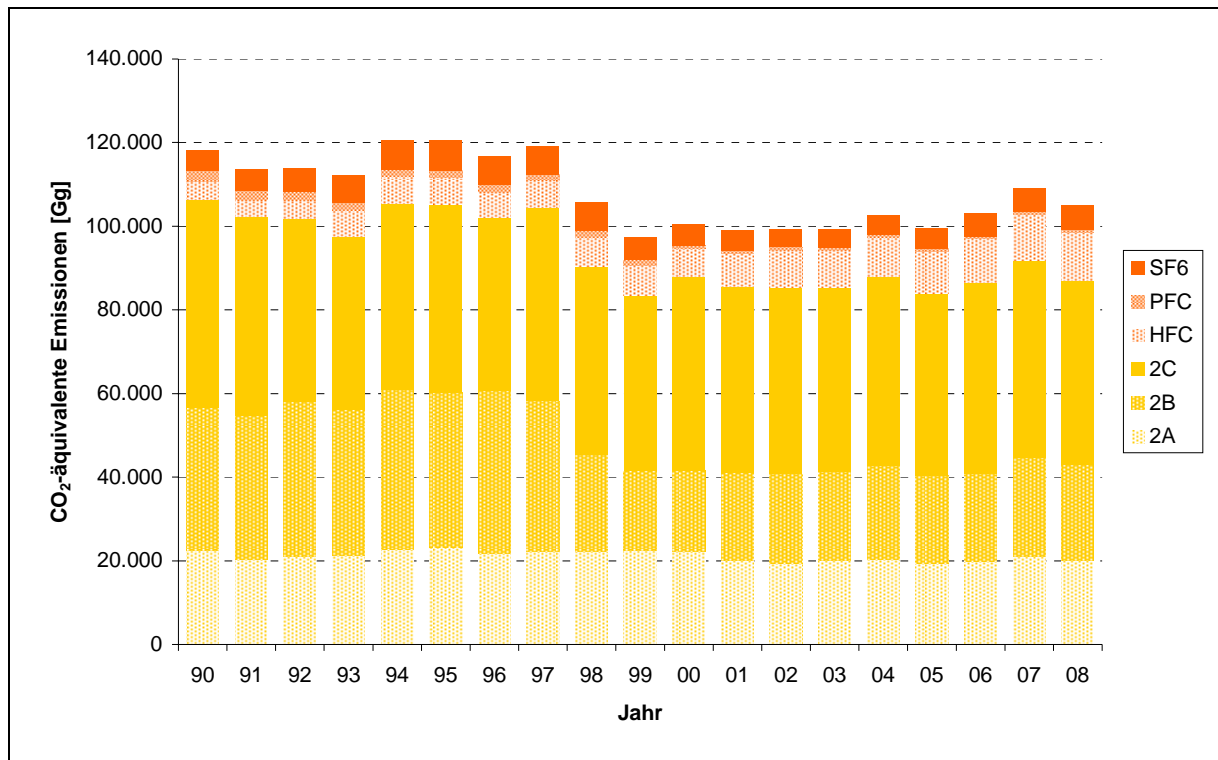
Figure 25:   Overview of greenhouse-gas emissions in CRF Sector 2 [CO_2-equivalent emissions [Gg]; Year]

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 include:

- Cement production (2.A.1),
- Lime burning (2.A.2),
- Limestone and dolomite use (2.A.3),
- Soda ash production (2.A.4),
- Bitumen roofing (2.A.5),
- Road paving with asphalt (2.A.6), and
- in Other (2.A.7), glass production and ceramics production.

4.2.1   Mineral Products: Cement production (2.A.1)

4.2.1.1   Source category description (2.A.1)

CRF 2.A.1

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008- contribution to total emissions	Trend
Zementproduktion	l / t	CO_2	1.23 %	1.40 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	NO	NO	NO	NO	NO	CS	NO	CS	CS
EF uncertainties in %	± 2	- -	- -	- -	- -	- -				
Distribution of uncertainties	N	- -	- -	- -	- -	- -				
EF-determination method	CS	- -	- -	- -	- -	- -				

The source category *"Cement production"* is a key source for CO_2 emissions in terms of both 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, 2009) clinker production in 2008 amounted to 25,366 kt[34]. 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 13,444 kt CO_2 in 2008.

Table 50:   Production and CO_2 emissions in the German cement industry

Year	Clinker production	Emission factor	Raw-material-related CO_2 emissions
	[kt/a]	[t CO_2/t]	[kt/a]
1990	28.577		15,146
1991	25.670		13,605
1992	26.983		14,301
1993	27.146		14,387
1994	28.658		15,189
1995	29.072		15,408
1996	27.669		14,664
1997	28.535		15,124
1998	29.039		15,391
1999	29.462	0.53	15,615
2000	28.494		15,102
2001	25.227		13,370
2002	23.954		12,696
2003	25.233		13,373
2004	26.281		13,929
2005	24.379		12,921
2006	24.921		13,208
2007	26.992		14,306
2008	25.366		13,444

Source: VDZ, 2009

---

[34] Provisional value.

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 consist of data published in the framework of CO_2 monitoring, and supplemented with data for plants that are not BDZ members (in part, also VDZ estimates) (VDZ, 2008).

Table 50 summarises the activity data, and the raw-material-related CO_2 emissions as determined from clinker production, for the years 1990 through 2008.

Emission factors

The emission factor used for emissions calculation, 0.53 t CO_2 / t cement clinkers, is based on 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; as raw materials, containing carbonate) in clinkers. The emission factor was confirmed in the framework of a research project (cf. also 4.2.1.6).

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:

$$CO_2 \text{ emissions} = \text{emission factor } (EF_{clinkers}) \text{ x clinker production}$$

(Table 50 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. Cf. also Chapter 4.2.1.6.

The listed uncertainties were determined via experts' 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 the surveys conducted in the framework of the project mentioned in Chapter 4.2.1.6.

4.2.1.4   Source-specific quality assurance / control and verification (2.A.1)

Quality control and quality assurance (pursuant to Tier 1 & 2), 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, VDZ and 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)

Working under commission to the Federal Environment Agency, the German Cement Works Association (VDZ) has carried out a project entitled "Emission factors for the cement industry" ("Emissionsfaktoren für die Zementindustrie")[35]. While the final report for that project was available at the time data were being entered for 2008, pertinent quality assurance had not yet been carried out and the project had not yet been formally completed. For this reason, the emission factors determined in the framework of the project were used only for verification of the factors already being used in the emissions inventory; i.e. they are not yet being used directly. A first assessment indicates that the emission factors are in good agreement and that the cement industry's emissions are being properly characterised as they currently are.

Where necessary, the CSE's listed emission factors for source category 2.A.1 are to be adjusted within the meaning of quality improvement. Such efforts are also include review of allocation of emissions to the categories of "fuel-related" and "process-related" emissions.

---

[35] The complete title is: "Provision of a quality-assured database for emissions reporting for implementation of international air-quality-control and climate-protection agreements for selected industrial sectors – sub-project 3: cement industry" ("Bereitstellung einer qualitätsgesicherten Datengrundlage für die Emissionsberichterstattung zur Umsetzung internationalen Luftreinhalte- und Klimaschutzvereinbarungen für ausgewählte Industriebranchen – Teilvorhaben 03: Zementindustrie"

4.2.2   Mineral Products: Lime production (2.A.2)

4.2.2.1   Source category description (2.A.2)

CRF 2.A.2					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Lime production	l / t	CO_2	0.50 %	0.59 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	NO	NO	NO	NO	NO	CS	NO	CS	CS
EF uncertainties in %	+5/-12[36]	--	--	--	--	--				
Distribution of uncertainties	L	--	--	--	--	--				
EF-determination method	CS	--	--	--	--	--				

The source category *"Lime production"* is a key source for CO_2 emissions in terms of both emissions level and trend.

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. In 2008, production again decreased by 0.3 % from the previous year, for economic reasons.

Table 51:   Production and CO_2 emissions in the German lime industry

Year	Lime		Dolomite lime	
	Production	**CO_2 emissions**	**Year**	**Production**
	[t]	**[Millions of t]**		**[t]**
1990	7,129,000	5.596	590,103	0.539
1991	6,303,335	4.948	591,824	0.540
1992	6,396,407	5.021	574,502	0.525
1993	6,668,149	5.234	515,167	0.470
1994	7,312,766	5.741	504,719	0.461
1995	7,411,000	5.818	543,651	0.496
1996	6,832,000	5.363	544,199	0.497
1997	6,926,000	5.437	529,928	0.484
1998	6,619,100	5.196	556,965	0.509
1999	6,629,306	5.204	479,909	0.438
2000	6,803,540	5.341	524,196	0.479
2001	6,482,592	5.089	511,234	0.467
2002	6,412,235	5.034	514,969	0.470
2003	6,549,476	5.141	435,785	0.398
2004	6,360,756	4.993	458,520	0.419
2005	6,359,666	4.992	463,174	0.423
2006	6,472,397	5.081	461,366	0.421
2007	6,691,134	5.253	458,246	0.418
2008[37]	6,672,620	5.238	453,918	0.414

Source: BV KALK, 2009

---

[36] Weighted uncertainty for the areas of lime and dolomite (for the individual uncertainties, cf. the CSE)
[37] Values for 2008 are provisional.

Dolomite-lime production, 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 %.

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 conforms to the specifications in *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC 2000, Chapter 3.1.2), and it maintains comparability with figures produced under other reporting obligations (for example, in the context of emissions trading).

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. Production amounts are determined via several different concurrent procedures; their quality is thus adequately assured (Tier 2). Most companies are also required to report lime-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 rates** used were estimated as -2.5 % and +2.5 %. These figures apply to both burnt lime and dolomite lime.

4.2.2.3   Uncertainties and time-series consistency (2.A.2)

Throughout the entire time series, the data for one small plant (one lime producer) cannot be included. As of 2008, the data for two smaller plants cannot be included. Data for one other small plant (a dolomite-lime producer) can be included only as of 2006. The non-included plants' share of production is considered small (< 0.4 % of total production), and that share has been taken into account, without any extrapolation, in uncertainties estimation.

The **uncertainties** for the **activity rates** used were estimated as -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 %. Further relevant descriptions are provided in the NIR 2007.

4.2.2.4   Source-specific quality assurance / control and verification (2.A.2)

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The estimated emissions and collected production-quantity data were compared with findings from emissions trading and with national statistical data. The emission factors used were compared with the IPCC default factors. Both reviews confirmed the method used and the country-specific emission factors.

4.2.2.5   Source-specific recalculations (2.A.2)

No recalculations are required.

4.2.2.6   Planned improvements (source-specific) (2.A.2)

A research project is currently underway to determine the extent to which the figures in the CSE can be verified with the help of emissions declarations from German lime works (including works for dolomite lime). That project is to be completed by August 2010.

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					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -	CO_2	IE	IE	-

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	IE	NO	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %	--	--	--	--	--	--				
Distribution of uncertainties	--	--	--	--	--	--				
EF-determination method	--	--	--	--	--	--				

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 the framework of a research project entitled "limestone balance" ("Kalksteinbilanz"), all use of limestone and dolomite has been systematically balanced (cf. Table 52). In addition, suitable, annually available data sources have been selected for reporting, and the relevant calculations have been integrated within the national reporting system. 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. The source category is structured in keeping with the IPCC 2006 Guidelines (Volume IPPU), which call for CO_2-emissions calculation to be carried out within the responsible source categories in each case.

The "limestone balance" project provides a substance-flow analysis, in the form of amounts balances that can be combined into time series, without any methodological discontinuities. This methodological work was carried out in a research project that drew on all of the Federal Environment Agency's available expertise (UBA 2006).

Table 52:   Limestone balance from UBA 2006

Limestone balance from UBA 2006, FKZ 20541217/02	[Millions of t]		
	1990	**1995**	**2004**
Production			
Domestic production (change in statistics from 1994 to 1995)	110.50	76.79	74.10
Imports	0.13	2.28	2.71
Exports	0.02	0.40	0.86
Total production	**110.61**	**78.66**	**75.96**
Use			
Lime industry	13.73	14.14	12.39
Cement industry	34.20	35.13	31.83
Soda ash production	2.27	1.83	1.70
Glass	0.70	0.89	0.90
Iron and steel	5.44	5.35	5.06
Sugar	0.69	0.78	0.85
Flue-gas desulphurisation, power stations	1.54	1.75	3.17
Agriculture and forestry	2.44	3.23	3.15
Water and sludge treatment	0.05	0.06	0.04
Other areas (such as construction, other construction-materials industry and chemical industry, etc.)	49.54	15.49	16.88
Total use	**110.61**	**78.66**	**75.96**

Source: UBA 2006

The natural limestone fraction found in raw materials used to make bricks was estimated. That fraction is not included in limestone production and thus has not been taken into account in the limestone balance.

Table 53:   .A.3: Secondary balance for limestone input, in raw materials, in brick production

Limestone input in raw meal [in millions of t]	1990	1995	2004
2.A.7 Production of bricks (wall bricks and roofing tiles)	1.11	1.52	1.08

Source: Calculations from the "limestone balance" project ("Kalksteinbilanz"; UBA 2006); cf. 4.2.8.

4.2.3.2   Methodological issues (2.A.3)

The prepared balance lists source categories in which limestone use leads to CO_2 emissions:

- 1.A.1.a   Limestone use in flue-gas desulphurisation in power stations
- 2.A.1.   Cement-clinker production (limestone fraction in the raw material)
- 2.A.2   Lime production (limestone input)
- 2.A.4.a   Soda ash production (limestone fraction in the raw material)
- 2.A.7   Glass production (limestone fraction in the raw material)
- 2.A.7   Ceramics – brick production (limestone fraction in the raw meal)
- 2.C.1   Iron and steel production (limestone input for raw iron and sinter)
- 2.D.2   Sugar production (limestone for caustification)

The inventory additions were updated with the revised data. The relevant methodological aspects are described in the pertinent source category chapters (cf. Chapters 3.2.6, 4.2.8, 4.4.1).

4.2.3.3 Uncertainties and time-series consistency (2.A.3)

Information regarding uncertainties for activity rates and emission factors 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 (pursuant to Tier 1) 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 2006.

The limestone-balance activity data and the emission factors are verified and updated in the relevant source categories.

The data surveys from the limestone-balance research project do not point to any persisting inventory gaps, and thus the surveys are considered adequate.

4.2.3.5 Source-specific recalculations (2.A.3)

Recalculations have been described and explained in those source categories in which limestone inputs are significant. For purposes of the present report, minor recalculations were made in the area of the iron and steel industry (Chapter 4.4.1.5).

4.2.3.6 Planned improvements (source-specific) (2.A.3)

No specific improvements are planned, but verification is carried out on an ongoing basis – for example, using data from the European Emissions Trading Scheme (ETS).

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					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NO / IE	NO	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %										
Distribution of uncertainties	-									
EF-determination method	CS									

The source category *"Soda ash production and use"* is not a key source.

In Germany, soda ash is produced only chemically. The country has 3 production facilities, all of which use the Solvay process[38]. With respect to the calcium carbonate it uses, that

---

[38] Ammonia-soda process after 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 application areas include the glass industry, metallurgy, production of detergents and cleansers, the chemical industry and exhaust-gas and wastewater treatment. In many cases, hydrogen carbonate is released in wastewater, but such releases are not climate-relevant. In addition, a significant share (8 - 25 %) of production is exported.

Emissions from soda-ash use are taken into account source-specifically and, where they are relevant, are included in the emission factors for the industries concerned (glass industry). No detailed information is available about the pertinent consumer groups and about possible releases, as CO_2, into the atmosphere.

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. Since 1995, the sum total has comprised the categories of *light soda* and *heavy soda* (production numbers – 2413 33 103, disodium carbonate in powder form, with a fill density of less than 700 g/l; and 2413 33 109, other disodium carbonate). Of these amounts, only the portions "intended for sale" ("zum Absatz bestimmt") are taken into account. This prevents double-counting, since heavy soda is produced from light soda.

Emission factor

Since the Solvay production process is neutral with regard to CO_2, an emission factor of "0" is used for production.

The amounts of coke that are converted into CO_2 during lime burning are already taken into account in the Energy Balance, without being listed separately with regard to their CO_2 emissions.

No emission factor for use of soda ash is given (IE: included elsewhere).

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 fluctuates widely, especially in the first years for which separate statistics are provided.

Because production is emissions-neutral, readers seeking further details are requested to consult the NIR 2007.

Emission factor

Since the emission factor is a substantiated "zero", there is no uncertainty.

4.2.4.4   Source-specific quality assurance / control 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.

4.2.4.5   Source-specific recalculations (2.A.4)

 No recalculations are required.

4.2.4.6   Planned improvements (source-specific) (2.A.4)

No improvements are planned at present.

4.2.5   Mineral Products: Bitumen for roofing (2.A.5)

CRF 2.A.5					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	NO	NO	NO	NO	NO	NO	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

As far as is currently known, the source category *"Bitumen for roofing"* produces no greenhouse-gas emissions and is thus not a key source.

4.2.5.1   Source category description (2.A.5)

Bitumen is used in production and laying of roof and sealing sheeting.

In 2008, some 175 million m^2 of roof and sealing sheeting were produced in Germany, and some 143 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.

Other types of emissions play only a secondary role.

4.2.5.2   Methodological issues (2.A.5)

The quantity of roof and sealing sheeting produced (**activity rate**) has been provided by the Verband der Dachbahnenindustrie roof-sheeting manufacturers association (VDD, 2009) ever since a relevant cooperation agreement was concluded. At present, no data

supplementation or extrapolation are being carried out. For purposes of international comparison, production quantities are converted into quantities of bitumen used, however.

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). 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 54:   Production and laying of roof and sealing sheeting with bitumen, and relevant activity rates and emission factors

	Area of sheeting produced or used in 2008 [millions of m^2]	**EF/ IEF [kg/ m^2]**
Production of roof and sealing sheeting with bitumen	175	NMVOC 0.00035795
Laying of roof and sealing sheeting with bitumen	143	NMVOC 0.000012 – 0.000025

4.2.5.3   Uncertainties and time-series consistency (2.A.5)

Data relative to the uncertainty of the new data of the VDD are not yet available. The Federal Environment Agency estimates the total uncertainty for production and laying of sheeting to be smaller than 10 %.

4.2.5.4   Source-specific quality assurance / control and verification (2.A.5)

Due to a lack of relevant specialised staff, it has not yet been possible to carry out quality control and quality assurance (i.e. for it to be carried out by source-category experts). In keeping with the co-operation agreement in place with the VDD, that organisation has carried out quality control. Additional 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 new emission factors accord with findings from pertinent Federal Environment Agency research projects and thus are plausible. In particular, the validity of the new 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)

Replacement of estimated activity data with a complete time series of association data, and – especially – use of new emission factors, have necessitated extensive recalculations. Currently, the total calculated emissions are about one percent of the corresponding figures given in previous reports.

4.2.5.6   Planned improvements (source-specific) (2.A.5)

For the next report, the VDD is expected to provide uncertainties figures and additional perspectives on export-import adjustment.

4.2.6   Mineral Products: Road paving with asphalt (2.A.6)

CRF 2.A.6

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
	- / -				

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NO	NO	NO	NO	NO	NO	CS	IE	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

As far as is currently known, the source category "Road paving with asphalt" produces no greenhouse-gas emissions and is thus not a key source.

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 2008, a total of about 51 million t of asphalt (DAV, 2009) was produced in Germany, in a total of some 700 asphalt-mixing plants. Asphalt is used primarily in road construction, where it competes directly with 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.

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).

Emission factors have been determined country-specifically, pursuant to Tier 2. For determination of emission factors for pollutants other than CO_2, emissions measurements from over 400 asphalt-mixing plants, made during the period 1989 through 2000, were used. 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 (proportional process emissions). CO occurs primarily in incomplete combustion processes. CO emissions are calculated solely in connection with fuel inputs.

Table 55:   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-quantity 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)

Due to a lack of relevant specialised staff, it has not yet been possible to carry out quality control and quality assurance (i.e. for it to be 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.

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   Planned improvements (source-specific) (2.A.6)

Relevant findings currently available from a research project are to used for specific evaluation of emission factors.

4.2.7   Mineral Products: Glass production (2.A.7 Glass)

CRF 2.A.7 Glas					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	CS	NO	NO	NO	NO	NO	CS	NO	CS	CS
EF uncertainties in %	+/- 10									
Distribution of uncertainties	N									
EF-determination method	CS									

The source category *"Mineral products: glass production"* is not a key source.

4.2.7.1   Source category description (2.A.7 Glass production)

Germany's glass industry produces a wide range of different glass types that differ in their 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 55.1 % of total glass production in 2008) and flat glass (about 24 % of total glass production in 2008). Together, these sectors account for 79.1 % of total glass production (BV Glas, 2009).

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 smaller 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.

4.2.7.2   Methodological issues (2.A.7 Glass production)

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 / sodium carbonate (Na_2CO_3), magnesium carbonate ($MgCO_3$) and barium carbonate ($BaCO_3$). In the present context, the CO_2 emissions are reported; 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, 2009). "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 2008:

Table 56:   Glass: Activity rates for the various industry sectors (types of glass)

Industry sector	Activity rate for 2008 [1,000 t]
Container glass	4141.8
Flat glass	1801.5
Special glass	398.0
Domestic glass	309.0
Glass fibre and wool	386.7
Stone wool	476.9

Source: BV Glas, 2009

The following sector-specific cullet percentages are assumed:

Table 57:   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 are being updated.

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 58: 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 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 compared the data with data of the *Federal Statistical Office*.

The uncertainty for the cullet figures for container glass for the period 1995 through 2006, and for the western German Länder as of 1990, is 0 %, since cullet distribution to the German container-glass industry is reported to the Gesellschaft für Glasrecycling und Abfallvermeidung mbH (GGA). That company kept precise records of all relevant quantities. For the new German Länder, an uncertainty of 20 % was assumed. 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 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 this comparison, the calculated emission factors may be considered accurate.

The calculated emissions were also cross-checked against the ETS data for Germany. Expansion of emissions trading to the rock-wool-production sector has created a need for further review in connection with such cross-checking.

Because the pertinent sources are of good quality, the data relative to the chemical composition of the various glass types involved are considered to be checked and correct.

4.2.7.5   Source-specific recalculations (2.A.7 Glass)

No source-specific recalculations have been carried out.

4.2.7.6   Planned improvements (source-specific) (2.A.7 Glass)

No improvements are planned at present.

4.2.8   Mineral Products: Ceramics production (2.A.7 Ceramics)

CRF 2.A.7 Ceramics					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	NO	NO	NO	NO	NO	CS	NO	CS	CS
EF uncertainties in %	+/-30									
Distribution of uncertainties	N									
EF-determination method	CS									

The source category *"Mineral products: ceramics production"* is not a key source.

4.2.8.1   Source category description (2.A.7 Ceramics)

The process-related emissions in the ceramics industry originate in the following structural elements:

1. "Production of ceramic products": This time series shows the quantity produced by the entire ceramics industry in Germany. These activity data are used to calculate the entire ceramics industry's emissions of NEC pollutants and dust. 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); " masonry brick" 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 59:　　　Activity rates and process-related CO_2 emissions in the ceramics industry
　　　　　　　　(CRF 2.A.7.b)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
						[kT]					
Ceramics products	21595	20772	22769	24534	30458	24730	22663	22939	22798	22395	21199
of which:											
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**
	2000	2001	2002	2003	2004	2005	2006	2007	2008		
						[kT]					
Ceramics products	21199	18003	16500	16443	16796	14643	16019	16035	13867		
of which:											
Masonry bricks	15383	12771	11686	11631	11697	9881	10883	10885	9302		
Roof tiles	2924	2642	2381	2383	2601	2485	2648	2618	2254		
Process-related CO_2 emissions											
Masonry bricks	448	372	340	338	340	288	316	317	271		
Roof tiles	84	76	68	68	74	71	76	75	64		
Total	**531**	**447**	**408**	**407**	**415**	**359**	**392**	**392**	**335**		

4.2.8.2　　Methodological issues (2.A.7 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 source.

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 production of masonry bricks and blown-clay products in cubic metres, and production of tiles in square metres and production of 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.

Details on derivation of the total production quantity for other ceramic sectors are provided in the NIR 2007.

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 59 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 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 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.

To date, data from greenhouse-gas-emissions trading have not been used directly for verification, because, as a result of applicability of threshold values to pertinent plants, data are available for only part of the ceramics industry – and only for some brick and roof-tile producers. At the same time, methodological comparisons relative to CO_2 calculations are carried out, and such comparisons confirm the plausibility of the calculations described here.

4.2.8.5   Source-specific recalculations (2.A.7 Ceramics)

No recalculations are required.

4.2.8.6   Planned improvements (source-specific) (2.A.7 Ceramics)

No improvements are planned at present.

4.3   Chemical industry (2.B)

Source category 2.B is sub-divided into 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 the CSE, sub-category *Other* (2.B.5) includes fertiliser and nitrous oxide production, organic products, soot and titanium-oxide production, sulphuric acid production and coke burn-off in catalyst regeneration in refineries.

4.3.1   Chemical industry: Ammonia production (2.B.1)

4.3.1.1   Source category description (2.B.1)

CRF 2.B.1					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Ammonia Production	l / t	CO_2	0,35 %	0,43 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	PS	NO	NO	NO	NO	NO	D	NO	NO	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	T3									

The source category "*Chemical industry*: *ammonia production*" is a key source 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 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* under mild conditions in a fired primary reformer and 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. The reasons for the re-increase as of 1995, to the 1990 level, are not understood; the re-increase may be due to a change in statistical survey methods, however. Since 1995, production levels have fluctuated only slightly; the rate of ammonia production has been stable since then.

4.3.1.2   Methodological issues (2.B.1)

In keeping with this source category's categorisation as a key source 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) agricultural 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 materials' C factors (CCF_i) and carbon-oxidation factors (COF_i),
- The relevant quantities of CO_2 subjected to 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 CO_2 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:

$$E_{CO2} = \sum (TFR_i * CCF_i * COF_i * 44/12) - R_{CO2}$$

Emission factor for NO_x:

For the NO_X emission factor, the default emission factor given in the *CORINAIR Guidebook*, 1 kg/tNH_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)

Activity rate:

Using equation 6.3 in IPCC GPGAUM, the IVA aggregated the uncertainty for the activity rate, as reported by the operators, and communicated the result to the Federal Environment Agency. The pertinent uncertainty is ± 0.6 %.

4.3.1.4   Source-specific quality assurance / control and verification (2.B.1)

Quality control and quality assurance (pursuant to Tier 1 & 2), 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)

The following tables provide an overview of the source-specific recalculations:

	AR [t]	AR [t]	CO₂ emissions (NIR 2009)	CO₂ emissions (NIR 2010)	Change in CO₂
Units	kt	kt	Gg	Gg	Gg
1990	2,532	2,705	4,596	4,292	**-304.4**
1991	2,123	2,411	3,854	3,756	**-97.8**
1992	2,113	2,404	3,834	3,803	**-31.2**
1993	2,116	2,306	3,841	3,648	**-193.2**
1994	2,170	2,377	3,938	3,615	**-323.0**
1995	2,593	2,906	4,707	4,505	**-201.7**
1996	2,565	2,976	4,656	4,503	**-153.1**
1997	2,547	2,926	4,623	4,416	**-206.7**
1998	2,558	3,047	4,642	4,580	**-62.2**
1999	2,471	2,889	4,484	4,436	**-48.1**
2000	2,634.3	3,220.8	4,781.3	4,773.0	**-8.3**
2001	2,602.6	2,958.5	4,723.7	4,346.0	**-377.7**
2002	2,652.6	3,169.9	4,814.5	4,623.0	**-191.5**
2003	2,895.2	3,195.0	5,254.8	4,510.0	**-744.8**
2004	2,847.9	2,966.3	5,168.9	4,278.0	**-890.9**
2005	2,894.4	3,289.4	5,253.4	4,570.0	**-683.4**
2006	2,830.7	3,212.0	5,137.7	4,281.0	**-856.7**
2007	2,865.3	3,265.8	5,200.5	4,331.0	**-869.5**
2008		3,112.6		4,111.0	

	NOx emission factor (NIR 2009)	NOx emission factor (NIR 2010)	NOx emissions (NIR 2009)	NOx emissions (NIR 2010)	Change in NOx
Units	kg/t NH₃	kg/t NH₃	Gg	Gg	Gg
1990	0.450	1.000	1.1396	0.0027	**-1.1369**
1991	0.445	1.000	0.9449	0.0024	**-0.9425**
1992	0.440	1.000	0.9295	0.0024	**-0.9271**
1993	0.435	1.000	0.9206	0.0023	**-0.9183**
1994	0.430	1.000	0.9330	0.0024	**-0.9306**
1995	0.425	1.000	1.1021	0.0029	**-1.0992**
1996	0.420	1.000	1.0774	0.0030	**-1.0745**
1997	0.415	1.000	1.0570	0.0029	**-1.0540**
1998	0.410	1.000	1.0486	0.0030	**-1.0456**
1999	0.405	1.000	1.0006	0.0029	**-0.9977**
2000	0.400	1.000	1.0537	0.0032	**-1.0505**
2001	0.390	1.000	1.0150	0.0030	**-1.0121**
2002	0.380	1.000	1.0080	0.0032	**-1.0048**
2003	0.370	1.000	1.0712	0.0032	**-1.0680**
2004	0.360	1.000	1.0252	0.0030	**-1.0223**
2005	0.350	1.000	1.0131	0.0033	**-1.0098**
2006	0.340	1.000	0.9624	0.0032	**-0.9592**
2007	0.330	1.000	0.9455	0.0033	**-0.9423**
2008		1.000		0.0031	

The time series for the activity rate (production quantity) correlates with previously reported AR. At the same time, the AR now being reported by plant operators are an average of 10 – 20 % higher. This fact can be explained in that AR were previously reported in t N and are now being reported in t NH₃.

The pertinent expert was unable to verify the existing NO_x emission factor. For this reason, the NO_x emission factor given in the *CORINAIR Guidebook* has been used.

4.3.1.6   Planned improvements (source-specific) (2.B.1)

In keeping with the IPCC Guidelines, reporting is to be plant-specific, in keeping 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

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
	- / -				

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NO	NO	NA	NA	NA	PS	CS	NO	NO	NO
EF uncertainties in %						±5				
Distribution of uncertainties						N				
EF-determination method						T3				

The source category "*Chemical industry: nitric acid production"* is not a key source.

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 C. The related 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:
- $4\,NH_3\ +\ 3\,O_2\ \rightarrow\ 2\,N_2\ +\ 6\,H_2O$
- $4\,NH_3\ +\ 4\,O_2\ \rightarrow\ 2\,N_2O\ +\ 6\,H_2O$
- 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)

Nitric acid production is a key source of N_2O emissions. In keeping with the IPCC Guidelines, as of the current reporting round such emissions are now being 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 emissions-control technologies 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 measured in the raw gas 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.
- 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 and quality assurance (pursuant to Tier 1 & 2), 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)

The following table provides an overview of the source-specific recalculations:

	AR (NIR 2009)	AR (NIR 2010)	N₂O EF (NIR 2009)	N₂O EF (NIR 2010)	N₂O emissions (NIR 2009)	N₂O emissions (NIR 2010)	N₂O emissions – change
Units	kt	kT	kg/t	kg/t	Gg	Gg	Gg
1990	2,740	1,697	5.5	6.43	15.07	10.92	**-4.15**
1991	2,173	1,559	5.5	6.40	11.95	9.98	**-1.97**
1992	2,001	1,476	5.5	6.21	11.01	9.17	**-1.84**
1993	1,995	1,476	5.5	6.64	10.98	9.80	**-1.18**
1994	2,025	1,458	5.5	6.70	11.14	9.77	**-1.37**
1995	2,308	1,624	5.5	6.86	12.70	11.15	**-1.55**
1996	2,197	1,660	5.5	6.77	12.08	11.24	**-0.84**
1997	2,202	1,633	5.5	6.77	12.12	11.06	**-1.06**
1998	2,189	1,631	5.5	6.77	12.04	11.05	**-0.99**
1999	2,279	1,685,	5.5	6.96	12.54	11.73	**-0.81**
2000	2,436	1,828	5.5	6.73	13.40	12.30	**-1.1**
2001	2,138	1,722	5.5	6.73	11.76	11.59	**-0.17**
2002	2,350	2,009	5.5	5.57	12.93	11.19	**-1.74**
2003	3,864	2,135	5.5	5.30	21.25	11.32	**-9.93**
2004	4,409	2,490	5.5	4.43	24.25	11.03	**-13.22**
2005	6,487	2,530	5.5	4.37	35.68	11.06	**-24.62**
2006	4,972	2,681	5.5	4.05	27.35	10.86	**-16.49**
2007	5,604	2,864	5.5	3.58	30.82	10.25	**-20.57**
2008		2,616		3.50		9.16	

	NOx EF (NIR 2009)	NOx EF (NIR 2010)	NOx emissions (NIR 2009)	NOx emissions (NIR 2009)	NOx emissions – change
Units	kg/t HNO	kg/t HNO	Gg	Gg	Gg
1990	7.918656674	10.0	21.70	16.98	**-4.73**
1991	6.598918861	10.0	14.34	15.60	**1.26**
1992	5.045221779	10.0	10.10	14.76	**4.67**
1993	3.674203781	10.0	7.33	14.76	**7.43**
1994	3	10.0	6.08	14.59	**8.51**
1995	2.5	10.0	5.77	16.25	**10.47**
1996	2.1	10.0	4.61	16.60	**11.99**
1997	1.8	10.0	3.97	16.33	**12.37**
1998	1.6	10.0	3.50	16.31	**12.81**
1999	1.5	10.0	3.42	16.86	**13.44**
2000	1.4	10.0	3.41	18.28	**14.87**
2001	1.346	10.0	2.88	17.22	**14.34**
2002	1.292	10.0	3.04	20.10	**17.06**
2003	1.24	10.0	4.79	21.36	**16.56**
2004	1.19	10.0	5.25	24.90	**19.65**
2005	1.13	10.0	7.33	25.30	**17.97**
2006	1.06	10.0	5.27	26.81	**21.54**
2007	1	10.0	5.60	28.64	**23.04**
2008		10.0		26.17	

To date, the activity data have been obtained from the *Federal Statistical Office* (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 3.1: manufacturing sector, production within the manufacturing sector). Until 2001, nitric acid was reported under reporting number (Melde-Nr.) 2415 10 503. Since 2002, the *Federal Statistical Office* no longer lists this position individually; it now lists it only as part of a sum under reporting number (Melde-Nr.) 2415 10 500 (nitric acid, nitrating acids). The relevant share for nitric acid has been estimated by multiplying this sum value by nitric acid's share of this sum value in 2001 (0.693).

This change, along with fluctuations in production, the appearance of a new producer and conversion of a major nitric acid producer's data-collection system, are seen as the reasons for the large deviations seen in the years 2002 to 2008. Until 2001, the AR now reported by the operators correlate with the AR previously reported. On the other hand, the recalculated AR are an average of 20 – 30 % lower. The reason for the 60 % discrepancy in 1990 could be that production figures for 1990 were estimated for the new German Länder, due to a lack of pertinent data.

The pertinent expert was unable to verify the existing NO_x emission factor. For this reason, the NO_x emission factor given in the *CORINAIR Guidebook* has been used.

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				
Key source by level (l) / trend (t)	**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Adipic acid production l / t	N_2O	1.53 %	0.57 %	falling

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NO	NO	NO	NO	NO	D, PS	NE	NE	NO	NO
EF uncertainties in %						+/- 10%				
Distribution of uncertainties						N				
EF-determination method						CS				

The source category "*Chemical industry: Adipic acid production*" is a key source 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.

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 2006 specifies uncertainties of +/- 0.05% for plants with thermal decomposition and of +/- 2.5% for plants with catalytic decomposition. The uncertainties relative to production quantities are given as +/- 2%. The EF is thus assumed to have an uncertainty of 2.5 %.

4.3.3.4 Source-specific quality assurance / control and verification (2.B.3)

Quality control and quality assurance (pursuant to Tier 1 & 2), 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 Planned improvements (source-specific) (2.B.3

No improvements are required; for this reason, none are planned.

4.3.4   Chemical industry: Carbide production (2.B.4)

4.3.4.1   Source category description (2.B.4)

CRF 2.B.4					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor CaC_2	PS	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emission factor SiC	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %	±10									
Distribution of uncertainties	N									
EF-determination method	PS									

The source category "*Chemical industry: carbide production*" is not a key source.

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 chalk. 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

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
Other	l / t	CO_2	0.56 %	1.07 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF), carbon black	D	CS	NO	NO	NO	NO	NO	D	NO	D
Emission factor (EF), ethylene, styrene	NO	D	NO	NO	NO	NO	NO	NO	CS	NO
Emission factor (EF), methanol, 1.2-dichloroethane	CS	D	NO	NO	NO	NO	NO	NO	NO	NO
Emission factor (EF), transformation processes, coke burn-off for catalyst regeneration, in refineries	CS	NO	NO	NO	NO	NO				
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category "*Chemical industry*: *Emissions from other production processes*" is a key source 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, along with transformation processes 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 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.

CH_4 can occur as a secondary product of industrial processes and then be emitted into the atmosphere. To date, the German greenhouse-gas inventory has not taken all such sources into account.

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.

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 60 below.

Table 60:   IPCC default emission factors for CH_4 from other chemical industry processes

Carbon black	Styrene	Ethylene	1,2 - dichloroethane[39]	Methanol
\[kg CH_4/t \]				
0.06 (with thermal post-combustion) 28.4 (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

---

[39] 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 61:   National emission factors for CH_4 from other chemical industry processes

Carbon black	Styrene	Ethylene	1,2-dichloroethane[40]	Methanol
[kg CH_4/t]				
0.03	0	0	0	0

NMVOC, CO and SO_2 – emission factors

For pollutants other than the methane considered above, the emission factors listed in Table 62 were used for Germany.

Table 62:   Emission factors used in Germany for other pollutants

	Carbon black [kg CO / t]	Carbon black [kg SO_2/t][41]	Ethylene [kg NMVOC / t]	1,2 - dichloroethane [kg NMVOC / t]	Polystyrene [kg NMVOC / t]	Styrene [kg NMVOC / t]
1990	4.8 / 5	19.5/ [(42)]	5	2.5	1	0.02
1991	4.6 / 5	19 / 20	5	2.5	1	0.02
1992	4.4 / 5	18.5 / 20	5	2.5	1	0.02
1993	4.2	18	5	2.5	1	0.02
1994	4	17.5	5	2.5	1	0.02
1995	3.75	17	0.4	0.03	0.6	0.02
1996	3.5	16	0.3	0.022	0.4	0.02
1997	3.25	15	0.3	0.022	0.4	0.02
1998	3	14	0.25	0.018	0.32	0.02
1999	2.9	13.4	0.25	0.018	0.32	0.02
2000	2.8	12.8	0.2	0.015	0.27	0.02
2001	2.7	12.54	0.2	0.015	0.27	0.02
2002	2.65	12.28	0.2	0.015	0.27	0.02
2003	2.6	12.0	0.2	0.015	0.27	0.02
2004	2.55	11.7	0.2	0.015	0.27	0.02
2005	2.5	11.5	0.2	0.015	0.27	0.02
2006	2.5	11.2	0.2	0.015	0.27	0.02
2007	2.5	10.9	0.2	0.015	0.27	0.02
2008	2.5	10.6	0.2	0.015	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, 2006b) and are identical with the default values presented in the 2008 CORINAIR manual (first order draft).

---

[40] 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".

[41] Where two EF are listed, the second figure refers to the new German Länder.

[42] No EF is listed for the new German Länder, since these SO_2 emissions can be taken account of only as a lump sum.

Activity rates

The production statistics of the Federal Statistical Office include the following products (Table 63).

Table 63:   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

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").

The reasons for the production fluctuations during the period under consideration are unknown. According to the Federal Statistical Office, the increase of about 100 % in carbon-black production, with respect to the corresponding figure in 1990, is the result of the appearance of a new producer.

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 and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

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 sub-divided into sub-categories 2.C.1 through 2.C.5. In the CSE, sub-category Iron and steel production (2.C.1) includes iron and steel production and tempered castings, pig-iron production, sinter production and steel products. 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					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Steel (integrated production)	l / t	CO_2	3.92 %	4.50 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	NO	NO	NO	NO	NO	CS	CS	CS	CS
EF uncertainties in %	-	-	-	-	-	-				
Distribution of uncertainties	-	-	-	-	-	-				
EF-determination method	T2	-	-	-	-	-				

The source category *"Iron and steel production"* is a key source of CO_2 emissions in terms of emissions level and trend.

In 2008, a total of 31.2 million t of raw steel, from ore, was produced in Germany in six integrated steel works. Electrical steel production amounted to 14.6 million t.

4.4.1.2   Methodological issues (2.C.1)

This sector comprises process-related emissions from sinter, pig-iron and oxygen-steel production (blown steel production) and from electric-steel works.

The other structural elements listed (foundries: iron and steel casting (including malleable casting); steel production: rolled-steel production; steel-pig-iron production) are used for calculation of other pollutant emissions.

Process-related CO_2 emissions from oxygen steel production in integrated steel works result primarily from use of reducing agents in blast furnaces. CO_2 emissions from limestone inputs in pig iron production and in electrode consumption in electrical steel production are added to process-related emissions in sector 2.C.1.

Energy-related emissions from steel production are reported under 1.A.2 (cf. Chapter 3.2.9.1).

Table 60 of the NIR 2009 shows allocation of fuel and reducing-agent inputs, and of the resulting CO_2 emissions, in the iron and steel industry, to process-related and energy-related emissions.

Because it is difficult to differentiate between between process-related and energy-related emissions in oxygen steel production, the following actions are taken:

1. All of the CO_2 emissions resulting from use of reducing agents and fuels are calculated.
2. Process-related CO_2 emissions are determined from the carbon requirements for the ideal blast-furnace process and from limestone inputs in pig-iron production, and CO_2 emissions are determined from electrode consumption in electrical steel production.
3. Then, the determined emissions are aggregated and allocated to the total process-related and energy-related CO_2 emissions from iron and steel production (2.C.1 and 1.A.2.a).

This approach rules out the possibility of any double-counting, and it simplifies the process of summing up all carbon inputs and outputs.

Determination of total CO_2 emissions from inputs of reducing agents and fuel in pig-iron and oxygen-steel production

For determination of total CO_2 emissions from inputs of reducing agents and fuel, pig-iron and oxygen-steel production are considered in one step. In terms of methods, this procedure for determining total emissions corresponds to that used until the NIR 2004 for determining iron and steel industry emissions as reported under 1.A.2.
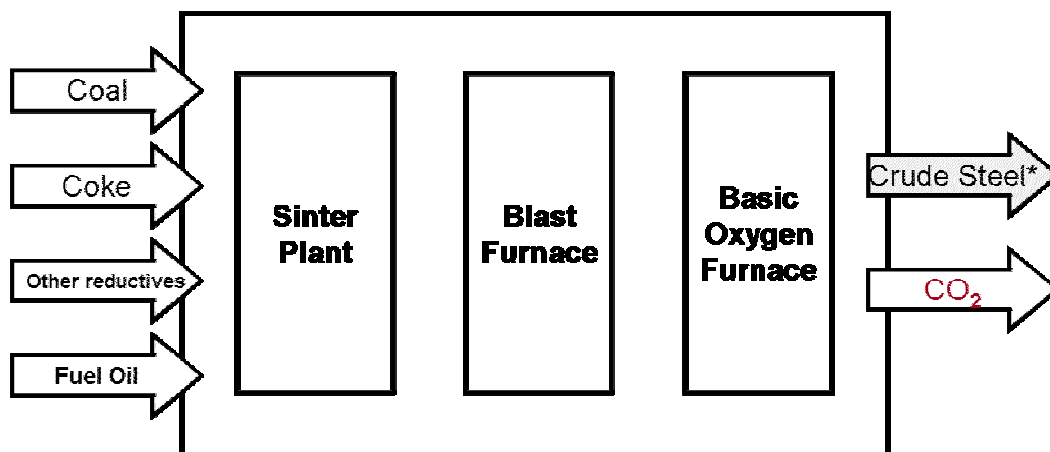
*The carbon content of crude steel is not considered in the balance (very low compared to CO_2 emissions)

Figure 26:   Carbon balance in pig-iron and oxygen-steel production

CO_2 emissions from reducing agents are determined in keeping with Tier 2 of the IPCC GPG (2000). Since, consistently, about 97% of the pig iron produced in Germany is processed into oxygen steel, in a modified Tier 2 approach, separate carbon balancing for pig iron production (blast furnace) and oxygen steel works is unnecessary (cf. Figure 26). It thus is also no longer necessary to calculate the carbon dissolved in the pig iron separately, since that carbon is released in oxygen steel works as CO_2. A similar approach can be taken for generated process gases, especially blast-furnace gas: regardless of whether the process gases are used within steel works or outside of steel works, for energy production – in the final analysis of all processes tied to steel production, the entire carbon content of reducing agents is released into the atmosphere as CO_2. To prevent double-counting in the process chain, all of this carbon input is entered into the balance sheet as CO_2 emissions. At the same time, the CO_2 emission factor for use of blast-furnace gas as an energy source is set to "0".

The carbon content in raw steel is not deducted, since over 2,000 types of steel, with carbon content varying between 0 and 2% (« 2% as a rule), are produced in Germany and the average carbon content of these steel types is not recorded statistically. In any case, that content is marginal (« 3%) by comparison to carbon releases in the form of CO_2.

In the iron and steel industry, secondary fuels are used only in pig iron production in blast furnaces. They are used as substitute reducing agents, instead of coke, and must thus be allocated to process-related emissions in 2.C.1. 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 (cf. Table 64).

Table 64: Inputs of secondary fuels in blast furnaces, their biogenic fractions and the relevant emission factors for CO_2

Secondary fuel	Units	Year	Animal fat	Recycled plastics
CO_2 emission factor	kg/TJ		71,380	74,630
	kg/t			2850
Biogenic mass fraction	%		100	0
Input quantities in blast furnaces	t	1996	-	48,467
	t	1997	-	112,055
	t	1998	-	118,132
	t	1999	-	104,139
	t	2000	-	135,855
	t	2001	-	146,753
	t	2002	14,589	148,483
	t	2003	28,877	105,924
	t	2004	13,476	93,958
	t	2005	-	39,142
	t	2006	-	34,232
	t	2007	-	22,531
	t	2008	-	17,103

Determination of process-related CO_2 emissions from carbon requirements for the ideal blast-furnace process

To ensure consistency with pertinent data of the German Emissions Trading Authority (Deutsche Emissionshandelsstelle), process-related CO_2 emissions from inputs of reducing agents, which emissions are to be reported in sector 2.C.1, are calculated, as called for in the Allocation Ordinance (Zuteilungsverordnung; ZuV 2004) for the German Greenhouse Gas Emissions Trading Act (Treibhausgas-Emissionshandelsgesetz; TEHG), with the help of a factor for the ideal blast-furnace process: The emission factor used, 1.307 t CO_2 / t product, is obtained by multiplying the carbon requirements for the ideal blast-furnace process, 356.5 kg C per tonne of pig iron (SCHOLZ, 2003), by 44/12 (CO_2 to C mass ratio).

Emissions from reducing agents that are in addition to the thusly calculated quantity of CO_2 are added to the energy-related emissions; cf. below.

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. On the other hand, (burnt) lime

(CaO) is used – inter alia, as a slag former – in actual refining of raw steel in oxygen-steel or electric-steel processes. 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 in such statistics, via specific input factors (kg of limestone per tonne of sinter or pig iron). The activity rates used as a basis until the NIR 2009 deviated slightly from the association data, however, and thus the values were corrected for the current reporting round. Multiplying the activity rates for limestone inputs by the stoichiometric emission factor for limestone produces the CO_2-emissions figures given in Table 65.

Table 65:   Limestone inputs and resulting CO_2 emissions in sinter and pig iron production

Year	Limestone inputs [kt/a]		CO_2 emissions [kt/a]		
	Sinter	Pig iron	Sinter	Pig iron	Total
1990	4,681	756	2,060	333	2,392
1991	4,532	757	1,994	333	2,327
1992	4,198	666	1,847	293	2,140
1993	3,891	627	1,712	276	1,988
1994	4,173	733	1,836	323	2,159
1995	4,600	751	2,024	330	2,354
1996	4,350	686	1,914	302	2,216
1997	4,471	629	1,967	277	2,244
1998	4,588	677	2,019	298	2,317
1999	4,144	817	1,823	359	2,183
2000	4,273	924	1,880	407	2,287
2001	4,136	866	1,820	381	2,201
2002	3,940	831	1,734	366	2,099
2003	4,047	833	1,781	366	2,147
2004	4,306	787	1,895	346	2,241
2005	4,410	823	1,941	362	2,303
2006	4,608	841	2,028	370	2,398
2007	4,541	790	1,998	348	2,346
2008	4,306	787	1,895	346	2,241

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 electrode consumption in electrical steel production.

In electrical 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 quantities of produced electrical steel, via a standard factor for electrode consumption (1.3 kg C per tonne of electrical steel), and via a stoichiometric factor (3.667 t CO/t C).

Allocation and aggregation of determined emissions quantities to the total process-related and energy-related CO_2 emissions from iron and steel production (2.C.1 and 1.A.2.a)

As described in this chapter, the total process-related emissions that must be reported under 2.C.1 include:

- Process-related CO_2 emissions from carbon requirements for the ideal blast-furnace process,

- CO_2 emissions from limestone inputs in pig iron production, and
- CO_2 emissions from electrode consumption in electrical steel production.

The relevant so-determined emissions quantities are shown in Table 67. The contribution of electrical steel production (electrode consumption), at 0.17% of total process-related CO_2 emissions, and 0.12% of total emissions from iron and steel production, is insignificant.

Table 66:   Total process-related emissions to be reported under 2.C.1

Year	Process-related CO_2 emissions pursuant to Scholz factor	CO_2 emissions from limestone input	CO_2 emissions from electrode consumption	2.C.1 total
	[t/a]	[t/a]	[t/a]	[t/a]
1990	45,858,709	2,392,065	75,242	48,326,016
1991	43,928,270	2,327,160	68,464	46,323,894
1992	40,686,910	2,140,160	64,358	42,891,428
1993	38,570,877	1,987,920	56,805	40,615,602
1994	41,712,905	2,158,707	62,447	43,934,059
1995	41,703,756	2,354,440	65,930	44,124,126
1996	38,487,229	2,215,840	67,249	40,770,318
1997	43,306,138	2,244,000	71,238	45,621,376
1998	41,758,650	2,316,600	66,528	44,141,778
1999	38,942,065	2,182,840	61,335	41,186,240
2000	43,198,964	2,286,680	66,620	45,552,264
2001	41,371,778	2,200,880	62,721	43,635,379
2002	41,574,363	2,099,240	62,993	43,736,596
2003	40,957,459	2,146,864	64,071	43,168,393
2004	42,003,059	2,225,326	67,910	44,296,296
2005	40,330,099	2,241,022	65,192	42,636,312
2006	42,542,850	2,302,664	69,995	44,915,509
2007	40,712,429	2,397,531	71,622	46,299,398
2008	40,769,882	2,345,812	69,828	43,185,522

The energy-related CO_2 emissions are obtained as the difference between

- Total emissions from inputs of reducing agents and fuels in pig-iron and oxygen-steel production (see above) and
- Process-related CO_2 emissions as determined from carbon requirements for the ideal blast-furnace process (see above).

The pertinent difference is formed in 2 steps.

Firstly, the emission factors for all reducing agents used in the blast furnace (specifically, hard coal, dry blast-furnace coke, other solid fuels and heavy heating oil) are set to "0" with regard to the energy picture.

Secondly, via a corrective time series in the CSE, non-process-related emissions from the blast furnace (the difference between the sum of the CO emissions resulting from the aforementioned reducing agents and the calculated process-related emissions from the ideal blast-furnace process (see above)) are added to the energy-related emissions listed under 1.A.2.a. Fuel-specific allocation of this difference would hardly be possible, and even if it were possible, it would not lead to greater precision.

Inputs of coke breeze in sinter plants, and inputs of coke-oven gas and of natural gas in blast furnaces (hot-blast stoves), are allocated completely to energy-related emissions.

All emission factors for top-gas inputs (also in power stations and in hot-blast stoves in pig iron production) are set to "0", since the relevant emissions were already taken into account in inputs of those reducing agents, into blast furnaces, that lead to the formation of top gas. In contrast to the procedure used in the 2006 NIR, CO_2 emissions from top gas are not reported in sectors 1.A.1 and 1.A.2; they are included in process-related emissions in 2.C.1. This approach ensures that no double-counting takes place.

Allocation of total emissions from iron and steel production to process-related and energy-related emissions (2.C.1 and 1.A.2.a), and the differences between the IPCC Good Practice Guidance approach and the approach described here, are illustrated in Figure 27. The difference, i.e. the different allocation to energy-related emissions, amounting to 1,476 kt/a CO_2 via the approach described here (and referred to in Figure 27 as "energy-related CO_2 from reducing agents"), accounts for only 2.6% of process-related emissions pursuant to IPCC GPG.
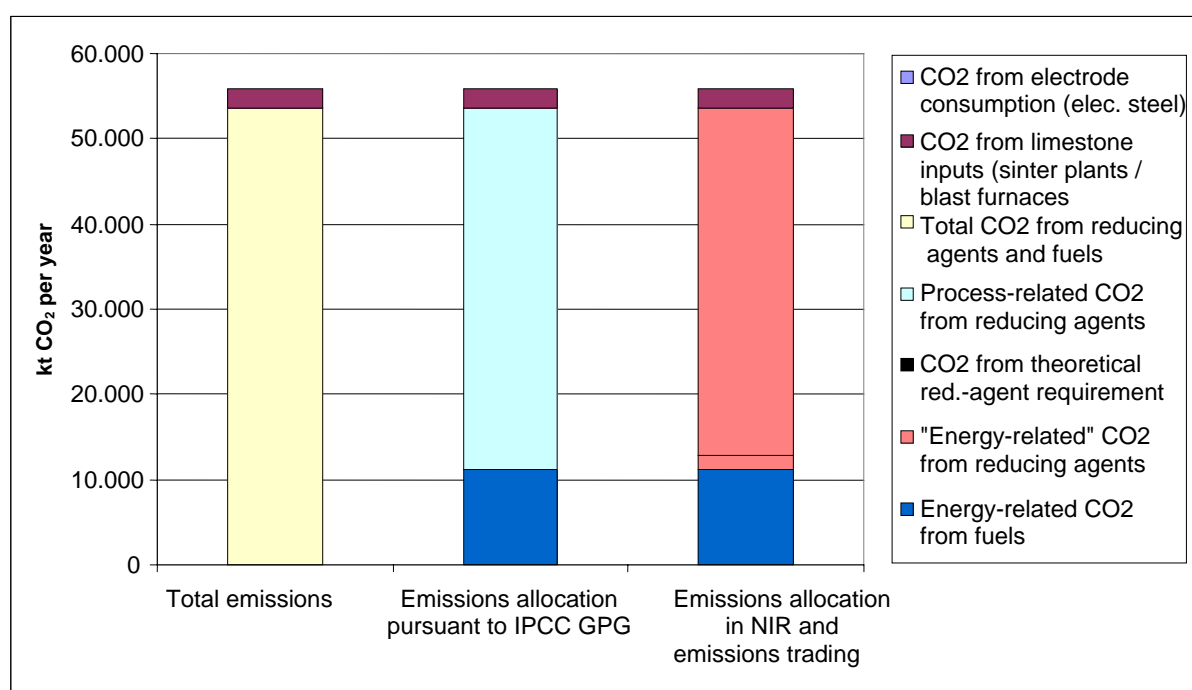
Remark: Joint representation of emissions from 2.C.1 and 1.A.2a; CO_2 emissions from electrode consumption in electrical steel production, amounting to 0.1% of total emissions, are not visible in the above figure.

Figure 27:   Allocation of total emissions from iron and steel production to process-related and energy-related emissions

4.4.1.3   Uncertainties and time-series consistency (2.C.1)

The time series is consistent, since the data is collected on a plant-specific basis and since it has been compiled in accordance with the same method for all years concerned. The uncertainties are ± 5 %, since they result only from inaccuracies in measurement and analysis.

A discontinuity in methods is seen only 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.

4.4.1.4   Source-specific quality assurance / control and verification (2.C.1)

Quality control and quality assurance (pursuant to Tier 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.

The plausibility of determined emissions quantities has been successfully checked with the help of pertinent data of the German Emissions Trading Authority (DEHSt).

4.4.1.5   Source-specific recalculations (2.C.1)

The activity rates used as a basis, until the NIR 2009, for limestone inputs during the years 2004 to 2007 deviated slightly from the association data, however, and thus the values were corrected for the current reporting round. The resulting changes in CO_2 emissions amount to between -152 and +16 Gg CO_2 per year.

No other recalculations are required.

4.4.1.6   Planned improvements (source-specific) (2.C.1)

The emission factors for electrode consumption are being reviewed in a research project that is scheduled to run until early 2010.

4.4.2   Metal production: Ferroalloys production (2.C.2)

4.4.2.1   Source category description (2.C.2)

CRF 2.C.2					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
		- / -			

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	NO	NO	NO	NO	NO	NE	NE	NE	NE
EF uncertainties in %	-	-	-	-	-	-				
Distribution of uncertainties	-	-	-	-	-	-				
EF-determination method	T2	-	-	-	-	-				

The source category *"Ferroalloys production"* is not a key source. Ferroalloys are aggregates that are alloyed with steel. Germany has one producer of ferrochrome, which is used as an alloying agent in stainless-steel production. For secrecy reasons, no activity rates can be obtained from the official statistics for 2.C.2. According to the relevant producer, 25,000 t of ferrochrome are produced annually. In addition, 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).

An activity rate figure of 25,000 t has been used consistently since 1995.

4.4.2.3   Uncertainties and time-series consistency (2.C.2)

This time series is consistent, because the same activity rate has been used year after year. 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.

The pertinent uncertainties have not been estimated.

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.

No comparison with other data sources for Germany was carried out, because no other suitable data sources for 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)

In keeping with suggestions made in the centralized review of the NIR 2009, review is underway to determine the extent to which reports of the U.S. Geological Survey (USGS), as made available in the Internet, could be used as a data source for completion or verification of reporting for this source category.

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					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Aluminium production	- / t	PFC	0,13 %	0,03 %	falling

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	CS	NE	NO	CS	NO	NO	NE	CS	NO	CS
EF uncertainties in %	15			15						
Distribution of uncertainties	N			N						
EF-determination method	T3			T3						

The source category *"Primary aluminium production"* is a key source of PFC emissions in terms of trend.

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 principal climate-relevant pollutants emitted are 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 87 % between 1995 and 2006. 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 2008 were taken from the monitoring report by the aluminium industry for the year 2008 (GDA, 2009). The average anode consumption is 430 kg of petrol coke per tonne of aluminium. Table 67 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 18.7.2). 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 67 were compared with the emission data in pertinent BAT Reference Documents (BREF)[43] and other sources (such as VDI Guideline 2286 sheet 1).

Table 67:   Activity rates and process-related emission factors for primary aluminium production in 2008

	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	605,932	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

---

[43] cf. http://www.bvt.umweltbundesamt.de/kurzue.htm

measurement data is not published, but it is 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 factors per anode effect[44] were calculated, in keeping with the technology 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.

4.4.3.4   Source-specific quality assurance / control and verification (2.C.3)

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.

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

---

[44] "...Organic fluorides occur only under certain conditions, and such conditions occur in the furnace repeatedly, at intervals of hours to severalls 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)

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 2007, the German emission factor for CF_4, resulting from anode effects, was 0.050 kg/t aluminium. This factor is smaller than the average international factor, as reported by the International Aluminium Institute (IAI), of 0.11 kg/t for point-feeder systems. Therefore, the emission factor has been verified.

4.4.3.5   Source-specific recalculations (2.C.3)

No recalculations are required.

4.4.3.6   Planned improvements (source-specific) (2.C.3)

Determination of uncertainties continues, with the involvement of the industry association.

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.4

Key source by level (l) / trend (t)		Gas (key source)	1995 – contribution to total emissions	2008 – contribution to total emissions	Trend
SF_6 used in aluminium and magnesium foundries	- / t	SF_6	C	C	C

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NO	NO	NO	NO	D	NO	NO	NO	NO	NO
EF uncertainties in %			-		-					
Distribution of uncertainties			-		-					
EF-determination method			NO		D					

The source category *"SF_6 in aluminium and magnesium production"* is a key source of SF_6 emissions in terms of trend.

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. Input quantities of SF_6 per tonne of magnesium (specific SF_6-coefficient) have decreased sharply since 1995. 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 SF_6 as a purification and protective gas 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).

Reports and archived survey records from 1996 have been used as a basis for the report years 1990 through 1994.

Emission factors

For aluminium and magnesium foundries, EF_{use} = 1 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 report 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 report 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 report year, data on the amounts used were obtained directly from users. Since the 2006 report year, the data have been obtained via surveys of gas sellers with regard to SF_6-sales figures. In the 2006 report report, the two methods were compared.

Since the 2007 report 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 are emitted to a degree of 100 % probably overstates the emissions. Without more precise measurements that would make it possible to determine an average degree of decomposition in the process, the uncertainties for the emission factors cannot be quantified.

4.4.4.4   Source-specific quality assurance / control and verification (2.C.4)

Quality control and quality assurance (pursuant to Tier 1 & 2), 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 report 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 report 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)

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.

4.4.5   Metal production: Other (2.C.5)

CRF 2.C.5					
Key source by level (l) / trend (t)		**Gas (key source)**	**1995 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	NO	NO	D	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method			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.

HFC-134a-emissions data are confidential, because of the small number of users involved. For this reason, the relevant emissions are reported in 2.G, in aggregation with other confidential data.

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   Planned improvements (quellenspezifisch) (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 processing, 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

Key source by level (l) / trend (t)		Gas (key source)	1995 – contribution to total emissions	2008 – contribution to total emissions	Trend
	- / -				

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NO	NO	NO	NO	NO	NO	CS	CS	D	D
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category *Other production – Pulp and paper* is not a key source.

All emissions of climate-relevant gases from the pulp and paper industry 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.

4.5.1.2   Methodological issues (2.D.1)

The pulp, paper and printing industry produces no process-related emissions of climate-relevant gases within the meaning of the *IPCC Good Practice Guidance* (IPCC, 2000). For other gases, the IPCC-Guidelines emission factors listed in Table 68 have been used until the 2004 report year.

Table 68:   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 report year 2005, plant operators have provided updated emission factors.

Table 69:   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 2008 the following quantities were produced, in a total of 138 plants:

Table 70:   Pulp and paper production, produced quantities

Product	Quantities produced in 2008	
Production of paper, cardboard and carton (PCC):	22.85 million tonnes	
Raw-material production:		
Paper pulp	1,524,603	t
of this, sulphite pulp	585,509	t
of this, sulphate pulp	939,094	t
Wood pulp	1,383,728	t
Recycled paper	12,928,000	t
Quantity of recycled paper used for this purpose	(15,464,251	t)

Source: Verband Deutscher Papierfabriken, Leistungsbericht 2009

These figures can be traced to the base year, 1990.

4.5.1.3   Uncertainties and time-series consistency (2.D.1)

Until the 2004 report year, the IPCC default values (IPCC, 1996b) were used for emissions calculation. As of report 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.

4.5.1.4   Source-specific quality assurance / control and verification (2.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.

4.5.1.5   Source-specific recalculations (2.D.1)

A range of measures in sulphite pulp production, carried out on a continual basis, led to reductions of SO_2 emissions. For this reason, liner interpolation was carried out between the default value for 1990 and the real, plant-based value for 2005.

4.5.1.6   Planned improvements (source-specific) (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 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					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	IE	NO	NO	NO	NO	NO	NO	NO	CS / IPCC	NO
EF uncertainties in %									20 - 100	
Distribution of uncertainties									N	
EF-determination method									CS	

The source category *Other production – Food and drink* is not a key source.

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. For this reason, this 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 155 billion in 2007, the food industry is one of Germany's most important economic sectors. In that same year, 530,000 people were employed in food-industry companies (BVE 2009). 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 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* (Fachserie 4, Reihe 3.1 and Fachserie 3, Reihe 3.2.1). 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.

shows the activity rates determined, emission factors used and the relevant NMVOC emissions calculated for the year 2008.

The following Table shows the activity rates determined, emission factors used and the relevant NMVOC emissions calculated for the year 2008.

Table 71:   NMVOC emissions from the food industry (2.D.2)

Product	Activity rates		Emission factors		Emissions [t]
Bread - Industrial bakeries - Craft bakeries	3,790,642 932,117	t	0.3* 3.0	kg/t kg/t	1,137.3 2,796.4
Cake, cookies and breakfast cereals	2,642,221	t	0.1*	kg/t	264.2
Sugar	3,540,109	t	0.9*	kg/t	3,180.3
Meat, poultry, fish - Meat/fish, smoked	1,536,012 2,278,718	t t	0.03* 0.0023*	kg/t kg/t	46.1 5.2
Animal fats	294,982	t	1*	kg/t	295.0
Coffee roasting	535,035	t	0.069*	kg/t	36.8
Feedstuffs	19,559,332	t	0.1*	kg/t	1,955.9
Beer	93,573,960	hl	0.002*	kg/hl	187.1
Wine - Red wine - White wine - Other wines	3,878,049 5,612,416 928,980	hl hl hl	0.08 0.035 0.058	kg/hl kg/hl kg/hl	310.2 196.4 53.9
Spirits	1,211,216	hl	2.93*	kg/hl	3,548.9

*With reduction measures taken into account

A total of 14.0 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 (FKZ 206 42 101/01), in the UFOPLAN framework, 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 (AEIGB, 2008) 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.

4.5.2.5   Source-specific recalculations (2.D.2)

Source-specific recalculations were carried out in the following source categories: wine, sugar, bread, cakes, cookies, breakfast cereals, meat, fish, poultry, animal fats and feedstuffs, since it proved possible to improve some of the pertinent activity-rate data.

4.5.2.6   Planned improvements (source-specific) (2.D.2)

No improvements are planned at present.

4.6   Production of halocarbons and SF$_6$ (2.E)

CRF 2.E				
Key source by level (l) / trend (t)		**Gas (key source)**	**1995 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Production of HCFC-22	l / t	HFC	C	C	C

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	NO	NO	PS	NO	PS	NO	NO	NO	NO	NO
EF uncertainties in %			-		-					
Distribution of uncertainties			-		-					
EF-determination method			-		-					

The source category *Production of halocarbons and SF$_6$* is a key source 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 two different companies, are located in Frankfurt and Bad Wimpfen. In 1995, in Frankfurt, a CFC-cracking plant went into operation 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, HCFC-23 concentrations in exhaust gas (as measured annually), sales of HFC-23 and quantities of HFC-23 delivered to the cracking plant. For report year 1995, emissions-reduction measures (the cracking plant) for the first production plant were assumed to have been in place since mid-year.

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 only emissions of HFC-23.

Sincer there are fewer than three producers in Germany, the pertinent emissions data are confidential. They are reported in aggregation with other confidential data in 2.G.

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 and quality assurance (pursuant to Tier 1 & 2), 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   Planned improvements (source-specific) (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, only one company produces these gases; its HFC (134a and 227ea) and 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, no complete synthesis of HFC-227ea takes place domestically. Part of the HFC-227ea produced in Tarragona, Spain, undergoes subsequent distillation to pharmaceutical purity (use in dosing aerosols). Some emissions also occur in this process, 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 reported emissions and production quantities. This 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. While the company's emissions and production-quantity data are reported to the Federal Environment Agency, for purposes of the inventory they are reported only under

2.G, in aggregation with emissions data for the CRF sub- source category 2.E.1 and for the areas use of SF_6 in sport shoes (2.F.8.c), use of SF_6 in welding (2.F.8.f), use of SF_6 in AWACS maintenance (2.F.8.e), use of HFC as solvents (2.F.5) and use of HFC in metal production (2.C.5).

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 and quality assurance (pursuant to Tier 1 & 2), 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   Planned improvements (source-specific) (2.E.2)

No improvements are planned at present.

4.6.3   Other (2.E.3)

No other sources of greenhouse-gas emissions are known.

4.7   Consumption of halocarbons and SF_6 (2.F)

CRF 2.F					
Key source by level (l) / trend (t)		**Gas (key source)**	**1995 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Consumption of halocarbons and SF_6	l / t	SF_6	0.52 %	0.32 %	falling
Consumption of halocarbons and SF_6	l / t	HFC	0.18 %	1.15 %	rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)			s. Text	s. Text	s. Text					
EF uncertainties in %			-	-	-					
Distribution of uncertainties			-	-	-					
EF-determination method			s. Text	s. Text	s. Text					

The source category *Consumption of halocarbons and SF_6* is a key source 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.6), Electrical operating equipment (2.F.7) and Other applications (2.F.8). 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", "semiconductor manufacturing" and "photovoltaic 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 come from shoes and aerosols.

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 operating equipment. As to the remaining emissions, production of solar cells 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 72:   Overview of methods and emission factors used for the current report year, in source category 2.F - *Consumption of halocarbons and SF₆*.

		Method	Gas			Emissionsfaktor (dimensionslos)		
			HFC	PFC	SF₆	Production	Application	Waste management
1. Air-conditioning and refrigeration systems	**2.F.1**							
Household refrigeration	2.F.1a					NO	0.003 (D)	NO
Commercial refrigeration	2.F.1b			PFC		0.002 (CS)	0.015 - 0,15 (D)	0.3-0.5 (CS)
Refrigeration for transports (vehicles and containers)	2.F.1c			PFC		0.005 (D)	0.15 - 0,30 (D)	0.3 (D)
Industrial refrigeration	2.F.1d			PFC		0.0015 (CS)	0.07 (D)	0.3 (CS)
Stationary air conditioning systems	2.F.1e					0.01 (D)	0.06 (D)	0.3 (CS)
Room air conditioners						0.025 (CS)	0.025 (D)	0.3 (D)
Mobile air conditioning systems		Tier 2a	HFC					
- 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)	0.3 (D)
- Ships						0.01 (CS)	0.05 (CS)	
- Railway vehicles						0.002 (CS)	0.15 – 0.25 (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)	0.014 (CS) 0.04 (D)	NO
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	HFC			0.015 (CS)	1 (D)	NO
5. Solvents	**2.F.5**	Tier 2				NO	1 (D)	
6. Semi-conductor production	**2.F.6**	Tier 2a		PFC	SF₆	CS	NO	
7. Electrical operating equipment	**2.F.7**							
Switching equipment	2.F.7a	Tier 3a			SF₆	0.02 (CS)	0.001 – 0.01 (CS)	0,02 (CS)
Other	2.F.7b	CS				0.15 – 1 (CS)	0.006 – 0.003 (CS)	NO
8. Other	**2.F.8**							
Insulated glass windows	2.F.8a	Equ. 3.24 ff			SF₆	0.33 (D)	0.01 (D)	1 (D)
Car tyres	2.F.8b	Equ. 3.23				NO	NO	1 (D)
Sports shoes	2.F.8c	Equ. 3.23		PFC		NO	NO	1 (D)
Trace gas	2.F.8d	Equ. 3.22				1 (D)	NO	NO
AWACS maintenance	2.F.8e	CS				NO	C	NO
Welding	2.F.8f	CS				NO	1 (CS)	NO
Optical glass fibre	2.F.8g	CS				0.7 (CS)	NO	NO
Photovoltaics	2.F.8h	CS				0.5 (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 report year, slowly escape from "stocks" and are emitted in production and waste management. On the other hand, the "stocks" – actually, the average quantities present in the report year in question (average annual stocks) – correspond to the potential emissions (P) listed in Table 2(II)s2. The "stocks" do not include quantities from storage only. These amounts vary widely, and thus neither is it possible to determine these quantities nor is it useful to work with an average value. For reasons of confidentiality, potential emissions for the sub- source categories "solvents" and "semiconductor manufacture" cannot be given. For open applications (aerosols / metered dose inhalers), annual emissions are equated with the quantities sold within the relevant 12-month period (100 % emissions in the relevant year of sales). As a result, this area has no "stocks" that increase annually. The potential emissions thus correspond approximately to the current emissions in the report year in question. In individual cases involving "open" applications, a situation can arise, as a result of the calculation method chosen and the difference in reference period, in which A > P and, thus, the relationship P/A < 1 (ÖKO-RECHERCHE, 2004).

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:

$$EM_{production} = EF_{production} * \text{domestic new consumption}$$

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 report 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 report year n:

Equation 3:

$$EM_{disposal} = EF_{disposal} * \text{New additions } (n\text{-}x)$$

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 room air conditioners, and mobile air conditioning systems (cf. Table 72).

In Germany, the leading pure-HFC refrigerants, far and away, are HFC-134a and the mixtures 404A and 507A.

For calculation of HFC emissions from the sub-categories of refrigeration and stationary air conditioning systems, individual data are collected, or refrigerant models 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 Household refrigeration (2.F.1.a)

In 1994, domestic producers of household refrigerators and freezers made a changeover from CFC-12 to HFC-134a. A short time later, they then switched to isobutane. A few devices containing HFC-134a, representing a small share of all relevant appliances, are imported.

Equation 2 is used to calculate annual HFC emissions on the basis of average stocks. To that end, annual HFC additions since 1994 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.

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 18 years. This is in keeping with the UNEP TEAP Task Force Decision XX/8 Report *Assessment of Alternatives to HCFC and HFC and update of the TEAP 2005 supplement report data* (May 2009).

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 R-404A also was not used until 1993. Use of the refrigerant mixture R-508B began in 1996, while use of R-407C did not begin until 1997.

Today, the mixture R-404A is the most important HFC refrigerant for stationary refrigeration systems, ranking ahead of even HFC-134a in this category. The mixtures R-407C and R-508B/B 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 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. This sum is then divided among 404A and 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-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 no fixed date can be given on which HFCs will completely supplant chlorine-containing refrigerants in new systems, 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", 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 much lower than that figure.

Ongoing (H)FC emissions from stationary refrigeration systems in the *commercial refrigeration* area vary widely in keeping with the type of system concerned. Refrigerant losses range from 1.5 % for individual appliances (except for those in food retail) to 15 % for old devices. These values are in the lower range of pertinent values given by IPCC-GPG (2000).

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 since 1993 as refrigerants in refrigerated vehicles. The refrigerants most commonly used today in refrigerated vehicles are R404A, R134A 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. R404A is also used to some extent, however.

The following refrigeration model is applied:

- 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 permissible gross vehicle weight.
- Fixed refrigerant types, and specific refrigerant fill amounts, are assigned to the various size classes. Each refrigerant is also assigned a fixed share of each size class. In some cases, the refrigerant breakdown used may have to be modified. Since report year 2006, the refrigerant R404A is used in half of the small systems of up to 5t permissible gross weight. Until 2005, only R134a was used.
- 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), CFC-12 was replaced with HFCs 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 the filling loss per system. Emissions from stocks are calculated with Equation 2.
- A service lifetime of 10 years is assumed. Disposal emissions occurred for the first time in 2003. For refrigerated vehicles, such emissions remain to be added to the database, however.
- The new HFC additions (initial filling) 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.
- The "bottom-up" approach described in IPCC-GPG (2000) refers only to refrigerated vehicles on roads.

Emission factors

The emission factors on which the emissions data are based are listed in Table 72. The emission factors used lie within the ranges recommended in the *IPCC Guidelines 2006*; they are thus *default values*.

Ongoing HFC emissions from new refrigeration units of refrigerated vehicles in the range 5-22 t permissible gross weight are estimated to account for 15 %. For units in vehicles up to 5 t permissible gross weight, the emission factor is 30 %.

For old units, the factor is estimated to average 25 %, for all unit size classes. "Old systems" are understood to be converted R12 systems. The emissions are thus at the lower boundary of the standard value range given in IPCC-GPG (2000), while the applicable service lifetime is longer than the proposed value.

Filling losses are small by comparison to ongoing emissions from stocks. Filling losses of refrigerant are placed at 5 grams per system, regardless of system size. That is a standard value for hose losses during on-site filling. A mathematical comparison of filling emissions to new consumption produces a ratio of 0.2 % for HFC-134a and a ratio of 0.05 % for R410A. Those values lie far below the range given by the IPCC-GPG, 0.2 to 1 percent.

Ongoing HFC emissions from refrigeration systems of refrigerated containers are estimated at 10 %. No filling emissions occur in Germany.

Activity data

The vehicle-registration figures, broken down by weight classes, were taken from statistical reports of the Federal Motor Transport Authority. Fill quantities in refrigeration systems, information on refrigerants used, and details on R12 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 externally, using a refrigerant model based on global new additions of refrigerated containers. 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 area, as in the area of *commercial refrigeration*, are usually not taken directly from series production. They tend to be customised systems, and thus the refrigeration model for this area is similar to that for *commercial refrigeration*. On the other hand, use of fluorine-based refrigerants has not yet become standard practice in industrial applications. In addition, natural refrigerants are used much more frequently, especially in the food industry.

Along with HFCs – which are also used in *commercial refrigeration* – HFC-227ea also plays a role (at higher temperatures).

The refrigeration model used is similar to that used for *commercial refrigeration*. It is thus described in the section for commercial refrigeration.

The emission factors on which the emissions data are based are listed in Table 72.

4.7.1.2.5   *Stationary air conditioning systems (2.F.1.e)*

The category of *stationary air conditioning systems* includes room air conditioners, stationary 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 1999).

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 CFC-22 had been available.

The following refrigeration model is used in this category:

- *Room air conditioners* are divided into the following four 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 internal unit, which translates into an emission factor of 0.025.
- Emissions from stocks are calculated with Equation 2.
- Disposal emissions occurred for the first time in 2008. They are calculated with Equation 3.

The country-specific emission factor (for use) lies within the middle of the range proposed in IPCC-GPG (2000); the estimated service lifetime of 10 years is at the lower boundary of the relevant range.

Emission factors

Ongoing HFC emissions from room air conditioners are estimated to be 2.5%, for all unit types (mobile, single-split, multi-split and VRF multi-split), unit sizes and refrigerant types.

The emission factors used, $EF_{Disposal}$ = 30 % and $EF_{Production}$ = 2.5 %, have been obtained via surveys of experts.

4.7.1.2.5.2   Large air conditioning systems

The most important refrigerant used in such systems is R407C; until 2004, only HFC-134a was used in turbocompressor systems. In 2005, HFC-134a was completely supplanted by the mixture R410A.

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.
- A specific fill amount and specific refrigerant composition are assumed 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 "number of new systems" by $EF_{production}$.
- 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) gives a service lifetime of 10 to 30 years for liquid chiller systems. The values used in the present case lie within this range: 12 years for systems with piston and scroll compressors, 20 years for systems with screw compressors and 25 years for turbocompressor systems.

The filling loss, at 0.01, lies within the value range given by IPCC-GPG (2000).

Emission factors

The emission factor used is 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).

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.

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 will not occur until 2010.

4.7.1.2.6   *Mobile air conditioning systems (2.F.1.f)*

"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. HFC-134a is now the only HFC-based refrigerant used in such systems. Since the 2002 report 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 (automobiles) 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 2003. These are calculated via Equation 3.

Emission factors

The emission factors used were obtained from the literature (e.g. CLODIC & 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.

The EF for filling is half as large as that given in IPCC-GPG (2000: p. 7.52).

The emission factor for disposal of HFC from mobile air conditioners is 0.3. It is thus now in line with the standard value in the IPCC-Guidelines (IPCC 1996b: p. 2.57).

Activity data

New registrations are reported by the Federal Motor Transport Authority.

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 report 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 report year, the emissions for the report 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 data on emissions from mobile air conditioning systems is quite good; in fact, it is better than that for refrigeration systems and stationary air conditioning systems. 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) 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 2010 report.

4.7.1.4   Source-specific recalculations (2.F.1 all)

For refrigerated containers, the average stocks and HFC-134a emissions had to be corrected for the year 2007, since those data were erroneously reported in the last submission. As a result, the relevant emissions have decreased from 44.22 t to 42.25 t.

Data review in a research project (ÖKO-RECHERCHE, 2009a) showed a need for correction of the $EF_{Production}$ for room air conditioners. This, in turn, made it necessary to recalculate the emissions data for production as of 1998. That work led to the changes listed in the following Table 73.

Table 73:   Overview of recalculation-related changes in emissions figures (EM) and emission factors for production of room air conditioners in source category 2.F.1.e

	Units	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HFC-125 EM from production (NIR 2009)	t	0.00001	0.00002	0.00004	0.00004	0.00004	0.00006	0.00007	0.00012	0.00015	0.00025
HFC-125 EM from production (NIR 2010)	t	0.00540	0.01613	0.03680	0.04035	0.03915	0.05507	0.07072	0.11779	0.15300	0.25200
Difference	**t**	**+ 0.00539**	**+ 0.01611**	**+ 0.03677**	**+ 0.04031**	**+ 0.03911**	**+ 0.05502**	**+ 0.07065**	**+ 0.11767**	**+ 0.15285**	**+ 0.25175**
HFC-134a EM from production (NIR 2009)	t	0.00001	0.00003	0.00007	0.00005	0.00005	0.00006	0.00004	0.00007	0.00006	0.00006
HFC-134a EM from production (NIR 2010)	t	0.01123	0.03354	0.07009	0.05490	0.04962	0.05580	0.04029	0.06513	0.05616	0.05824
Difference	**t**	**+ 0.01122**	**+ 0.03351**	**+ 0.07002**	**+ 0.05485**	**+ 0.04957**	**+ 0.05574**	**+ 0.04025**	**+ 0.06506**	**+ 0.05610**	**+ 0.05818**
HFC-32 EM from production (NIR 2009)	t	0.000005	0.00001	0.00003	0.00004	0.00004	0.00005	0.00007	0.00012	0.00015	0.00025
HFC-32 EM from production (NIR 2010)	t	0.00497	0.01484	0.03411	0.03824	0.03724	0.05293	0.06917	0.11528	0.15084	0.24976
Difference	**t**	**+ 0.00496**	**+ 0.01482**	**+ 0.03407**	**+ 0.03820**	**+ 0.03720**	**+ 0.05287**	**+ 0.06910**	**+ 0.11517**	**+ 0.15069**	**+ 0.24951**
EF production (NIR 2009)		0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025
EF production (NIR 2010)		0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Difference	**[%]**	**+ 99.9**	**+ 99.9**	**+ 99.9**	**+ 99.9**	**+ 99.9**	**+ 99.9**	**+ 99.9**	**+ 99.9**	**+ 99.9**	**+ 99.9**

In the area of air conditioners of utility vehicles, the activity rate for disposal in 2007 was changed from 300.11 t to 282.63 t, in a correction necessitated via data review.

Correction of an erroneous value for new registrations of imported automobiles in 1995 made it necessary to recalculate the emissions and stocks data for use and disposal of automobile air conditioners as of 1995. The recalculations led to the changes listed in the following Table 74.

Table 74:   Overview of recalculation-related changes in activity rates (AR) and emissions (EM) for use and disposal of HFC-134a in mobile air conditioners of automobiles in source category 2.F.1.f.

	Units	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
AR stocks (NIR 2009)	t	1249.3	2207.9	3635.6	5436.8	7529.3	9658.5	11721.4	13721.9	15632.7	17509.6	19301.8	20956.4	22364.1
AR stocks (NIR 2010)	t	1294.9	2299.2	3726.9	5528.0	7620.5	9749.7	11812.6	13813.1	15724.0	17600.9	19393.1	21047.7	22409.8
Difference	**t**	**+ 45.6**	**+ 91.3**	**+ 91.3**	**+ 91.3**	**+ 91.3**	**+ 91.3**	**+ 91.3**	**+ 91.3**	**+ 91.3**	**+ 91.3**	**+ 91.3**	**+ 91.3**	**+ 45.6**
EM stocks (NIR 2009)	t	124.93	220.79	363.56	543.68	752.93	965.85	1.172.14	1.372.19	1.563.27	1.750.96	1.930.18	2.095.64	2.236.41
EM stocks (NIR 2010)	t	129.49	229.92	372.69	552.80	762.05	974.97	1.181.26	1.381.31	1.572.40	1.760.09	1.939.31	2.104.77	2.240.98
Difference	**t**	**+ 4.56**	**+ 9.13**	**+ 9.13**	**+ 9.13**	**+ 9.13**	**+ 9.13**	**+ 9.13**	**+ 9.13**	**+ 9.13**	**+ 9.13**	**+ 9.13**	**+ 9.13**	**+ 4.56**
AR disposal (NIR 2009)	t													666.815
AR disposal (NIR 2010)	t													758.084
Difference	**t**													**+ 91.3**
EM disposal (NIR 2009)	t													200.044
EM disposal (NIR 2010)	t													227.425
Difference	**t**													**+ 27.38**

4.7.1.5   Planned improvements (2.F.1 alle)

No improvements are planned at present.

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.

In the national CSE database, the area of foams is divided into hard and soft foams. 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, PU 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 integral-foam and hard-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 foams. HFCs have been giving way to hydrocarbons such as pentane.

The time series, which does not begin until 1996, shows a small initial increase in emissions. Both of these factors – the time of commencement and the small initial increase – 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.

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.

From 2002 to 2004, HFC-227ea was still used for hard foams and integral foams. Use of HFC-134a in production of PUR hard foams was discontinued in 2004.

4.7.2.1.2   Methodological issues (2.F.2)

Emissions are determined by means of Equation 1 and 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 72. In the case of PUR hard foams with HFC-134a, the factors are in line with the standard values given in IPCC-GPG (2000). 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/245fa was increased from 10 % to 15 %, since that HFC mixture has been used increasingly since 2004 in open on-site applications, especially in spray foams.

The emission factor for HFKW-365mfc from stocks was taken from an estimate based on test products.

In the case of integral foams, all of the 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 PUR one-component foams (in cans) used in Germany contain HFC-134a or HFC-152a. As of 4 July 2008, a ban on placing on the market of one-component foams filled with fluorinated greenhouse gases applies, with just a few exceptions, in the EU. Pertinent emissions can be expected to decrease sharply as a result.

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.

Activity data

The following 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[45] or by its industry group EXIBA[46] .

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

---

[45] CEFIC – The European Chemical Industry Council

[46] EXIBA – European Extruded Polystyrene Insulation Board Association

for the export rate) of the HFC-134a contained in products amount 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[47] association or by its EXIBA[48] 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. As a result, the value given refers to boards of medium thickness.

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 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

---

[47] CEFIC – The European Chemical Industry Council

[48] EXIBA – European Extruded Polystyrene Insulation Board Association

have been carried out; such measurements could be considered more conclusive than laboratory values.

4.7.2.5   Source-specific recalculations (2.F.2)

In keeping with new findings obtained via a study of PUR one-component foams, commissioned by the Federal Environment Agency (ÖKO-RECHERCHE, 2009b), the emission factor for production $EF_{Production}$ for HFC-134a and HFC-152a was retroactively changed for the years as of 2003 from 1 g/unit to 0.5 g/unit. In addition, production of PUR one-component foams with HFC-152a was discontinued in Germany in 2004, and not in 2006 as was previously reported. On the other hand, the number of cans of PUR one-component foams with HFC-134a produced in 2006 and 2007 is higher than was previously reported. Changes also resulted in the figures for HFC quantities used in production of cans of PUR one-component foams. For the aforementioned reasons, it was necessary to recalculate all of the time series having to do with production of cans of PUR one-component foams. The recalculations led to the changes listed in the following Table 75.

Table 75:   Overview of the recalculation-related changes in activity rates (AR), emissions (EM) and emission factors in production of PUR one-component foam with HFC-134a and HFC 152a in source category 2.F.2

	Units	2003	2004	2005	2006	2007
AR production, HFC-134a (NIR 2009)	t	424.6	117.4	90.0	92.7	46.3
AR production, HFC-134a (NIR 2010)	t	1050.0	284.0	240.0	189.0	170.0
Difference	**t**	**+ 625.4**	**+ 166.6**	**+ 150.0**	**+ 96.4**	**+ 123.7**
AR production, HFC-152a (NIR 2009)	t	529.6	176.2	60.0		
AR production, HFC-152a (NIR 2010)	t	200.0	100.0	0		
Difference	**t**	**- 329.6**	**- 76.2**	**- 60.0**		
EF production (NIR 2009)	g/can	1	1	1	1	1
EF production (NIR 2010)	g/can	0.5	0.5	0.5	0.5	0.5
Difference	g/can	- 0.5	- 0.5	- 0.5	- 0.5	- 0.5
EM production, HFC-134a (NIR 2009)	t	11.6	3.2	3.0	3.5	1.8
EM production, HFC-134a (NIR 2010)	t	10.9	3.0	2.5	2.1	2.0
Difference	**t**	**- 0.7**	**- 0.2**	**- 0.5**	**- 1.4**	**+ 0.3**
EM production, HFC-152a (NIR 2009)	t	14.4	4.8	2.0		
EM production, HFC-152a (NIR 2010)	t	2.1	1.0	0		
Difference	**t**	**- 12.4**	**- 3.8**	**- 2.0**		

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 (200), 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.

An EF$_{Use}$ is used only for HFC-236fa. That EF, which is based on experts' assessments, increases from 1 % to 5 % by the year 2007, in order to take account of the greater probability of leaks in older systems.

In keeping with the *IPCC Guidelines 2006*, the emission factor for use of HFC-23 is set to 4 % and the emission factor for disposal is set to 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). As a result, not all of the market is covered, since there are other sellers. This fact is addressed via extrapolation on the basis of market shares as 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)

Recalculations for HFC-23 had to be carried out to take account of a) new findings regarding the pertinent installed quantities and b) adjustment of the emission factor for use to the relevant figure given in the IPCC Guidelines 2006. These recalculations led to the following changes:

	Units	2004	2005	2006	2007
HFC-23 emissions from use of fire extinguishers (NIR 2009)	t	0	0.00175	0.00525	0.00875
HFC-23 emissions from use of fire extinguishers (NIR 2010)	t	0.002	0.008	0.016	0.024
Change	t	0.002	0.00625	0.01075	0.01525

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. Such devices have been filled domestically only since 2001. Since 1999, HFC-227ea has been used in addition to HFC-134a.

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 $EF_{Production}$ on which production emissions is based is itself based on very precise producers' data on 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, 1996b, p. 2.61), a 100 % emissions level (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 report year 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 report year 2006, the activity-rate figures for production are based on experts' estimates. As of report year 2007, the activity-rate figures for use are based on such estimates. The surveys of the *Federal Statistical Office* for the area of metered dose inhalers normally do not become available for the corresponding current report year. Retroactive data cross-checking is carried out, however.

4.7.4.2   Other aerosols (2.F.4.b)

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-GL, 1996b, 2.61), a 100 % emissions level for use ($EF_{Use} = 1$) is assumed; this is appropriate and justified. Of the numbers of spray cans sold in Germany, it is assumed, in keeping with the pertinent assumption in IPCC-GPG (2000), that half of the cans are used in the same year they are purchased and the other half are used in the following year.

The $EF_{Production}$ for general-purpose aerosols is based on estimates of experts.

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. In the case of general-purpose aerosols, filling emissions (= production emissions) are also taken into account. 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 has been largely unchanged since 1995.

4.7.4.3.1   *Source-specific recalculations (2.F.4, all)*

No recalculations are required.

4.7.4.3.2   *Planned improvements (source-specific) (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 up 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

No emission factor for production can be defined. 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-4310mee. Since the data are confidential, they are reported, under 2.G, in aggregation with data from production of halocarbons and SF_6 (2.E) and from metal production (2.C.5).

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 have been carried out.

4.7.5.5   Planned improvements (source-specific) (2.F.5)

No improvements are planned at present.

4.7.6   *Semiconductor manufacturing (2.F.6)*

4.7.6.1   Source category description (2.F.6)

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.

4.7.6.2   Methodological issues (2.F.6)

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 exhaust-gas-scrubbing systems. Furthermore, a residue of approximately 10 % per gas bottle must be taken into account as non-consumption.

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.

4.7.6.3   Source-specific recalculations (2.F.6)

No recalculations have been carried out.

4.7.6.4   Planned improvements (source-specific) (2.F.6)

No improvements are planned at present.

4.7.7   Electrical equipment (2.F.7)

This source category consists primarily of use of electrical operating equipment (2.F.7.a), which is further sub-divided into high-voltage (HS – Hochspannungs-), medium-voltage (MS – Mittelspannungs-) and other electrical operating equipment. The area of particle accelerators is reported under 2.F.7.b.

4.7.7.1   Use of electrical operating equipment (2.F.7.a)

4.7.7.1.1   Source category description (2.F.7.a)

In electricity transmission and distribution, SF_6 is used primarily in switching systems and equipment in high-voltage (52-380 kV) and, increasingly, in 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 switching systems (converters, fairleads) or supplied directly to operators (high-voltage converters for outdoor applications).

As a result of first-time inclusion, in the 2002 report 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 equipment". 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" equipment and as a result of again-lower emissions rates in switching systems. In 1996, industry, represented by producers' and operators' associations and the SF_6 producer, committed itself to reducing emissions in life cycles of switching systems 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 applications 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. SF_6 foams were introduced as substitutes in some sub-areas of fairlead applications. This brought about further reductions in specific emissions rates and absolute emissions, even though production continued to increase.

4.7.7.1.2   Methodological issues (2.F.7.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.

Emissions from use:

Ongoing emissions from products in service include the amount of SF_6 in service, as accumulated since 1970 via annual additions of switching systems; they are given as the average for year n.

The final amount of SF_6 in all electrical equipment 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 switching systems 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 switching systems:

- 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 switching systems, because operators/manufacturers estimated the SF_6 stocks in service for 1995. Their estimate was broken down into high voltage and medium voltage (770 t and 157.6 t, respectively).
- In the area of high-voltage systems, 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 equipment (gas-insulated switchgear (GIS), power switches, outdoor converters). Emission factors determined on the basis of reference systems are then applied to such stocks data.

- The group of operators of medium-voltage switching systems is very numerous and highly diverse. It is thus not feasible to conduct direct surveys. Manufacturers of medium-voltage systems 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, 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 switching systems 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 amounts of SF_6 (AR), from old systems (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 operating equipment, and stocks of medium-voltage switching systems, are reported to the Federal Environment Agency by the German Electrical and Electronic Manufacturers' Association (ZVEI), while stocks of high-voltage switching systems, outdoor-mounted converters, gas-insulated lines and transformers are reported by the Association of German network operators (VDN) 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.

The following Table shows the 2007 inventory data, broken down by sub- source categories, along with pertinent explanations. The sum total for electrical operating equipment for energy transmission and distribution agrees with the data in Table 2 (II)F, Sheet 2, source category 2.F.8 in the CRF.

Source category 2.F.7 – electrical operating equipment for energy transmission and distribution, with sub- source categories – 2008 inventory	Activity data			Emissions	
	Annual consumption, production	Stocks	Decommissioned	Production	Operation
	(Tonnes of SF$_6$)				
Electrical operating equipment for energy transmission and distribution 2.F.8 (Total), including:	914.6	1860	3.1	14.9	7.6
MV switching systems and equipment (in hermetically sealed pressurised systems)*	180.0	747.1	0.21	1.0	0.7
HV switching systems and equipment (in hermetically sealed pressurised systems)**	651.7	952.6	7.03	5.2	6.4
Other electrical operating equipment ***	82.7	160.2	IE	8.7	0.4

IE= included in "HV switching systems…"; 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 outdoor-mounted voltage transformers (all emissions categories) + gas-insulated lines (GIL) (all emissions categories) + high-voltage fairleads (only production emissions) + medium-voltage cast-resin voltage transformers (only production emissions) + testing of medium-voltage components (only production emissions) + 1000V capacitors (only production emissions)

4.7.7.1.3   *Uncertainties and time-series consistency (2.F.7.a)*

Since there are only about ten different manufacturers of operating equipment (including fairleads and converters), 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' model labels. 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, as well as 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 switching systems 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, an unusual development occurred in high-voltage in-service stocks and, thus, in emissions, both of which had been increasing since 1995: a decrease with respect to

the previous year. For in-service stocks, the decrease amounted to over 25 t, while for emissions it amounted to 0.85 t. This decrease, which is due to trends in high-voltage gas-insulated switching systems (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 these changes, personnel assignments relative to operating equipment in service were repeatedly changed. As a result, double-counting cannot be ruled out in 1999, nor can the possibility be ruled out that some systems were not included in 2000. Apart from these aspects, the uncertainty today – now that a stable state has been attained – 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.

4.7.7.1.4   *Source-specific recalculations (2.F.7.a)*

A slight correction had to be made in the stocks of medium-voltage (MS) systems. That correction led to the following emissions changes:

	Units	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Use emissions, medium-voltage (MS) switches and systems (NIR 2009)	t	0.266	0.313	0.350	0.386	0.431	0.482	0.526	0.575	0.629	0.686
Use emissions, medium-voltage (MS) switches and systems (NIR 2010)	t	0.271	0.308	0.344	0.389	0.440	0.485	0.530	0.578	0.632	0.689
Change	t	**0.005**	**-0.005**	**-0.006**	**0.003**	**0.009**	**0.003**	**0.004**	**0.003**	**0.003**	**0.003**

4.7.7.1.5   *Planned improvements (source-specific) (2.F.7a)*

No improvements are planned at present.

4.7.7.2   **Use in particle accelerators (2.F.7.b)**

4.7.7.2.1   *Source category description (2.F.7b)*

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.

4.7.7.2.2   *Methodological issues (2.F.7.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 receives 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.

4.7.7.2.3   Uncertainties and time-series consistency (2.F.7.b)

The uncertainties for this source category have been systematically quantified.

4.7.7.2.4   Source-specific recalculations (2.F.7b)

No recalculations have been carried out.

4.7.7.2.5   Planned improvements (source-specific) (2.F.7b)

No improvements are planned at present.

4.7.8   Other (2.F.8)

This source category comprises the uses *Insulating glass windows* (2.F.8.a), *Automobile tyres* (2.F.8.b), *Sport shoes* (2.F.8.c), *Trace gas* (2.F.8.d), *AWACS maintenance* (2.F.8.e), *Welding* (2.F.8.f), *Optical glass fibres* (2.F.8.g) and *Photovoltaics* (2.F.8.h).

4.7.8.1   Insulating glass windows (2.F.8.a)

4.7.8.1.1   Source category description (2.F.8.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, soundproof windows are produced by numerous companies and filled with gas as is necessary. 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 come, and will continue to come, primarily from open waste management of old windows, 25 years (assumed time) after they were filled. For this reason, total emissions are expected to continue growing until the year 2020.

4.7.8.1.2   Methodological issues (2.F.8.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 soundproof windows 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 the 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 E_{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). Practical reasons – the large number of manufacturers involved (nearly 400) – preclude any double-checking via bottom-up survey (manufacturers' purchase data). Since 2006, data for annual new consumption are checked against the *Federal Statistical Office's* pertinent annual surveys.

4.7.8.2   Automobile tyres (2.F.8.b)

4.7.8.2.1   Source category description (2.F.8.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 largest annual consumption occurred in 1995, when over 500 of the some 3,500 tyre-sales outlets in Germany had the option of 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 automobile tyres filled with fluorinated greenhouse gases. The bulk of today's emissions originates from gas in older filled tyres.

4.7.8.2.2   *Methodological issues (2.F.8.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 of gas suppliers, regarding their domestic sales to tyre dealers and automobile service centres. Since 2006, consumption data are checked against the *Federal Statistical Office's* pertinent annual surveys.

4.7.8.3   Sport shoes (2.F.8.c)

4.7.8.3.1   *Source category description (2.F.8.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 was followed throughout Europe. Beginning in 2004, PFC-218 (C_3F_8) was used. Use of that substance was discontinued in 2006, and now nitrogen is used in most cases. 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.

4.7.8.3.2   *Methodological issues (2.F.8.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, together with data for aircraft radar, welding and production of SF_6.

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.

4.7.8.4   Trace gas (2.F.8.d)

4.7.8.4.1   Source category description (2.F.8.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, total domestic use of SF_6 as a trace gas has been down sharply from previous years.

4.7.8.4.2   Methodological issues (2.F.8.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. Since 2006, data are checked against the Federal Statistical Office's pertinent annual surveys.

4.7.8.5   AWACS (airborne warning and control system) maintenance (2.F.8.e)

4.7.8.5.1   Source category description (2.F.8.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 very high, since SF_6 is released to equalize pressure as aircraft climb.

4.7.8.5.2   Methodological issues (2.F.8.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, together with data on sport-shoe soles, welding applications and production of SF_6, since the data are confidential.

4.7.8.6   Welding (2.F.8.f)

4.7.8.6.1   Source category description (2.F.8.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.

4.7.8.6.2   Methodological issues (2.F.8.f)

Because they confidential, data on consumption and emissions in connection with welding are reported under CRF 2.G, together with data for applications in sport shoes, for AWACS maintenance and for production of SF_6.

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 consumption figures are obtained via surveys of gas suppliers, with regard to their domestic sales. Since 2007, data for annual new consumption are checked against the Federal Statistical Office's pertinent annual surveys.

4.7.8.7   Optical glass fibre (2.F.8.g)

4.7.8.7.1   Source category description (2.F.8.g)

Use of SF_6 in production of optical glass fibre began in 2002. In production of optical glass fibre, SF_6 is used for fluorine doping. Numerous production operations are in place in Germany.

4.7.8.7.2   Methodological issues (2.F.8.g)

Emissions occur in production of optical glass fibre cable.

Emission factors

The 2006 IPCC Guidelines[49] 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 applied.

Activity data

The annual consumption figures are obtained via surveys of gas suppliers, with regard to their domestic sales. Since 2007, data for annual new consumption are checked against the Federal Statistical Office's pertinent annual surveys.

4.7.8.8   Photovoltaics (2.F.8.h)

4.7.8.8.1   *Source category description (2.F.8.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 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.

4.7.8.8.2   *Methodological issues (2.F.8.h)*

As 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 gas purification systems.

Emission factors

Use of waste-gas purification systems in Germany is not as wide as the use assumed for calculation of the IPCC emission factor. For this reason, the IPCC's Tier-2 emission factor[50] is increased from 0.4 to the value $EF_{Production} = 0.5$.

Activity data

The annual consumption figures are obtained via surveys of gas suppliers, with regard to their domestic sales. Since 2007, data for annual new consumption are checked against the *Federal Statistical Office's* pertinent annual surveys.

4.7.8.9   Uncertainties and time-series consistency (2.F.8, all)

In the case of insulating glass windows, since 2006 data from the top-down survey of annual new consumption, carried out on the basis of of commercial sales data, have been compared with data from the *Federal Statistical Office's* pertinent annual surveys. This procedure, which

---

[49] IPCC GL 2006, Vol. 6, chapter 6: Electronics Industry
[50] IPCC GL 2006, Vol. 6, chapter 6: Electronics Industry, Table 6.5

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.

4.7.8.10   Source-specific recalculations (2.F.8, all)

No recalculations have been carried out.

4.7.8.11   Planned improvements (source-specific) (2.F.8, all)

No improvements are planned at present.

4.7.9   Source-specific quality assurance / control and verification (2.F, all)

Quality control and quality assurance (pursuant to Tier 1 & 2), 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 these 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[51], production and sales figures[52], etc.) are consulted, and experts (users, refrigerant manufacturers, suppliers, etc.) are consulted to determine the sources' reliability.

The data for electrical equipment and semiconductor production have undergone an internal association process of quality assurance / control and verification.

4.8   Other areas (2.G.)

For reasons of confidentiality, SF_6 emissions from *production of SF_6* (2.E Production of halocarbons and SF_6), from use in *sport shoes* (2.F.8.c Other – sport shoes), from use in *AWACS maintenance* (2.F.8.e Other – AWACS maintenance), from use in *welding* (2.F.8.f Other – welding) and from *aluminium production* (2.C.4 Metal production: SF_6 in aluminium and magnesium production) are reported under 2.G.

---

[51] Surveys pursuant to Art. 11 of the Environmental Statistics Act (UstatG).

[52] Surveys pursuant to the Foreign Trade Statistics Act (AHStatGes) and production statistics.

HFC emissions from HFC production (2.E Production of halocarbons and SF_6), from solvent use (2.F.5 Solvents) and from metal production (2.C.5 Metal production: Other) are reported under 2.G, for reasons of confidentiality.

PFC emissions from PFC production (2.E Production of halocarbons and SF_6), from use in sport shoes (2.F.8.c Other – sport shoes) and from industrial refrigeration (2.F.1d Industrial refrigeration) are reported under 2.G, for reasons of confidentiality.

No other sources of greenhouse-gas emissions are known.

5   SOLVENTS AND OTHER PRODUCT USE (CRF SECTOR 3)

5.1   Overview (CRF Sector 3)
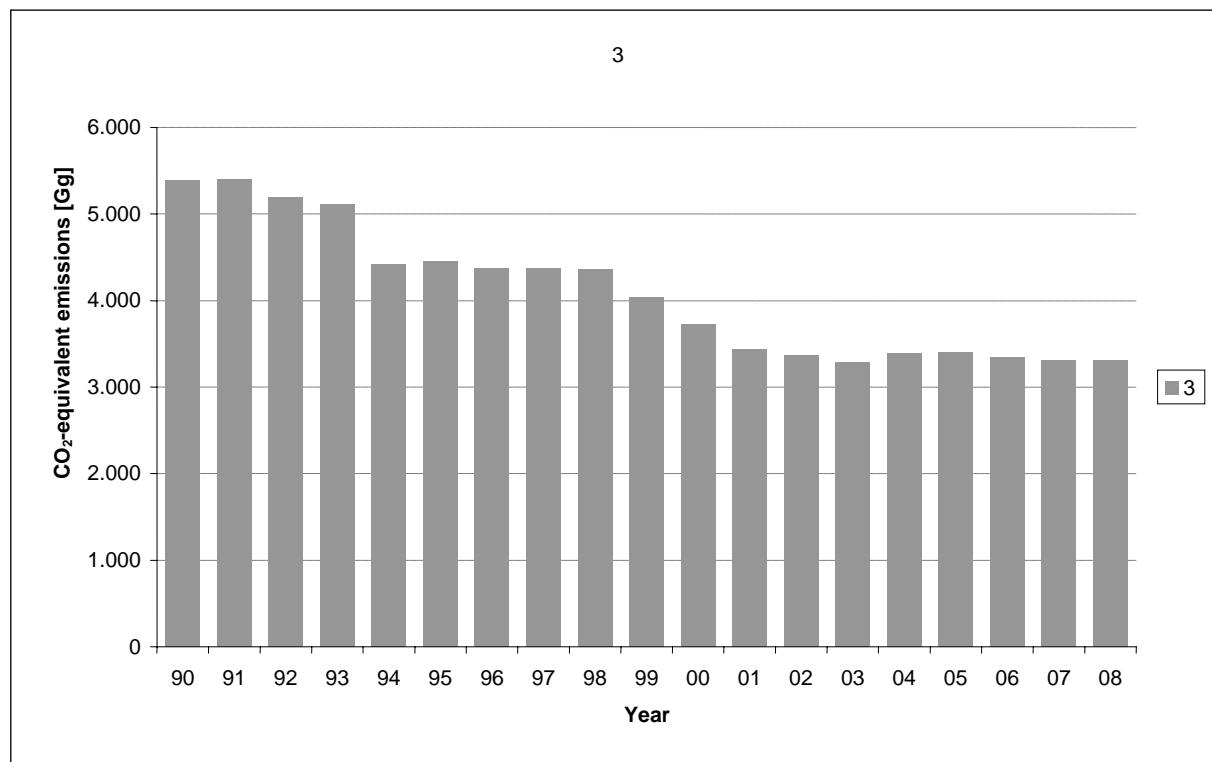
Figure 28:   Overview of greenhouse-gas emissions in CRF Sector 3

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 *Painting and lacquering* (3.A), *Degreasing, dry cleaning* (3.B), *Production and use of chemical products* (3.C) and *Other solvent uses* (3.D). *Other* (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 3A through 3C.

The N_2O emissions from source category 3.D *Other solvent uses* 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 3A - 3C, 3D (NMVOC)				
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	CS	NO	NO	NO	NO	CS	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

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 source.

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 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[53] .

Source category 3.D *Other solvent uses* 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[54]. For purposes of the definition of solvents, the term "solvent use" is also defined in keeping with the EC solvents directive[55].

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

---

[53]In the present area, this involves "SNAP Level 3" detailing.

[54] 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.

[55] 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.

(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 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 issues (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 the sub-categories 3.A – 3.D, 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, so the data, NMVOC emissions from use of solvents and solvent-containing products have decreased by nearly 38 %. The main emissions reductions have been achieved in the years since 1999. This successful reduction has occurred especially as a result of regulatory provisions such as 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 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 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 have been calculated for the first time. The following relationship was used for pertinent conversion:

$$EM_{Indirect\ CO2} = EM_{NMVOC} * \text{molar mass } CO_2 / \text{molar mass } C * 75\%$$

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)

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.

5.2.5 Source-specific recalculations (3.A-3.C & 3.D)

No recalculations were carried out.

5.2.6 Planned improvements (source-specific) (3.A-3.C & 3.D)

No improvements are planned at present.

5.3   Other - N$_2$O (3.D)

5.3.1   Narcotic use of N$_2$O (3.D.1)

5.3.1.1   Source category description (3.D.1)

CRF 3.D.1					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF) N$_2$O als Anästhetika						CS				
EF uncertainties in %										
Distribution of uncertainties						N				
EF-determination method						CS				

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$_2$O-emissions source. In addition, food-technology applications, and various other technical applications, can be considered possible sources.

N$_2$O in medical applications

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$_2$O is not prohibited, there is strong resistance – especially in the German medical sector – against widespread, general use of the substance.

Use of xenon as an anaesthetic could bring about a further reduction of N$_2$O emissions. Xenon is the only noble gas that exhibits anesthetic properties at normal pressure. The narcotic effects of xenon are 1.5 times stronger than those of nitrous oxide. The gas was certified in fall 2005 for use in Germany. Certification for the entire EU region is expected to follow later. On the other hand, in light of its overall properties and its availability, xenon can only serve as a supplement to nitrous oxide – and not as a substitute for it.

The 1990 figure for N$_2$O 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$_2$O 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 1200 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$_2$O emissions of 6200 t were estimated, as a rough approximation, for Germany in 1990. The N$_2$O figure for 2001 was obtained via a written memorandum 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. Due to a lack of other data, a linear reduction of N_2O use in this sector is assumed between 1990 and 2001.

The reduction in N_2O use in this period results from acceptance of the "low-flow method"[56] and a "Say-no-to-N_2O" posture. Use would increase in future only if nitrous oxide were commonly used to assist mothers giving birth (as is customary in the U.S. and the UK) or if it became an accepted painkiller in trauma medicine. Since no reliable figures are available to support assumptions that the reducing trend will continue, a conservative perspective is applied, in the framework of a "worst-case scenario", and N_2O emissions are expected to remain constant as of 2004. The reference to this assumption as a "worst-case scenario" is based on the fact that N_2O use shows a falling trend since 1990.

N_2O use in the food industry

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 food to which N_2O is added include whipped cream (from spray cans), the dairy product known in Germany as "quark", and various types of desserts, such as ready-to-eat puddings. (DIE VERBRAUCHER INITIATIVE E.V, 2005; LINDE GAS GMBH, 2005)

Relevant research was not able to turn up any data from which the amounts and trends of N_2O emissions in the food sector could be derived. The agency commissioned to carry out the research[57] was informed, however, that the N_2O amounts involved are small (less than 5 %) and thus are insignificant.

N_2O in technical applications

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).

In automotive technology, nitrous oxide is used to improve combustion in gasoline / petrol engines, via so-called "laughing-gas injection". This "tuning" tactic can quickly increase engine performance. In Germany, relevant systems are not certified by the TÜV technical certification agency. They are thus illegal and are not considered in the present context.

For the technical-applications sector, there is also a lack of any statistics that could be used to estimate N_2O emissions. At the same time, the amount of N_2O in question is considerably smaller than the relevant N_2O-emissions amounts from medical applications. As a result, this sector plays a minor role in the area of "product use"[58].

---

[56] The "low-flow method" is a form of anaesthesia in which only very small amounts of fresh gas are used; this can greatly reduce N_2O emissions (Schmidt, 2001)

[57] Personal communication from the Industriegaseverband e.V. (IGV) industrial-gas association

[58] Written communication from the Industriegaseverband e.V. (IGV) industrial-gas association

5.3.1.2   Methodological issues (3.D.1)

With regard to development of N_2O-emissions time series for product use, to date only N_2O emissions from medical applications have actually been determined. At the same time, this approach is justified, since this sector is the main source of N_2O emissions in the area of product use, accounting for 90 % of such emissions (SCHÖN et al., 1993, page 82). The remaining 10 % can be broken down into technical applications (less than 10 %[59]) and food-technology applications (less than 5 %[60]) . From this information, the pertinent share for the *food-technology industry* is estimated at 3 %, and thus the corresponding share for the *technical use* area is estimated at 7 %, the difference between the total remaining share (10 %) and the 3 % for foods.

The N_2O-applications distribution in 2001 is 90 % for medical applications and 10 % for food technology and technical uses (i.e. as a sum). In the time-series trend, a constant N_2O-emissions level is assumed in the *other* area, since no detailed figures on trends in this sector are available.

In product use (medical and other applications), the input nitrous oxide escapes into the air directly and completely. As a result, the emission factor for this sector is 1 t/t, for all years in question.

5.3.1.3   Uncertainties and time-series consistency (3.D.1)

The uncertainty in the time-series trend for product use results from the following data spectrum and assumptions:

- N_2O use in 2001: 3,000 t ~ 3,500 t/a
- Constant level, or linear reduction of N_2O emissions from 2002 to 2004

From these figures, values for maximum and minimum N_2O emissions can be estimated. The reference figure for the uncertainty calculation is defined as 3250 t/a. In the process, the aforementioned distribution is retained (medical applications in 2001 at 90 %; constant N_2O level for the "other" sector between 1990 and 2005). These figures lead to the following theoretically possible combinations:

1. N_2O emissions in 2001, 3,500 t/a;
    constant level for N_2O emissions from 2002 through 2004
2. N_2O emissions in 2001, 3,500 t/a;
    linear reduction of N_2O emissions from 2002 through 2004
3. N_2O emissions in 2001, 3,000 t/a;
    constant level for N_2O emissions from 2002 through 2004
4. N_2O emissions in 2001, 3,000 t/a;
    linear reduction of N_2O emissions from 2002 through 2004

Consequently, 1) shows the maximum possible N_2O quantity, and 4) shows the minimum N_2O quantity. The following uncertainties thus result: Between 1990 and 2001, a symmetric uncertainty can be seen in both directions (U_{min} and U_{max}). From 1990 to 2001, U_{max} shows a linear increase in the uncertainty that reaches a level of 8 %. As of 2001, this value remains constant. U_{min} also shows a linear progression between 1990 and 2001. Its increase as of 2001 is much larger, however, reaching an uncertainty level of +/- 40 % in 2005.

---

[59] Personal communication from the Industriegaseverband e.V. (IGV) industrial-gas association
[60] Personal communication from the Industriegaseverband e.V. (IGV) industrial-gas association

With these results, the time series can be considered to show a normal distribution (distribution type).

The uncertainty in the emission factors 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.

5.3.1.4 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.

The figures for 2001 were obtained via direct enquiry of the IGV; as a result, the data for that year can be considered to be of higher quality. No data verification was carried out for the other years in question.

5.3.1.5 Source-specific recalculations (3.D.1)

No recalculations are required.

5.3.1.6 Planned improvements (source-specific) (3.D.1)

No improvements are planned at present. At the same time, plans call for close co-operation with the Industriegaseverband e.V. industrial-gas association to continue in future, so that it will remain possible to obtain data.

5.3.2 Explosives (3.D)

5.3.2.1 Source category description (3.D)

CRF 3.D					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -				

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF) Explosives						CS				
EF uncertainties in %						±40 %				
Distribution of uncertainties						N				
EF-determination method						CS				

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:

$$NH_4NO_3 \longrightarrow N_2O + 2H_2O$$
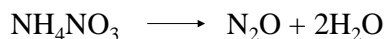
But in a fast, detonative reaction of an AN-containing explosive, the reaction occurs as follows:

$$NH_4NO_3 \longrightarrow 2H_2O + N_2 + 0,5O_2$$
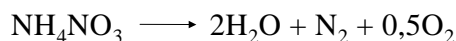
This means that under high pressure and temperature AN primarily forms nitrogen, oxygen and water as it reacts. Only a small concentration of primarily formed N_2O remains intact in the detonation process. For example, detonation clouds of amatols[61] , which contain some 80 % AN, have only 0.1 mole 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 44g/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 formation in detonation of explosives with ammonium nitrate

In 2003, a total of 59 kt of explosives was produced in Germany. Of this figure, 13 kt were exported abroad, and 5.8 kt were imported into the Federal Republic of Germany[62]. This yields 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[63], 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).

---

[61] Amatol x/y : military explosives. pourable mixtures, i.a. of x % TNT and y % ammonium nitrate

[62] Personal communication: Federal Office for Material Research and Testing (BAM).

[63] 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

5.3.2.2   Methodological issues (3.D)

According to the *Federal Office for Material Research and Testing* (BAM), levels of explosives use in Germany remained constant from 1990 to 2005.

The N_2O-emissions amount estimated above represents only the theoretically maximum emittable amount. No information is available as to distribution, i.e. as to the number of detonations that would be required to emit this maximum amount of N_2O. For this reason, it is also assumed here that detonations are carried out primarily as "controlled" detonations[64], and that thus the maximum N_2O-emissions levels are seldom attained.

No figures are available to permit determination of the amounts of N_2O emissions actually emitted upon detonations. The above figure (68 g N_2O per kg AN) is a theoretical one, and it could be far off the actual value. When a 5 % emissions rate is assumed, the N_2O amount is 3.4 g. This figure is of the same order as the maximum emissions rate (2 g) given by BENNDORF (1999, page 4), a figure that corresponds to about 3 % of the above-determined theoretical maximum N_2O emissions level. For a "worst-case scenario", the time-series trend in this project is calculated using the higher value (3.4 g).

To determine the relevant emission factors in kg/t, the explosives amounts involved are used. With the above-presented time-series trend for N_2O emissions, the time-series trend for the pertinent emission factors can also be obtained.

5.3.2.3   Uncertainties and time-series consistency (3.D)

It is not known how explosives use has developed over the years in question. What is more, N_2O emissions are not measured upon detonation, as industry sources report, and thus no information regarding average amounts of N_2O emissions can be provided. Here, it is assumed that the reference value for the uncertainty calculation is 5 % of the theoretically attainable maximum value. Within the framework of an experts' assessment, the minimum amount is set at 3 % (cf. Chapter 5.3.2.2). The same deviation (2 %) is used for the maximum value, and thus U_{max} is 7 %. A normal distribution is assumed.

5.3.2.4   Source-specific quality assurance / control and verification (3.D)

The data for this source category were collected by an external expert, on behalf of the Federal Environment Agency. Quality control was carried out by the external expert.

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.

Nearly no data have been published relative to determination of N_2O emissions from explosives use. An experts' assessment was carried out this year relative to the emission factors. If the quality of the emission factors is to be improved, emissions and usage data for each type of explosive will be required.

5.3.2.5   Source-specific recalculations (3.D)

No recalculations are required.

---

[64] A "controlled" detonation is one on which an effort is made to achieve an ideal detonation. In an ideal detonation, chemical reactions within the detonation front are practically complete. Factors such as temperature, pressure, fuzes, etc. can influence such reactions.

5.3.2.6   Planned improvements (source-specific) (3.D)

No improvements are planned at present.

6   AGRICULTURE (CRF SECTOR 4)

6.1   Overview (CRF Sector 4)

Preliminary remarks: As a result of methods changes that were made in the area of agriculture, recalculations had to be carried out for the period until 1990. In some cases, such as that of nitrous oxide emissions from soils, this results in that an international review of the 2009 report concluded that the new 2006 IPCC Guidelines could not be used. This made it necessary, for the present report, to return to the methods used until 2008. For all reported years, the increases seen in agricultural emissions, in comparison to the relevant previous-year figures (cf. NIR 2009), are due primarily to the methods changes. These changes are described in detail in chapters 6.2.5, 6.3.2.5, 6.3.4.5, 6.5.5 "recalculations" and 10.1.1.2 and 10.1.1.4.
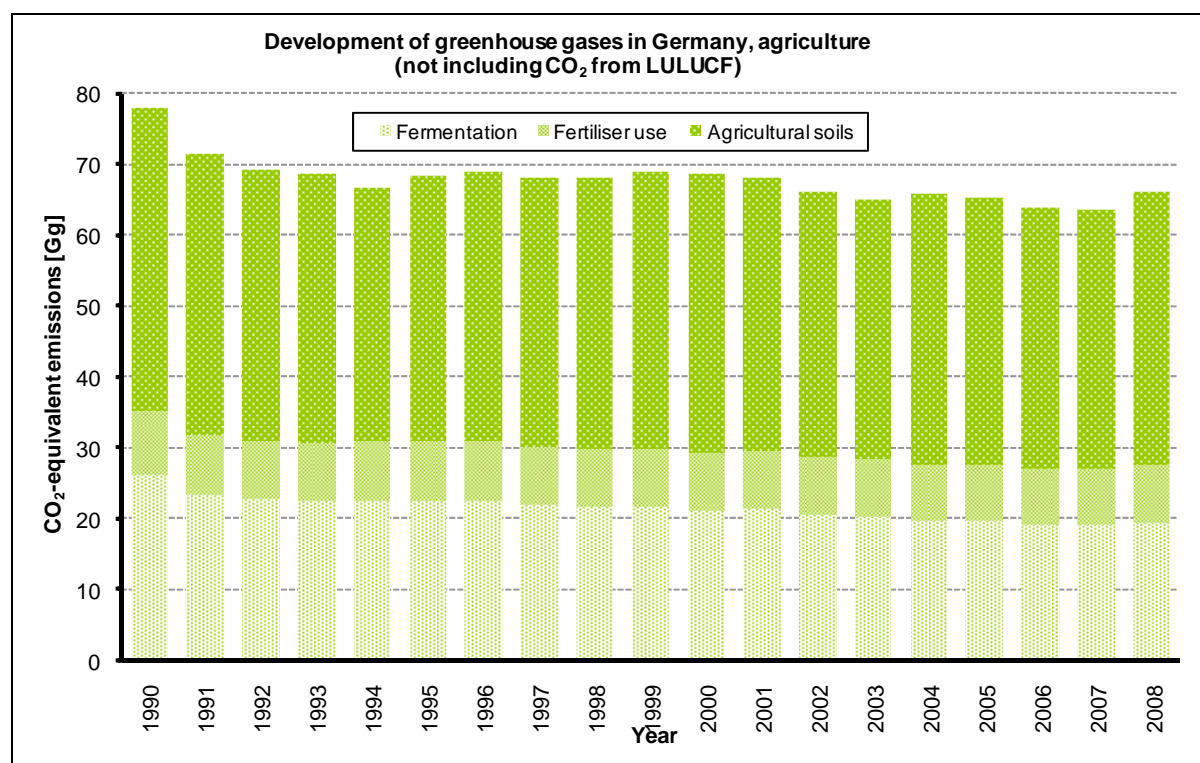
Figure 29:   Overview of greenhouse-gas emissions in CRF Sector 4

6.1.1   Detailed report, and manuals used

The following remarks amount to a summary of the detailed report on preparation of the 2010 emissions inventory, for the years 1990 to 2008, that will go to press in early 2010[65] (HAENEL et al., 2010).

The German inventories for the gases methane (CH_4), non-methane volatile organic compounds (NMVOC), carbon dioxide (CO_2), ammonia (NH_3), nitrous oxide (N_2O) and nitrogen monoxide (NO) from agricultural sources have been prepared with the help of the relevant manuals (UN ECE: EMEP, 2003; EMEP, 2006; IPCC Guidelines: IPCC, 1996b; IPCC 2006, IPCC Good Practice Guidance: IPCC, 2000) as well as with the help of other substantiated sources.

---

[65] The detailed report is also available in electronic form at: dieter.haenel@vti.bund.de.

Chapter 19.4 presents a detailed description of the reasons why the 2006 IPCC Guidelines 2006 were used instead of the 1996 IPCC Guidelines, for those instances in which such substitution was made.

6.1.2   Emissions

Source category 4, "Agriculture", in Germany 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).

Dinitrogen (N_2) emissions levels have to be known before the relevant N quantities added to the soil can be calculated – i.e. before relevant indirect emissions can be determined. While these emissions have been calculated, they are not reported separately.

The CO_2 emissions from agricultural soils that are tied to use of urea were calculated with the help of the data records used for the area of "agriculture". While those calculations are described in the present context, they are not reported under CRF 4. Instead, they are reported in CRF 5 (IV), since CO_2 emissions cannot be reported under CRF.

The CO_2 emissions from agricultural soils that are tied to use of agricultural lime are described and reported under CRF 5.

The following chapters describe the various pertinent emissions contributions.

An overview of the greenhouse-gas emissions (CO_2 equivalents) calculated in the German inventory is presented in connection with determination of the greenhouse-gas inventory's total uncertainty, in Chapter 6.1.5, Table 83.

6.1.3   Characterisation of animal stocks

6.1.3.1   Animal categories (CRF 4.A, 4.B)

The total animal population is divided into main and sub-categories for which activity data and emission factors are available. Disaggregation is carried out only where emission factors differ significantly. The following table compares the German sub-categories and the IPCC proposals.

Table 76:   Characterisation of animal stocks pursuant to IPCC, and the categories used in the German inventory

	IPCC main categories	**IPCC sub-categories**	**Germany**
Cattle	Dairy cows	Subdivision into two or more yield classes	Dairy cows, 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
			Young female cattle (heifers)
			Young male cattle (fattening bulls)
Swine	Mature swine	Pregnant sows Farrowing sows	Sows (including suckling pigs)
		Boars	Boars
	Growing swine	Suckling pigs Fattening pigs Replacement	Weaners
			Fattening pigs
Sheep	Ewes	Pregnant ewes Dairy sheep	Sheep, ewes, 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 stall 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, donkeys and mules, fur-bearing animals, buffalo, geese

Columns 1 and 2 pursuant to IPCC (2006)

In the German inventory, 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, weaners, fattening pigs and boars.

For the category "sheep" (CRF 4.A.3), it proved necessary to consider lambs and other sheep separately; the results are reported in aggregated form, for "sheep", however.

The category "poultry" (CRF 4.A.9) is divided into the categories of laying hens, broilers, geese, ducks, male turkeys and female turkeys. For turkeys, male and female birds differ so markedly in terms of feeding and weights that they have to be considered separately.

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 sub-categories were aggregated following the calculations.

6.1.3.2   Activity data (CRF 4.A, 4.B)

Livestock herd/flock counts, i.e. the numbers of animal places used for production, were taken, where available, from official German agricultural statistics. The animal censuses cover all cattle, pigs, horses and sheep and all poultry.

The Agricultural Statistics Act (Agrarstatistikgesetz) was amended in 1998. This changed the survey bases for determining herd sizes – considerably, in some cases. Impacts were seen especially in numbers of horses and sheep. Therefore, correction factors were derived, to permit standardised description of the time series (DÄMMGEN, 2005).

In all likelihood, the number of horses in Germany is up to twice as large as the relevant figure from agricultural statistics, since many of the horses in question are not kept in agricultural operations (horses kept for recreational use). This fact is reflected in the high uncertainty of the horse counts; cf. Chapter 6.1.5.

As of the 2008 inventory, cattle head counts are taken from a special database (HIT) in which each animal is registered. As a result, the relevant numbers of animals are higher than in earlier years, when, due to the cut-off definitions used, official statistics failed to include all animals concerned.

Animal census results for German districts are available for every second year in the period until 2007. For the years in between and thereafter, the relevant animal head counts are available only at the Länder level. For reasons of data protection, unpublished district-level data records are incomplete. In co-operation with the Federal Statistical Office, the inventory was prepared with inclusion of the pertinent confidential data.

German agricultural statistics do not include herd-size figures for goats, asses and mules, fur animals and buffalo. Such figures are obtained elsewhere:

In the past, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) estimated the goat populations for the entire national territory. The Federal Statistical Office then continued that time series for 2005 and 2006. Since 2007, the 2006 figure has been used in the inventory, since the Federal Statistical Office no longer provides goat-herd counts.

As to asses and mules, about 6,000 to 8,000 asses, and about 500 mules and hinnies, are kept in Germany (Deutsches Eselstammbuch, 2003). No time series is available for the relevant animal head counts. Provisionally, the number of asses and mules involved is estimated to be 8,500 for each year. No figures for asses and mules are reported.

The relevant figures for buffalo are provided by Deutscher Büffel-Verband (the German Buffalo Association) for the years 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", the time series for the buffalo population was completed for the years prior to 2000. This was accomplished via linear extrapolation. In the process, arithmetically negative animal populations resulted for the years 1990 to 1995 and were replaced with "zero".

As a result of the need to form maximally homogeneous animal categories, some of the officially defined animal categories have to be modified. The herd-size figures used in the inventory for calves, heifers, fattening bulls, weaners, fattening pigs, laying hens and pullets diverge from the relevant figures in the official statistics. In the "turkey" category, roosters and hens have to be considered separately. The total for all cattle, the total for all swine, the sum

of the figures for pullets and laying hens, and the sum of the figures for turkey roosters and turkey hens are each in accordance with the official statistics, however. As a result of the above-mentioned corrections, the figures for sheep and horses diverge in part from the relevant official statistics.

The animal population figures on which the inventory is based are presented in the following Table 77. The head counts for cattle, swine and sheep have decreased. The numbers of horses and goats, and total poultry populations – especially the populations of broilers and of turkeys considered in the present context – have increased. With regard to the uncertainties for the animal population figures, cf. Chapter 6.1.5.

Table 77:   Numbers of animal places used for purposes of the inventory (4.A, 4.B)

(in thou-sands)	Dairy cows	Other cattle	Swine	Sheep	Goats	Horses	Donkeys and mules	Buffalo	Poultry
1990	6354.6	13133.4	30818.8	3309.6	90	491	8.5	0	113878.7
1991	5632.5	11502.3	26063.7	2872.4	86	491	8.5	0	113951.7
1992	5365	10843	26514.9	2765.8	90	531	8.5	0	103661.6
1993	5301	10596.6	26075.8	2775.6	92	531	8.5	0	103734.6
1994	5273.1	10689.8	24698.4	2766.5	95	598.8	8.5	0	109948.3
1995	5229.2	10661.2	23737	2799.1	100	598.8	8.5	0	110035.5
1996	5194.7	10564.8	24283	2753.9	105	652.4	8.5	0.048	112507.4
1997	5026.4	10201.1	24795.2	2669.9	115	652.4	8.5	0.172	112507.4
1998	4833	10109.5	26294.1	2669.9	125	652.4	8.5	0.297	112507.4
1999	4765.1	10131.5	26101.2	2723.6	135	735.2	8.5	0.421	118303
2000	4569.8	9968.3	25633.2	2743.3	140	735.2	8.5	0.626	118303
2001	4548.6	10054.5	25783.9	2771.1	160	789.7	8.5	0.625	122056.1
2002	4427.4	9560.3	26103	2721.6	160	789.7	8.5	0.755	122056.1
2003	4371.4	9273	26322.1	2697	160	822	8.5	0.894	123407.7
2004	4285.1	8910.9	25659.1	2713.6	160	822	8.5	1.021	123407.7
2005	4236.4	8799.2	26857.7	2643.1	170	784.9	8.5	1.187	120562.3
2006	4081.8	8667.1	26521	2560.8	180	784.9	8.5	1.324	120562.3
2007	4071.2	8615.5	27125.3	2537.8	180	846.4	8.5	1.541	126862.5
2008	4217.7	8752	26686.8	2437	180	846.4	8.5	1.793	126862.5

6.1.3.3   Additional information (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 output, 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, digestibility and feed efficiency). To divide officially recorded total numbers of turkeys 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.

Data such as frequency distributions relative to feeding, to husbandry methods (shares for pasturing/stabling; shares for various housing methods), to types of storage and to techniques for spreading farm manure 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), which is operated and developed by the Institute of Rural Studies of the vTI (Federal Research Institute for Rural Areas, Forestry and Fisheries). For a pertinent introduction, cf. WEINGARTEN (1995); a detailed description is provided in HENRICHSMEYER et al. (1996).

The data that enter into RAUMIS include 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 Agriculture (herd-size-class distribution) and survey data. Where relevant statistical data are missing, models are formulated with the aid of experts.

The following section presents a compilation of additional animal-husbandry data of key relevance to yields.

Table 78:   Mean animal weights (4.B)

(kg/animal)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	583.3	600.7	614.6	625.8	627.9	624.7	626.9	624.6	629.5	633.0
Other cattle	266.7	265.8	275.7	279.7	279.4	278.8	282.8	281.2	285.5	287.9
Swine	64.9	65.0	65.3	65.6	66.4	66.8	67.3	67.0	66.7	66.3
Poultry	1.77	1.79	1.81	1.76	1.73	1.71	1.68	1.69	1.74	1.71
(kg/animal)	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	637.6	646.6	644.1	640.5	638.1	639.1	640.1	642.0	638.3	
Other cattle	290.2	289.6	287.2	286.1	285.6	285.6	289.9	293.5	288.6	
Swine	65.9	65.8	66.3	66.7	67.1	66.5	66.7	67.3	67.1	
Poultry	1.80	1.91	1.82	1.93	2.16	2.19	2.16	2.28	2.27	

In the category of swine, updated animal weights for sows and boars were taken into account.

Due to a lack of pertinent time series, constant weight figures are assumed for other animal categories (Haenel et al., 2010): sheep, 50 kg/animal; goats, 40 kg/animal; horses, 484 kg/animal; asses and mules, 245 kg/animal; and buffalo, 700 kg/animal.

Table 79:   Mean daily milk yield for dairy cows (kg/day) (4.A)

(kg/day)	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/day)	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Milk yield	16.6	17.0	17.2	17.9	18.0	18.5	18.8	19.0	18.7	

In comparison to earlier inventories, a lower per-cow milk yield results. The reason for this is that, as of the 2008 inventory, dairy-cow head counts are taken from a special database (HIT) in which each animal is registered. As a result, the relevant numbers of animals are higher than in earlier years, when, due to the cut-off definitions used, official statistics failed to include all animals concerned. (The procedures for preparing milk statistics have remained unchanged.).

Table 80:   Average pregnancy levels (4.A).

(%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	75.5	74.5	78.1	79.7	79.2	79.2	79.9	79.3	79.1	79.4
Heifers, suckling cows	53.8	54.5	56.7	56.6	57.5	57.9	58.0	58.5	59.2	59.2
Sows	65.7	68.5	66.8	66.2	67.7	68.0	67.6	66.3	68.7	65.9
(%)	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	78.1	78.6	76.1	77.1	78.0	77.9	77.8	79.5	79.1	
Heifers, suckling cows	60.0	61.4	60.6	60.9	60.5	60.2	59.7	59.8	59.2	
Sows	68.1	69.7	69.9	69.8	69.5	70.6	71.1	73.2	71.7	

For buffalo, an average pregnancy level of 25 % is assumed. No pertinent figures are available (NA) for horses, asses and mules, sheep and goats.

Table 81:   Mean daily gross energy ingestion (GE) (4.A)

(MJ/animal)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	269.1	274.2	283.4	288.5	288.0	291.1	295.0	296.9	301.5	304.7
Other cattle	100.5	101.9	104.9	105.6	104.2	104.8	105.3	104.9	105.3	105.6
Swine	23.1	23.9	23.7	23.8	24.0	24.3	24.4	24.6	24.8	24.5
(MJ/animal)	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	308.9	314.3	315.9	319.4	320.4	324.0	325.7	328.6	325.2	
Other cattle	106.1	106.3	105.6	105.8	105.3	105.6	105.9	106.3	105.5	
Swine	24.6	24.6	24.7	24.8	24.8	24.8	24.8	25.0	25.1	

IPCC, 1996b: Tab. A-4, p. 4.35) gives daily GE ingestion figures of 20 MJ/animal for sheep, 14 MJ/animal for goats, 110 MJ/animal for horses and 60 MJ/animal for asses and mules. The 1996 IPCC Guidelines (1996b, Tab. B-2, p. 4.42) give a value of 119 MJ/animal for buffalo. Those data do not enter into German emissions calculation, however. No data are available (NA) for poultry.

Table 82:   Feed digestibility (4.A)

(%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	74.5	74.6	74.9	74.9	74.7	74.8	74.9	74.9	75.0	75.1
Other cattle	73.3	73.1	72.9	72.7	72.8	72.6	72.5	72.4	72.4	72.3
Swine	72.5	74.9	71.9	71.9	72.2	72.3	72.2	72.2	72.1	71.6
(%)	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	75.1	75.3	75.3	75.4	75.4	75.5	75.6	75.6	75.5	
Other cattle	72.3	72.3	72.4	72.4	72.3	72.3	72.3	72.4	72.4	
Swine	71.7	71.4	71.5	71.6	71.6	71.5	71.4	71.6	71.7	

With regard to other animals, reference is made to IPCC default values: relevant figures are presented in the 2006 IPCC Guidelines (Tab. 10A-9, p. 10.82) for sheep (60 %), goats (60 %), horses (70 %) and asses and mules (70 %); no figures are presented for buffalo, however. For buffalo, IPCC (1996) gives a digestibility figure of 55 %. For poultry, neither the 2006 IPCC Guidelines nor the 1996 IPCC Guidelines provide digestibility data (NR).

The following chapters present further information relative to animal husbandry – for example, excretion data (VS, N) and key data on manure management.

6.1.4   *Characterisation of agriculturally used soils*

Direct emissions of CO_2 and N_2O in the area of agriculturally used soils occur via spreading of mineral and farm fertiliser, via use of urea, from crop residues, from cultivated organic

soils, via grazing and via spreading of sewage sludges. Indirect N_2O emissions occur as the result of deposition of reactive nitrogen and via nitrogen leaching and surface run-off.

To describe the various emissions-relevant processes at work, one must collect a large range of different types of data. This requirement is discussed in Chapters 6.5.2 and 6.5.3.

6.1.5   *Uncertainty of the German greenhouse-gas inventory*

For this inventory, and in addition to the emissions calculations, a first-ever calculation of the total uncertainty of the German greenhouse-gas inventory was carried out – cf. Table 83. The basis for this work consisted of the Tier 1 procedure described in IPCC GPGAUM (2000) "Quantifying Uncertainties in Practice". That procedure consistently employs Gaussian error calculation. By way of convention, that method's requirement for a normal distribution is ignored; some of the activity data and emission factors employed do not fulfill that requirement. Furthermore, Gaussian error calculation is oriented to use of standard deviations. In contrast to that orientation, the Tier 1 procedure 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. In a normal distribution, that value amounts to about double the standard deviation. It can be shown, however, that the calculation rules for Guassian error calculation (cf. Equ. 6.3 and Equ. 6.4 in IPCC GPGAUM, 2000) also apply to multiples of the standard deviation. Consequently, a value of double the standard deviation (as a percentage of the mean value) was used in the calculation, shown in Table 83, of the total uncertainty of the German greenhouse-gas inventory in the case of normally distributed values.

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.

With regard to the sources for all of the uncertainty data entering into the total uncertainty calculation for the GG inventory, we refer to HAENEL et al. (2010).

At this juncture, it is useful to note the procedure applied to N_2O emissions from storage. Since such emissions are calculated in the framework of the N-flow concept (cf. Chapter 6.3.3.1), a procedure in which they are indirectly influenced by NH_3 emissions from stalls, the uncertainty of the N_2O emission factor from farm manure management was estimated, for the first time ever, on the basis of Gaussian error calculation (HAENEL et al., 2010). The calculation results indicated that a value of 53 % may be assumed as the uncertainty of the N_2O emission factor for emissions from storage, for all animals. In view of the manner in which it was calculated, that value may be characterised as a standard deviation. On that basis, the value half the 95 % confidence interval was approximated as 100 % of the mean value.

The complexity of the emissions-relevant processes described in the German agricultural-sector inventory precludes any comprehensive use of Gaussian error calculation in the manner described for the N_2O emission factor for emissions from storage. The only recourse in this area would be to use the Tier 2 method pursuant to IPCC (2000) (Monte Carlo method), a recourse for which the staffing and technical resources are currently lacking.

The following Table 83 shows the total uncertainty of the agricultural section of the German greenhouse-gas inventory in the form of half the 95 % confidence interval. All emissions values are given as CO_2 equivalents; the underlying conversion factors (GWP) are 21 kg kg^{-1} for CH_4 and 310 kg kg^{-1} for N_2O.

The CO_2 emissions from use of lime fertiliser and urea have also been taken into account, even though they are not reported under CRF 4.

It should be noted that the uncertainty for the cattle and buffalo head counts has decreased over the years. For this reason, an estimated mean value of the activity uncertainty is used in the calculation. Comparative calculations have shown that the precision of these estimated uncertainties has no impact on the total uncertainty of the greenhouse-gas inventory.

The uncertainty given for poultry relative to the emission factor for CH_4 from farm-manure management (half the 95 % confidence interval), 40 %, does not take account of the higher relevant value that applies to ducks and geese (60 %), since those groups contribute only slightly to CH_4 emissions from management of farm manure from poultry. Sample calculations have shown that the precision of the uncertainty value for all poultry is of no consequence for the greenhouse-gas inventory's total uncertainty.

On the other hand, as column H in Table 83 indicates, the greenhouse-gas inventory's total uncertainty is influenced to a considerable degree by the uncertainties for the N_2O emissions from the area of agricultural soils (with the exception of the contributions from biological N fixing, grazing and sewage-sludge application, which are relatively small).

Table 83:　　　Uncertainties calculation for the agricultural section of the German greenhouse-gas inventory

Source category	Gas	Base year emissions, in CO$_2$ equivalents	Year 2008 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 2008	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 acticity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg a-1	Gg a-1	%	%	%	%	%	%	%	%	%
Soils, liming	CO2	2753.6	1967.1	20	0	20.0	0.6	0.00	0.02	0.00	0.69	0.69
Soils, urea application	CO2	479.6	647.9	20	0	20.0	0.2	0.00	0.01	0.00	0.23	0.23
Enteric fermentation, dairy cows	CH4	13119.4	10080.2	6	40	40.4	5.9	-0.01	0.12	-0.50	1.05	1.17
Enteric fermentation, other cattle	CH4	11747.1	8178.4	6	40	40.4	4.8	-0.02	0.10	-0.86	0.86	1.22
Enteric fermentation, pigs	CH4	590.1	553.0	10	40	41.2	0.3	0.00	0.01	0.03	0.10	0.10
Enteric fermentation, sheep	CH4	556.0	409.4	20	60	63.2	0.4	0.00	0.01	-0.04	0.14	0.15
Enteric fermentation, goats	CH4	9.5	18.9	20	60	63.2	0.0	0.00	0.00	0.01	0.01	0.01
Enteric fermentation, horses	CH4	169.7	290.5	100	60	116.6	0.5	0.00	0.00	0.11	0.51	0.52
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	2.1	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, dairy cows	CH4	2484.2	2398.9	6	40	40.4	1.4	0.00	0.03	0.15	0.25	0.29
Manure management, other cattle	CH4	1585.8	1033.7	6	40	40.4	0.6	0.00	0.01	-0.15	0.11	0.19
Manure management, pigs	CH4	2212.3	2176.8	10	40	41.2	1.3	0.00	0.03	0.15	0.38	0.41
Manure management, sheep	CH4	15.2	11.2	20	60	63.2	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, goats	CH4	0.3	0.7	20	60	63.2	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, horses	CH4	26.3	45.0	100	40	107.7	0.1	0.00	0.00	0.01	0.08	0.08
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	0.3	10	60	60.8	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, poultry	CH4	57.0	81.0	20	40	44.7	0.1	0.00	0.00	0.02	0.03	0.03
Manure management, dairy cows	N2O	1160.6	971.9	6	100	100.2	1.4	0.00	0.01	-0.01	0.10	0.10
Manure management, other cattle	N2O	1135.0	768.3	6	100	100.2	1.1	0.00	0.01	-0.24	0.08	0.25
Manure management, pigs	N2O	150.2	70.6	10	100	100.5	0.1	0.00	0.00	-0.07	0.01	0.07
Manure management, sheep	N2O	18.2	13.6	20	100	102.0	0.0	0.00	0.00	0.00	0.00	0.01
Manure management, goats	N2O	1.1	2.2	20	100	102.0	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, horses	N2O	53.2	91.0	100	100	141.4	0.2	0.00	0.00	0.06	0.16	0.17
Manure management, mules, asses	N2O	0.6	0.6	100	100	141.4	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, buffalo	N2O	0.0	0.3	10	100	100.5	0.0	0.00	0.00	0.00	0.00	0.00
Manure management, poultry	N2O	38.0	47.2	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 2008 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 2008	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 acticity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg a-1	Gg a-1	%	%	%	%	%	%	%	%	%
Soils, mineral fertilizers	N2O	13174.7	11004.4	20	80	82.5	13.2	0.00	0.14	-0.13	3.84	3.84
Soils, application of manure	N2O	7227.7	6110.7	60	80	100.0	8.9	0.00	0.08	0.00	6.39	6.39
Soils, N fixing crops	N2O	855.1	464.9	50	80	94.3	0.6	0.00	0.01	-0.25	0.41	0.48
Soils, crop residues	N2O	6610.3	7651.3	50	80	94.3	10.5	0.03	0.09	2.03	6.67	6.98
Soils, organic soils	N2O	5079.2	5008.8	20	200	201.0	14.7	0.01	0.06	1.76	1.75	2.48
Soils, grazing	N2O	2117.5	1661.8	40	200	204.0	4.9	0.00	0.02	-0.32	1.16	1.20
Soils, indirect emissions (deposition)	N2O	2791.3	2428.3	50	400	403.1	14.3	0.00	0.03	0.34	2.12	2.14
Soils, indirect emissions (leaching, run-off)	N2O	4699.4	4210.9	300	230	378.0	23.2	0.00	0.05	0.67	22.03	22.04
Soils, sewage sludge emissions	N2O	166.9	158.0	20	80	82.5	0.2	0.00	0.00	0.02	0.06	0.06
Total		81087.3	68561.9									
uncertainty in total national emissions in 2008 as half the 95% confidence interval (%)							37.6					24.6

In keeping with IPCC, GWP CH_4 = 21, GWP N_2O = 310

6.1.6   Quality assurance and control

6.1.6.1   Review of input data and inventory results

Numerous input data were checked for errors resulting from erroneous transfer between data sources and the tabular database used for emissions calculations. As part of a redesign of the animal models for the categories "dairy cows" and "swine", the available data sources were comprehensively reviewed for currentness. The review was then extended to include the category "other cattle". In connection with review of the pertinent comprehensive report (cf. Chapter 6.1.1), numerous calculation pathways and data flows were also checked.

At the conclusion of this year's inventory preparation process, as the results were entered into the CSE (cf. Chapter 6.1.6.2), the results were checked again, via comparative calculations within the CSE framework.

6.1.6.2   Quality System for Emissions Inventories

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

6.1.6.3   Comparisons with the results of the previous year's NIR

Comparisons with results in the previous year's NIR are conducted in the framework of source-specific recalculations (cf. the relevant sub-chapters below). The results of such comparisons are used to check the current year's inventory results.

6.1.6.4   Verification (comparisons with other countries' results)

The German inventory results are also checked via comparisons with other countries' results. That process is discussed in the following, in the relevant sub-chapters.

6.1.6.5   Reviews and Synthesis & Assessment Reports

The agricultural section of the 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. The highlighted shortcomings (use of Tier-1 methods in calculation of emissions from keeping of cattle; lack of calculations for goats) were promptly eliminated.

In June 2006, the German inventory was reviewed in the framework of the "Initial Review under the Kyoto Protocol and Annual 2006 Review under the Convention". In the pertinent final report, completion of the time series for buffalo populations was recommended. The present inventory follows up on that recommendation.

Comments provided in the Synthesis & Assessment Reports were addressed via specific, targeted review of calculation procedures.

6.2   Enteric fermentation (4.A)

6.2.1   Source category description (4.A)

CRF 4.A				
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
Enteric fermentation, dairy cattle (CRF 4.A.1.a)	l / -	CH_4	1.07 %	1.05 %	stagna-ting
Enteric fermentation, non-dairy cattle (CRF 4.A.1.b)	l / t	CH_4	0.95 %	0.85 %	falling

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NO	CS/ D	NO	NO	NO	NO	NO	NO	NO	NO
EF uncertainties in %		-40/ +60								
Distribution of uncertainties		N								
EF-determination method		CS/D/T1 /T2								

Within the source category *Enteric fermentation*, the sub- source category *Dairy cows* (4.A.1.a) is a key source of CH_4 emissions in terms of level; the sub- source category *Other cattle* (4.A.1.b) is a key source in terms of level and trend.

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 efficiency and feed composition.

Germany reports on emissions of methane (CH_4) from enteric fermentation in the stomachs of dairy cows, other cattle (calves, heifers, bulls, suckling cows, stud bulls), swine, sheep, goats, horses, mules and asses and buffalo. Methods are lacking for treating poultry in this context (NA); in accordance with the IPCC (1996b, Chapter 4, Tab. A-4), the relevant quantities are considered negligible and are not calculated (NO).

CH_4 emissions from enteric fermentation, as a percentage of total CH_4 emissions from the German agricultural sector, have decreased slightly (1990: 80.4 %; 2008: 77.3 %).

6.2.2   Methodological issues (4.A)

6.2.2.1   Methods

IPCC (2006) calls for use of a more detailed calculation method (Tier 2) in cases in which methane emissions from animal husbandry are listed as a key source. In analysis of key sources in German agriculture, CH_4 emissions from dairy cows and other cattle in category 4 A, "Enteric fermentation", have been identified as key sources. For this reason, CH_4 emissions from cattle are calculated in accordance with the Tier-2 method. The fact that suckling calves are not ruminants was taken into account in relevant calculations. Even though swine do not constitute a key source, the emissions pertaining to them (with the exception of stud boars) were also calculated in accordance with the Tier-2 method. CH_4 emissions from all other relevant mammals (sheep, goats, horses, mules and asses, buffalo) were calculated via the Tier-1 method.

In principle, in both methods the emissions are calculated via the following steps:

- Determination of relevant characteristics and emissions of homogeneous livestock herds (animal categories, sub- source categories)

- Determination of activity data, i.e. of the relevant numbers of animals involved, by animal type (main category) and by sub-categories based on age, sex and weight
- Determination of emission factors for each relevant category
- Calculation of total emissions as a product of a) number of animals and b) emission factor

In the simpler Tier-1 method, default emission factors are used. In the Tier-2 method, country-specific / region-specific and time-dependent emission factors are calculated from correspondingly variable figures for gross energy intake. Such energy intake figures are obtained via calculation of feed intake, which depends on useful-energy requirements (or net energy for lactation in dairy cows) and the energy content of the pertinent feed. The applicable methane-conversion factor is also significant; cf. Chapter 6.2.3.

A more detailed description of the relevant procedure is provided by HAENEL et al. (2010).

For the present inventory, the dairy-cow model's "excretions" module was thoroughly revised, taking account of feed characteristics and quantities (DÄMMGEN et al., 2009b). That work included correlation with feed types (mixed grass/corn/concentrated-feed and grass/concentrated-feed), for each relevant rural district, and definition of typical feed compositions and characteristics. The previous module for calculation of emissions from enteric fermentation in dairy cows was supplanted with an approach that takes account of feed composition.

In addition, derivation of living weights from slaughter weights was updated for dairy cows; this resulted in higher weight figures and higher energy requirements. Furthermore, TAN-based (TAN = total ammoniacal nitrogen) NH_3 emission factors were derived for stalls and storage (DÄMMGEN et al., 2009c[66]). Such factors are significant with regard to use of the N-flow concept (cf. Chapter 6.3.3.1) – inter alia, for calculation of N_2O and NO emissions from farm-manure management.

Calculation of the inventory's head-count figures for calves, heifers and stud bulls, on the basis of statistical data, has been improved. As a result, the head-count figure used for calves is 1/3 lower than the figure used in earlier submissions, and the figures for heifers and stud bulls are correspondingly higher. In one consequence, this change has increased the mean-weight figure, and the methane-conversion factor, for "other cattle". Furthermore, the slaughter weights for heifers and stud bulls have been recalculated. For heifers in particular, this has yielded considerably higher final weights.

For heifers, transfer errors in the figures for mean-energy content of feed, and conversion errors in calculation of N ingested with feed, have been corrected. Even though the animal-weight figures have increased as a result, lower N excretions have been calculated, as well as correspondingly lower emissions of N species. In a related result, NMVOC emissions tied to NH_3 emissions also decreased.

For stud bulls, daily weight gains were calculated on the basis of an improved database. The new weight-gain figures are somewhat higher than the earlier figures. Since final weights have not changed, a shorter fattening period results. That has slightly lowered energy requirements as summed over the entire fattening period. And that result, in turn, has led to lower N excretions and, thus, to lower emissions of N species. This has entailed a slight

---

[66] In preparation for publication in connection with the detailed report; cf. Chapter 6.1.1

decrease in NMVOC emissions tied to NH_3 emissions. New N_2O emission factors, higher than those formerly used, have had a similar effect; as a consequence of their use, less N is available for NH_3 emissions.

For swine, the calculation of the head counts of relevance for the inventory was revised, since it had emerged that the percentage of suckling pigs within the official head-count statistics for young pigs was larger than had previously been assumed. This is significant, since suckling pigs are counted along with sows. In addition, differentiation between the categories of weaners and fattening pigs was revised, since it emerged that the official young-pig figures on which the "fattening pigs" inventory category was based included not-inconsiderable numbers of animals that belong within the "weaners" inventory category. Overall, the shifting throughout the spectrum of animal head counts resulted in lower numbers for the "fattening pigs" inventory category, while net head counts within the "weaners" inventory category remained nearly unchanged. These effects, in turn, lowered the average animal weight and the methane-conversion factor in the "swine" category, with regard to last year's inventory.

For all swine categories, calculation of usable energy requirements was revised on the basis of recent literature (GfE, 2006). In addition, for sows, the previously used simple parametrisation of N excretions was supplanted with a complete animal N balance sheet that takes account of energy requirements. For weaners, calculation of average weight gains, and the key figures for relevant feed, were updated.

TAN-based NH_3 emission factors for stalls and storage were also derived for swine (DÄMMGEN et al., 2009d, in preparation for publication in connection with the pertinent detailed report; cf. Chapter 6.1.1).

Under the assumption that the husbandry framework for buffalo is similar to that for dairy cows, the TAN content of buffalo N excretions was raised to the level typical for dairy cows. Also in this area, the partial emission factors for NH_3 emissions from stalls were brought into line with the relevant figures for dairy cows.

For all straw-based housing systems, the pertinent straw quantities were reviewed for currentness and adjusted as necessary. For periods of all-day pasturing, the need to consider the straw quantities used for straw bedding does not apply.

For all animals, transcription errors within the module for farm-manure management were eliminated (transformation TAN/N_{org} for liquid manure). For animals that produce liquid manure, the TAN levels in storage are somewhat lower as a result – and, thus, the pertinent emissions are lower as well.

6.2.2.2   Activity data and additional information (4.A)

With regard to animal head counts, we refer to Chapter 6.1.3.2. The data on gross energy intake (GE) are provided in Chapter 6.1.3.3. The methane-conversion factor, averaged for all housing systems, for dairy cows, other cattle and swine is shown in the following table.

Table 84:   Methane-conversion factor (4.A)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	5.58	5.55	5.51	5.48	5.49	5.47	5.45	5.45	5.43	5.41
Other cattle	6.16	6.17	6.16	6.15	6.15	6.15	6.16	6.17	6.17	6.15
Swine	0.525	0.543	0.521	0.521	0.523	0.524	0.523	0.523	0.523	0.519
[%]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
Dairy cows	5.40	5.38	5.37	5.36	5.35	5.34	5.33	5.32	5.34	
Other cattle	6.15	6.16	6.15	6.15	6.16	6.14	6.15	6.15	6.14	
Swine	0.519	0.517	0.518	0.519	0.519	0.518	0.517	0.518	0.520	

National data were used to calculate the methane-conversion factor for dairy cows and calves. For mother cows, heifers, fattening bulls and stud bulls, the methane-conversion factors given in IPCC (2006), Table 10.12, were used.

Since IPCC (2006) does not provide any factors for swine, the inventory uses the value recommended in IPCC (1996b), 0.6 %. In the inventory, emissions are not calculated separately for weaners (weaners are included in the "sows" category). Since the average methane-conversion factor must refer to the totality of all swine, however (including weaners), a calculated conversion factor results that is smaller than the default value used.

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. At the same time, IPCC (2006, Table 10.13) gives a value of 4.5 % for lambs and a value of 6.5 % for adult sheep; the value given in IPCC (1996b: Table A-4), 6 %, seems to be a plausible average. For buffalo, IPCC (2006: Table 10.12) gives a conversion factor of 6.5 %. On the other hand, IPCC (2006) does not provide any figures for goats, horses and mules and asses. IPCC (1996b: Table A-4), gives a value of 5 % for goats and a value of 2.5 % for horses, mules and asses.

No figures are given for poultry (NA).

6.2.2.3   Calculated emissions (4.A)

The CH_4 emissions from enteric fermentation, for all German animal husbandry, are listed in Table 85.

Table 85: CH_4 emissions E_{CH4} from animal husbandry (enteric fermentation) (4s1.A)

[Tg a^{-1} CH$_4$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	1.25	1.12	1.09	1.08	1.07	1.07	1.07	1.04	1.03	1.03
[Tg a^{-1} CH$_4$]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
E_{CH4}	1.01	1.02	0.98	0.97	0.94	0.93	0.91	0.92	0.93	

In Germany, almost all CH_4 emissions from enteric fermentation come from keeping of cattle. Dairy cows are the most important source category within the cattle category. The emissions reduction seen since 1990 (in conjunction with increasing emission factors for dairy cows, heifers, fattening bulls, fattening pigs, sows and weaners; and constant emission factors for all other animals) is a result of decreases in the numbers of animals kept (especially decreases in the period 1990/1991, resulting from German reunification). These decreases, in turn, can be explained as the result of changing dietary patterns on the part of consumers, as well as of increases in yields per individual animal (milk production, weight gains).

The following tables list emissions for dairy cows, other cattle, swine and sheep. The relevant contributions from other animals are extremely low by comparison.

Table 86: CH_4 emissions from enteric fermentation (4.A.1.a)

[Tg a^{-1} CH$_4$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	0.62	0.56	0.55	0.55	0.55	0.55	0.55	0.53	0.52	0.52
Other cattle	0.56	0.50	0.48	0.47	0.47	0.47	0.47	0.45	0.45	0.45
Swine	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Sheep	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
[Tg a^{-1} CH$_4$]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	0.50	0.50	0.49	0.49	0.48	0.48	0.46	0.47	0.48	
Other cattle	0.45	0.45	0.43	0.41	0.40	0.39	0.39	0.39	0.39	
Swine	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
Sheep	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	

6.2.2.4   Emission factors (4.A)

Table 87 shows the trends in mean emission factors $IEF_{CH4, ent}$ for dairy cows, other cattle and swine.

Table 87: CH_4 emission factors for animal husbandry (enteric fermentation) (4.A.1.a)

[kg pl^{-1} a^{-1} CH$_4$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	98.3	100.1	102.3	103.7	103.6	104.4	105.5	106.0	107.2	108.1
Other cattle	42.6	43.4	44.4	44.7	44.1	44.3	44.5	44.4	44.6	44.7
Swine	0.91	0.94	0.93	0.94	0.95	0.96	0.96	0.97	0.98	0.96
[kg pl^{-1} a^{-1} CH$_4$]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	109.2	110.8	111.2	112.1	112.4	113.4	113.9	114.7	113.8	
Other cattle	44.9	45.0	44.7	44.7	44.5	44.6	44.7	44.9	44.5	
Swine	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.99	

The emission factors for the group of other cattle can be broken down as follows (by way of example for 2008):

Table 88: CH_4 emission factors IEF_{CH4} (enteric fermentation) for other cattle, and relevant default values from IPCC (2006) for comparison

Sub-category	EF_{CH4} [kg place^{-1} a^{-1} CH$_4$]
Calves	4.3
Heifers	41.3
Bulls	55.4
Suckling cows	61.4
Stud bulls (mature males)	77.5
IPCC (2006) default	57

For sheep, goats, large horses and buffalo, the default emission factors pursuant to IPCC (2006)-10.28 were used. The result for horses deviated overall from the IPCC default value, since a smaller emission factor (12 kg place^{-1} a^{-1} CH$_4$) was used in calculations for small horses. The following table shows the emission factors used.

Table 89:   Emission factors: Default values (EF_d) pursuant to IPCC (2006: 10-28, Table 10.10), and the resulting emission factors used in the present report (IEF)

Animal category	EF_d pursuant to IPCC (2006-10.28) [kg place^{-1} a^{-1} CH$_4$]	IEF after application of national data records for 2008 [kg place^{-1} a^{-1} CH$_4$]
Sheep	8	
Goats	5	
Horses	18	16.3
Donkeys and mules	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, we refer to Chapter 6.1.5 (total uncertainty of the German GG inventory). All the time series are consistent.

6.2.4   Source-specific quality assurance / control and verification (4.A)

With regard to source-specific QA/QC and verification, we refer to Chapter 6.1.6.

For purposes of verification, and in light of dairy cows' great share of methane emissions from enteric fermentation, the present Chapter presents a comparison of a) emission factors (IEF) and other relevant data from German dairy-cattle husbandry in 2008 and b) relevant data of neighbouring countries and of the UK (from the year 2007, UNFCCC Submission 2009). The comparison shows that the emission factor calculated for Germany, for dairy cattle, compares well with the other values.

Table 90:   Methane emissions from enteric fermentation in dairy cows, in various countries – a comparison of Implied Emission Factors (IEF); Figures for Germany for 2008; data of other countries for 2007.

	IEF_{CH_4}	Milk yield	Weight	Pregnant-cow percentage
	[kg place^{-1} a^{-1} CH$_4$]	kg place^{-1} d^{-1}	[kg animal^{-1}]	[%]
Austria	115.04	16.43	700	90
Belgium	118.29		1200	
Czech Republic	115.33	18.08	585	90
Denmark	130.55	23.53	575	90
Germany	**113.81**	**18.69**	**653**	**79**
France	117.84	17.37		
Netherlands	128.99			
Poland	95.88	12.12	500	84
Switzerland	110.78			
UK	105.02	19.14	577	

Source (except for figures for Germany): UNFCCC 2009

6.2.5   Source-specific recalculations (4.A)

In comparison to the NIR 2009, the following main changes have resulted for 2007 (cf. Table 91 and Table 92):

*   The methane-conversion factor for dairy cows increased for earlier years (for 1990, by about 8 %), while the value for 2007 hardly changed at all. This is due to the revision of the dairy-cow model (cf. Chapter 6.1.3).

For other cattle, the methane-conversion factor increased by about 3 % for all years in question. This is due to changes in calculation of figures for calves, heifers and fattening bulls (cf. Chapter 6.1.3).

For swine, the methane-conversion factor increased by about 5 % for all years in question. This is due to changes in calculation of figures for weaners and fattening pigs (cf. Chapter 6.1.3).

Table 91:   Comparison of the methane-conversion factors used in 2010 and in 2009 (4.A)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2010	5.58	5.55	5.51	5.48	5.49	5.47	5.45	5.45	5.43	5.41
Dairy cows, 2009	5.17	5.17	5.21	5.22	5.22	5.23	5.25	5.26	5.26	5.28
Other cattle, 2010	6.16	6.17	6.16	6.15	6.15	6.15	6.16	6.17	6.17	6.15
Other cattle, 2009	5.98	6.01	5.99	5.98	5.98	5.98	5.99	6.00	6.01	5.97
Swine, 2010	0.525	0.543	0.521	0.521	0.523	0.524	0.523	0.523	0.523	0.519
Swine, 2009	0.551	0.548	0.549	0.550	0.551	5.550	5.550	5.550	5.550	0.547
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows, 2010	5.40	5.38	5.37	5.36	5.35	5.34	5.33	5.32	5.34	
Dairy cows, 2009	5.29	5.30	5.29	5.31	5.31	5.32	5.33	5.33		
Other cattle, 2010	6.15	6.16	6.15	6.15	6.16	6.14	6.15	6.15	6.14	
Other cattle, 2009	5.97	5.98	5.98	5.98	5.98	5.96	5.98	5.98		
Swine, 2010	0.519	0.517	0.518	0.519	0.519	0.518	0.517	0.518	0.520	
Swine, 2009	0.548	0.546	0.547	0.548	0.547	0.547	0.546	0.547		

Methane emissions from enteric fermentation in dairy cows have increased sharply (although this effect decreased over the years in question: 1990: about 35 %; 2007: ca. 24 %). Along with the higher methane-conversion factor, the main reason for this is that calculation with the new dairy-cow model has yielded higher energy requirements.

Methane emissions from enteric fermentation in other cattle also increased sharply (although this effect decreased over the years in question: 1990: about 10 %; 2007: ca. 5 %). This is due primarily to the higher numbers of heifers and fattening bulls that calculations have yielded (cf. Chapter 6.1.3).

Methane emissions from enteric fermentation in swine have decreased (1990: about 12 %; 2007: ca. 16 %). The main reason for this is that recalculation of swine head counts has sharply decreased the numbers of fattening pigs and correspondingly increased the numbers of sucklng pigs. The impacts of the other changes in the models for the various swine categories are insignificant by comparison (cf. Chapter 6.1.3).

- All in all, the total methane emissions from enteric fermentation in German animal husbandry have increased as a result of the changes (with a decreasing effect over the years in question: 1990: about 20 %; 2007: ca. 14 %).

Table 92:   Comparison of the CH₄ emissions from enteric fermentation as reported in 2010 and in 2009 (4.A)

[Tg a⁻¹ CH₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2010	1.25	1.12	1.09	1.08	1.07	1.07	1.07	1.04	1.03	1.03
Total, 2009	1.04	0.92	0.90	0.91	0.90	0.90	0.91	0.88	0.88	0.88
Dairy cows, 2010	0.62	0.56	0.55	0.55	0.55	0.55	0.55	0.53	0.52	0.52
Dairy cows, 2009	0.46	0.41	0.41	0.42	0.41	0.42	0.42	0.40	0.40	0.40
Other cattle, 2010	0.56	0.50	0.48	0.47	0.47	0.47	0.47	0.45	0.45	0.45
Other cattle, 2009	0.51	0.44	0.44	0.43	0.42	0.43	0.43	0.42	0.42	0.42
Swine, 2010	0.028	0.025	0.025	0.024	0.023	0.023	0.023	0.024	0.026	0.025
Swine, 2009	0.034	0.028	0.029	0.029	0.028	0.027	0.028	0.029	0.031	0.030
[Tg a⁻¹ CH₄]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
Total, 2010	1.01	1.02	0.98	0.97	0.94	0.93	0.91	0.92	0.93	
Total, 2009	0.87	0.89	0.85	0.84	0.82	0.82	0.80	0.81		
Dairy cows, 2010	0.50	0.50	0.49	0.49	0.48	0.48	0.46	0.47	0.48	
Dairy cows, 2009	0.39	0.40	0.39	0.39	0.38	0.38	0.37	0.38		
Other cattle, 2010	0.45	0.45	0.43	0.41	0.40	0.39	0.39	0.39	0.39	
Other cattle, 2009	0.42	0.43	0.40	0.39	0.37	0.37	0.36	0.37		
Swine, 2010	0.025	0.025	0.025	0.026	0.025	0.026	0.026	0.027	0.026	
Swine, 2009	0.030	0.030	0.030	0.031	0.030	0.032	0.031	0.032		

6.2.6   *Planned improvements (4.A)*

In some areas of the present inventory, the resources for data outside of official statistics is still unsatisfactory. This reflects a difficulty seen in inventories of past years. Efforts continue to obtain the relevant data by expanding pertinent agricultural statistics or by conducting suitable surveys. Such efforts are proceeding on the basis of, inter alia, co-operation agreements with the *Federal Statistical Office* and the *Association for Technology and Structures in Agriculture* (KTBL).

6.3   **Manure management (4.B)**

6.3.1   *Source category description (4.B)*

CRF 4.B				
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
	- / -			

Gas	CO₂	CH₄	HFC	PFC	SF₆	N₂O	NOₓ	CO	NMVOC	SO₂
Emission factor (EF)	NO	CS/D	NO	NO	NO	D	D	-	CS	NO
EF uncertainties in %		-40/+60				30				
Distribution of uncertainties		N				N				
EF-determination method		D/T1/T2				CS/T1				

The source category *Manure management* is not a key source.

CH_4 and NMVOC, and NH_3, N_2O, NO, and N_2, are released in storage of farm manure in stalls, on paved areas outside of stalls, in pastures and in storage facilities (in the narrower sense), and such emissions are also released when manure is applied. Emissions depend on a range of factors, including animal category, animal excretions (which depend on animal yield and diet), time spent in specific types of areas (pastures, stalls, paved areas), species-specific behaviour, stall type, use of straw, type and duration of manure storage, time and place of manure application, method used to apply manure and ways in which manure is worked into the soil.

In 2008, a total of 22.7 % (1990: 19.6 %) of all CH_4 emissions from the German agricultural sector were CH_4 emissions from manure management.

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, as well as 6.3.3.2.

6.3.2.2   Methodological issues (4.B, methane)

6.3.2.2.1   Methods (4.B, methane)

The Tier 2 method pursuant to IPCC (2006) was used for dairy cows, other cattle and swine. That method requires detailed calculation of variable VS excretions that depend on yield / weight gain and feeds. Furthermore, such data are combined with emission factors that take account of the frequency of a) various procedures for storing solid and liquid manure, b) pasturing in Germany and c) climate effects, and that thus can vary by place and time for each relevant category.

The Tier 2 method is also used for laying hens, broilers, pullets and turkeys.

For sheep, goats, horses, mules and asses, buffalo, geese and ducks, a mixed method, sited between the Tier 1 and Tier 2 methods (UNECE: improved methods), was used in which default values for VS excretions are combined with the frequency distributions for the manure-management systems in the relevant region.

Pursuant to DLG (2005: p. 54), the average daily digestible energy requirements for a small horse or pony amount to 57.5 MJ d^{-1}, while those of a large horse amount to 89 MJ d^{-1}. That relationship serves as a basis for estimating the VS excretions of small horses and ponies on the basis of VS excretions of large horses.

To compute the methane emissions occurring in fermentation of straw that enters solid manure as straw bedding, Germany previously used an approach in which the VS quantities that enter the manure with straw bedding are considered separately (for example, cf. DÄMMGEN et al., 2009a). That approach was not in line with the procedure described in IPCC (2006: p. 10.41). To improve comparability with the results of other countries, as of the present inventory Germany is using the IPCC (2006) approach, in which straw bedding is not considered in calculation of CH_4 emissions.

Additional relevant methodological aspects are described in Chapter 6.2.2.1.

For a more detailed description of calculation of methane emissions from farm-manure storage, we refer to HAENEL et al. (2010).

6.3.2.2.2   *Activity data and additional information (4.B, methane)*

With regard to animal head counts, we refer to Chapter 6.1.3.2. In the categories of cattle, swine and poultry (except geese), excretions of volatile solids (VS) are calculated in accordance with Tier 2 determinations of energy and substance flows. The results are summarised in the following table.

Table 93:   Daily VS excretions per animal, for dairy cows, other cattle, swine and poultry (not including geese) (4.B(a)s1)

[kg d^{-1} VS]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	3.70	3.75	3.85	3.91	3.93	3.96	4.01	4.03	4.08	4.11
Other cattle	1.32	1.35	1.39	1.41	1.39	1.41	1.42	1.42	1.43	1.44
Swine	0.22	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.23
Poultry[1]	0.017	0.017	0.017	0.018	0.018	0.017	0.018	0.018	0.018	0.018
[kg d^{-1} VS]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	4.16	4.21	4.23	4.26	4.27	4.30	4.32	4.35	4.32	
Other cattle	1.45	1.45	1.43	1.43	1.43	1.43	1.43	1.44	1.42	
Swine	0.23	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.24	
Poultry[1]	0.019	0.019	0.019	0.020	0.021	0.022	0.022	0.022	0.022	

[1] The poultry category here does not include geese

It was not possible to calculate VS excretions of geese. What is more, no current default value is available; cf. IPCC (2006), Table 10A-9.

For all other animals, the default values pursuant to IPCC (2006), Tables 10A-9 and 10A-6, were used. The VS excretions of small horses and ponies were derived from those of large horses, on the basis of the ratio of pertinent energy requirements (cf. Chapter 6.3.2.1):

Table 94:   Daily VS excretions per animal, for sheep, goats, horses, mules and asses and buffalo (4.B(a)s1)

[kg place^{-1} d^{-1}]	VS
Sheep	0.40
Goats	0.30
Heavy horses	2.13
Small horses and ponies	1.38
Donkeys and mules	0.94
Buffalo	3.9

Germany does not have national data on maximum rates of methane formation that could be used for calculation of CH_4 emissions from manure storage. For this reason, IPCC default values are used for those animals for which Tier 2 calculations are carried out (IPCC, 2006: 10.77 ff); in this regard, cf. the following Table 95 and Table 96.

Table 95:   Maximum methane-formation capacity B_o for cattle, pursuant to IPCC (2006)-10.77ff (4.B(a)s1)

[m^3 kg^{-1} CH$_4$]	B_o
Dairy cows	0.24
Other cattle	0.18

Table 96:   Maximum methane-formation capacity B_o for sows, weaners, fattening pigs and boars, pursuant to IPCC (2006)-10.77ff (4.B(a)s1)

[m^3 kg^{-1} CH$_4$]	B_o
Sows	0.45
Weaners	0.48
Fattening pigs	0.48
Boars	0.45

The following Table 97 shows the average B_o values calculated for swine overall.

Table 97:   Maximum methane-formation capacity B_o for swine overall (4.B(a)s1)

[m^3 kg^{-1} CH$_4$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Swine	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476	0.476
[m^3 kg^{-1} CH$_4$]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Swine	0.476	0.476	0.476	0.477	0.477	0.477	0.477	0.477	0.477	

The Tier 2 method is not used for sheep, goats, horses, mules and asses, buffalo and poultry. Nonetheless, B_o data are required for CRF Table 4.B. In this regard, default values (IPCC, 2006: 10.82) are used (figures in m^3 kg^{-1} CH$_4$): Sheep, 0.19; goats, 0.18; horses, 0.3; mules and asses, 0.33; buffalo, 0.1; laying hens, 0.39; broilers, 0.36; turkeys, 0.36; ducks, 0.36. No figures are provided for pullets and geese; for those categories, it seems appropriate to use a B_o of 0.36 m^3 kg^{-1} CH$_4$ as well. Table 98 shows the average B_o values calculated for poultry overall.

Table 98:   Maximum methane-formation capacity B_o for poultry (4.B(a)s1)

[m^3 kg^{-1} CH$_4$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Poultry	0.374	0.374	0.373	0.373	0.373	0.373	0.372	0.372	0.372	0.371
[m^3 kg^{-1} CH$_4$]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Poultry	0.371	0.371	0.371	0.370	0.370	0.370	0.370	0.370	0.370	

The following tables show the distribution of the various relevant types of manure-management systems (figures in % of excreted nitrogen).

Table 99:   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 cows	54.3	54.3	55.0	55.0	70.8	70.8	70.9	70.9	70.9	72.3
Other cattle	58.9	57.9	58.4	57.6	56.5	55.6	54.9	54.4	54.0	53.5
Swine	80.4	79.8	80.0	80.4	86.9	87.0	87.3	87.3	87.5	89.0
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	38.5	38.5	38.5	38.5
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	72.3	72.4	72.4	72.5	72.5	72.5	72.5	72.5	72.5	
Other cattle	53.3	53.6	53.6	53.6	53.2	53.1	53.2	53.2	53.2	
Swine	89.1	89.1	89.2	89.3	89.3	89.5	89.5	89.5	89.7	
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Buffalo	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	

Table 100:   Relative shares of straw-manure-based systems, in % of excreted N (4.B(a)s2)

[%]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	28.2	28.2	27.3	27.3	16.1	16.1	16.0	16.0	16.0	14.9
Other cattle	27.7	27.9	26.0	26.3	26.7	27.0	27.2	27.3	27.4	27.5
Swine	19.6	20.2	20.0	19.6	13.1	13.0	12.7	12.7	12.5	11.0
Sheep	28.0	28.3	28.3	28.3	28.2	28.2	28.2	28.1	28.1	27.9
Goats	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6
Horses	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4
Mules/asses	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4
Buffalo	0.0	0.0	0.0	0.0	0.0	0.0	43.8	43.8	43.8	43.8
Poultry	100	100	100	100	100	100	100	100	100	100
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	14.9	14.9	14.9	14.7	14.7	14.7	14.7	14.8	14.8	
Other cattle	27.6	27.4	27.3	27.3	27.5	27.5	27.4	27.3	27.3	
Swine	10.9	10.9	10.8	10.7	10.7	10.5	10.5	10.5	10.3	
Sheep	28.4	28.2	28.5	27.7	28.3	28.3	28.8	28.8	28.9	
Goats	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6	67.6	
Horses	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	
Mules/asses	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	68.4	
Buffalo	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	43.8	
Poultry	100	100	100	100	100	100	100	100	100	

Table 101:   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 cows	17.5	17.5	17.7	17.7	13.1	13.1	13.1	13.1	13.1	12.8
Other cattle	13.4	14.2	15.6	16.1	16.8	17.4	17.9	18.3	18.7	18.9
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	72.0	71.7	71.7	71.7	71.8	71.8	71.8	71.9	71.9	72.1
Goats	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4
Horses	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6
Mules/asses	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6
Buffalo	0.0	0.0	0.0	0.0	0.0	0.0	17.7	17.7	17.7	17.7
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.7	12.7	
Other cattle	19.1	19.0	19.1	19.1	19.3	19.4	19.4	19.4	19.5	
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Sheep	71.6	71.8	71.5	72.3	71.7	71.7	71.2	71.2	71.1	
Goats	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	32.4	
Horses	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	
Mules/asses	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	
Buffalo	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	

The methane-conversion factors (MCF) for liquid-manure-based systems in German animal husbandry (dairy cows, other cattle and swine) are listed in Table 102. For buffalo, an MCF of 10 % has been used in the inventory (storage in open tanks with floating covers).

Table 102:   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 cows	13.9	13.9	13.9	13.8	13.4	13.4	13.4	13.4	13.4	13.4
Other cattle	13.8	13.8	13.8	13.7	13.2	13.3	13.3	13.3	13.3	13.3
Swine	17.0	17.0	17.0	17.0	16.4	16.4	16.4	16.4	16.4	16.4
[%]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	
Other cattle	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	
Swine	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	

Throughout the entire report period, calculations for mammals in straw-based systems used the default MCF of 2 % (exception: a figure of 1 % was used for goats). For pasturing, a default MCF of 1 % was used, for all relevant years. The figures were taken from IPCC (2006)-10.77 ff.

For poultry, the default MCF pursuant to IPCC (2006)-10.82 is 1.5 %.

6.3.2.2.3   Calculated CH_4 emissions (4.B, methane)

Table 103 presents the time series for total CH_4 emissions from manure management.

Table 103: CH_4 emissions E_{CH4} from manure management (4s1)

[Tg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	0.30	0.27	0.27	0.27	0.28	0.28	0.28	0.28	0.28	0.28
[Tg a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
E_{CH4}	0.28	0.28	0.28	0.28	0.27	0.27	0.27	0.27	0.27	

Table 103 shows an emissions decrease that is limited primarily to the years after German reunification and that points primarily to decreases in herd sizes. Cattle contribute nearly 2/3 of the total emissions. Swine account for an additional 1/3. As these figures indicate,

emissions from keeping of horses, mules and asses, sheep, goats and buffalo are negligible by comparison.

The following Table 104 lists CH_4 emissions from manure management for dairy cows, other cattle and swine.

Table 104: CH_4 emissions from manure management (4.s1.)

[Gg a^{-1} CH$_4$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	118.3	108.7	106.1	105.9	126.7	126.7	127.3	123.6	120.4	121.8
Other cattle	75.5	68.5	65.7	64.2	61.0	60.9	60.5	58.0	57.6	57.7
Swine	105.3	91.8	92.7	91.9	89.9	87.8	90.1	92.8	99.4	98.6
[Gg a^{-1} CH$_4$]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	117.9	119.3	116.6	116.2	114.1	113.7	109.9	110.7	114.2	
Other cattle	57.1	57.8	54.3	52.8	50.4	49.8	49.2	49.1	49.2	
Swine	97.3	98.0	99.5	101.0	98.5	103.4	101.9	104.7	103.7	

6.3.2.2.4   *CH$_4$ emission factors (4.B, methane)*

Table 105 shows the chronological development of mean emission factors for CH_4 emissions from manure management for dairy cows, other cattle and swine.

Table 105: CH_4 emission factors (IEF) for manure management (4.B(a)s1)

[kg pl^{-1} a^{-1} CH$_4$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	18.6	19.3	19.8	20.0	24.0	24.2	24.5	24.6	24.9	25.6
Other cattle	5.7	6.0	6.1	6.1	5.7	5.7	5.7	5.7	5.7	5.7
Swine	3.4	3.5	3.5	3.5	3.6	3.7	3.7	3.7	3.8	3.8
[kg pl^{-1} a^{-1} CH$_4$]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	25.8	26.2	26.3	26.6	26.6	26.8	26.9	27.2	27.1	
Other cattle	5.7	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.6	
Swine	3.8	3.8	3.8	3.8	3.8	3.9	3.8	3.9	3.9	

6.3.2.3   Source-specific quality assurance / control and verification (4.B, methane)

With regard to source-specific QA/QC and verification, we refer to Chapter 6.1.6.

6.3.2.3.1   *Comparison with results of other countries (4.B, methane)*

A comparison of a) results obtained for 2008 and b) those of neighbouring countries and of the UK for 2007 (2009 submission for 2007, UNFCCC 2009) shows that the German emission factor for CH_4 emissions from manure management for dairy cows is higher than that reported by neighouring countries. The German emission factors for other cattle and for swine are within the customary range. For poultry, the mean emission factor for Germany is the same as the default value from IPCC (1996b). The comparison in this area is hampered in that Germany is already using MCF from IPCC (2006), while some of the data for comparison were obtained with the help of data from IPCC (1996b) (cold climate: 0.10 kg kg^{-1}) or IPCC (2000) (cold climate: 0.39 kg kg^{-1}).

Within the international comparison, Germany's figures for VS excretions of cattle and swine are at the lower end of the pertinent range, while its figures for poultry are at the upper end of the range.

Table 106:　　Methane emissions from storage of farm manure from dairy cows, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters (those of Germany, for 2008; those of other countries, for 2007)

	IEF$_{CH4}$	VS excretions	Frequency of liquid-manure systems	Mean *MCF* for liquid-manure systems
	[kg place^{-1} a^{-1} CH$_4$]	[kg place^{-1} d^{-1}]	[%]	[%]
Austria	20.36	4.23	18.95	39
Belgium	15.70		32.90	19
Czech Republic	14.0			
Denmark	18.79	4.94	85.80	10
Germany	**27.08**	**4.32**	**83.4**	**13.4**
France	18.31	5.10	10.6	45 / 72
Netherlands	39.19			
Poland	10.40	4.52	7.68	39
Switzerland	24.19	5.62	64.89	
UK	25.79	0.01		
Default (IPCC, 2006-10.77)	21 to 29	5.1	35.7	17 to 25

Source (except for figures for Germany): UNFCCC 2009

Table 107:　　Methane emissions from storage of farm manure from other cattle, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters (those of Germany, for 2008; those of other countries, for 2007)

	IEF$_{CH4}$	VS excretions	Frequency of liquid-manure systems	Mean *MCF* for liquid-manure systems
	[kg place^{-1} a^{-1} CH$_4$]	[kg place^{-1} d^{-1}]	[%]	[%]
Austria	7.36	1.95	23.76	39
Belgium	2.63		15.40	19
Czech Republic	6.00			
Denmark	1.72	1.60	30.81	10
Germany	**5.62**	**1.42**	**64.71**	**13.3**
France	20.20	2.70	37.05	45 / 72
Netherlands	Other source categories for cattle			
Poland	4.81	2.10	11.89	39
Switzerland	3.02 [1]			
UK	4.18	0.01		
Default (IPCC, 2006-10.78)	6 to 8	2.6	25.2	17 to 25

[1] calculated from original data

Source (except for figures for Germany): UNFCCC 2009

Table 108:   Methane emissions from storage of farm manure from swine, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters (those of Germany, for 2008; those of other countries, for 2007)

	IEF_{CH4}	VS excretions	Frequency of liquid-manure systems	Mean *MCF* for liquid-manure systems
	[kg place^{-1} a^{-1} CH$_4$]	[kg place^{-1} d^{-1}]	[%]	[%]
Austria	5.90	0.40	71.5	39
Belgium	9.53		100	20
Czech Republic	3.00			
Denmark	2.60	0.41	92	10
Germany	**3.88**	**0.238**	**91.52**	**16.4**
France	20.97	0.50	83 to 85	45 / 72
Netherlands	4.42			
Poland	6.54	0.50	28.6	39
Switzerland	3.08	0.50	93	
UK	7.06		31.3	
Default (IPCC 2006-10.80, 10.81)	Sows: 9 to 12 Other: 6 to 8	Sows: 0.46 Other: 0.3	"pit": 70 %	

Source (except for figures for Germany): UNFCCC 2009

Table 109:   Methane emissions from storage of farm manure from poultry, in various countries – a comparison of Implied Emission Factors (*IEF*) and important emissions-relevant parameters (those of Germany, for 2008; those of other countries, for 2007)

	IEF_{CH4}	VS excretions	Mean animal weights
	[kg place^{-1} a^{-1} CH$_4$]	[kg place^{-1} d^{-1}]	[%]
Austria	0.08	0.10	1.10
Belgium	0.03		1.54
Czech Republic	0.08		
Denmark	0.02	0.01	2.00
Germany	**0.03**	**0.022** [1]	**2.27**
France	0.12	0.10	
Netherlands	0.03		
Poland	0.08	0.10	1.10
Switzerland	0.12	0.10	
UK	0.08		
Default (IPCC, 2006-10.82)	0.02 to 0.09	0.02 to 0.07	

[1] not including geese

Source (except for figures for Germany): UNFCCC 2009

6.3.2.4   Uncertainties and time-series consistency (4.B, methane)

With regard to the uncertainties in the area of methane emissions from manure management, we refer to Chapter 6.1.5 (total uncertainty of the German GG inventory). All the time series are consistent.

6.3.2.5   Source-specific recalculations (4.B, methane)

In comparison to the NIR 2009, the following main changes have resulted for 2007 (cf. Table 110):

- The VS excretions for dairy cows are about 40 % higher, throughout the entire report period. This is due to the revision of the dairy-cow model (cf. Chapter 6.2.2).

- The average VS excretions for other cattle are also higher (in 1990, by about 10 %; in 2007, by about 4 %). Ultimately, this is due primarily to the higher final weight of heifers (cf. Chapter 6.2.2), which is reflected in higher energy requirements. Energy requirements for fattening bulls and calves have also increased, slightly, as a result of the recalculations.

- For swine, the average VS excretions are lower (in 1990, by about 15 %; in 2007, by about 17 %). This is due to changes in calculation of digestible energy within the various swine models (cf. Chapter 6.2.2). The key factor in those changes is a reduction in energy requirements for fattening pigs (the calculatory energy requirements for other swine categories have increased slightly), in conjunction with a lower calculated number of fattening pigs.

Table 110:   Comparison of daily VS excretions per animal, as reported in 2010 and as reported in 2009, for dairy cows, other cattle and swine (4.B)

[kg d^{-1} VS]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2010	3.70	3.75	3.85	3.91	3.93	3.96	4.01	4.03	4.08	4.11
Dairy cows, 2009	2.66	2.68	2.75	2.83	2.84	2.86	2.83	2.86	2.89	2.93
Other cattle, 2010	1.32	1.35	1.39	1.41	1.39	1.41	1.42	1.42	1.43	1.44
Other cattle, 2009	1.21	1.18	1.26	1.29	1.25	1.27	1.31	1.30	1.33	1.34
Swine, 2010	0.22	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.23
Swine, 2009	0.26	0.26	0.26	0.27	0.27	0.28	0.28	0.28	0.28	0.28
[kg d^{-1} VS]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows, 2010	4.16	4.21	4.23	4.26	4.27	4.30	4.32	4.35	4.32	
Dairy cows, 2009	2.97	3.01	3.01	3.05	3.06	3.07	3.08	3.10		
Other cattle, 2010	1.45	1.45	1.43	1.43	1.43	1.43	1.43	1.44	1.42	
Other cattle, 2009	1.36	1.37	1.35	1.35	1.34	1.35	1.36	1.37		
Swine, 2010	0.23	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.24	
Swine, 2009	0.28	0.28	0.28	0.28	0.28	0.28	0.29	0.29		

As a result, the following changes in CH_4 emissions also occur (cf. Table 111):

- Significantly higher CH_4 emissions are seen among dairy cows, while only slightly higher CH_4 emissions are seen in other cattle.

- Noticeably lower CH_4 emissions for swine have resulted.

- Total CH_4 emissions from manure management are increased slightly throughout (for example, in 2007, from 261 Gg to 271 Gg), although higher emissions in the cattle categories have been partly offset by lower emissions for swine.

Table 111:   Comparison of CH$_4$ emissions, as reported in 2010 and as reported in 2009, for dairy cows, other cattle and swine (4.B)

[Gg a^{-1} CH$_4$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2010	303.9	273.6	268.9	266.6	282.4	280.2	282.9	279.4	282.5	283.5
Total, 2009	296.6	257.9	257.3	257.3	265.0	262.5	266.2	263.6	269.2	271.1
Dairy cows, 2010	118.3	108.7	106.1	105.9	126.7	126.7	127.3	123.6	120.4	121.8
Dairy cows, 2009	87.7	80.4	78.2	79.2	92.3	92.7	92.2	89.0	86.7	87.9
Other cattle, 2010	75.5	68.5	65.7	64.2	61.0	60.9	60.5	58.0	57.6	57.7
Other cattle, 2009	72.9	64.3	62.7	61.6	57.6	57.7	58.7	56.1	56.2	56.7
Swine, 2010	105.3	91.8	92.7	91.9	89.9	87.8	90.1	92.8	99.4	98.6
Swine, 2009	129.9	107.2	110.5	110.6	108.0	105.6	108.6	111.7	119.5	119.2
[Gg a^{-1} CH$_4$]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total, 2010	277.9	281.0	276.3	276.1	269.2	273.1	267.1	271.0	273.7	
Total, 2009	266.7	270.5	265.9	262.4	255.9	260.6	256.4	261.0		
Dairy cows, 2010	117.9	119.3	116.6	116.2	114.1	113.7	109.9	110.7	114.2	
Dairy cows, 2009	85.2	86.4	84.1	84.1	82.6	82.2	79.3	79.9		
Other cattle, 2010	57.1	57.8	54.3	52.8	50.4	49.8	49.2	49.1	49.2	
Other cattle, 2009	56.5	57.8	53.8	52.1	49.6	49.1	48.7	48.9		
Swine, 2010	97.3	98.0	99.5	101.0	98.5	103.4	101.9	104.7	103.7	
Swine, 2009	117.5	118.4	120.2	118.1	115.3	121.1	120.2	123.5		

6.3.2.6   Planned improvements (4.B, methane)

In some areas of the present inventory, the resources for data outside of official statistics are still unsatisfactory. This reflects a difficulty seen in inventories of past years. Efforts continue to obtain the relevant data by expanding pertinent agricultural statistics or by conducting suitable surveys. Such efforts are proceeding on the basis of, inter alia, co-operation agreements with the *Federal Statistical Office* and the *Association for Technology and Structures in Agriculture* (KTBL).

6.3.3   NMVOC emissions from manure management (4.B, NMVOC)

6.3.3.1   Source category description (4.B, NMVOC)

Cf. Chapter 6.3.1 and 6.3.3.2.

6.3.3.2   Methodological issues (4.B, NMVOC)

6.3.3.2.1   Methods (4.B, NMVOC)

Microbial conversion of proteins in farm manure (about 50 % of the nitrogen contained in excretions is bound in proteins) produces both ammonia (NH$_3$) and non-methane volatile organic compounds (NMVOC). In the UK, the consistent proportionality seen between NH$_3$ emissions and NMVOC emissions from a range of different farm manures was used in preparation of a first NMVOC-emissions inventory. Germany is using the relative emission factors listed there (HOBBS et al., 2004) to carry out a first estimate of NMVOC emissions from animal husbandry.

For a description of the relevant procedure, cf. HAENEL et al. (2010).

6.3.3.2.2   Calculated NMVOC emissions (4.B, NMVOC)

Due to a lack of suitable calculation procedures, it was not possible to calculate NMVOC emissions for horses, mules and asses, buffalo, goats, geese, ducks and turkeys. The NMVOC-emissions time series shown in Table 112 includes NMVOC emissions for the other relevant animals. Throughout the entire report period, the relevant percentage share for cattle is on the order of 60 %, while swine contribute about one-third. Most of the remainder

is contributed by those poultry species for which it was possible to calculate NMVOC emissions. The contribution from sheep is considerably less than 1 %.

Table 112:   NMVOC emissions E_{NMVOC} from animal husbandry (manure management), given as NMVOC and NMVOC-C (4s1.B, 4s2.B)

[Gg a^{-1} NMVOC, or Gg a^{-1} C]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NMVOC}	300.1	269.8	264.6	262.4	252.3	250.7	252.9	249.9	252.6	250.3
$E_{NMVOC-C}$	145.1	130.2	128.1	127.1	122.4	121.7	122.8	121.2	122.2	121.2
[Gg a^{-1} NMVOC, or Gg a^{-1} C]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
E_{NMVOC}	246.4	249.0	243.9	242.3	237.7	239.7	234.3	239.0	240.1	
$E_{NMVOC-C}$	119.0	120.2	117.6	116.9	114.4	115.3	112.7	114.5	115.2	

Beginning in about 1994, following a decrease in animal-herd sizes, resulting from German reunification, emissions remained constant.

In modelling of NMVOC emissions, it was also found that considerable amounts of dimethyl sulfide are emitted. According to these estimates, emissions of sulphur bound in NMVOC amount to about 0.04 Tg a^{-1}.

6.3.3.3   Uncertainties and time-series consistency (4.B, NMVOC)

The uncertainty for NMVOC emissions depends both on the uncertainty for NH$_3$ emissions and on the uncertainty for the emission factors EF_{NMVOC}. The first of those uncertainties is on the order of 20 % (cf. Chapter 6.1.5), while a value of 30 to 50 % is assumed for the second. As a result, the uncertainty for NMVOC emissions is on the order of 50 %. A normal distribution is assumed. According to HOBBS et al. (2004), the uncertainty for NMVOC emissions from sheep manure is higher than that for NMVOC emissions from cattle and swine. For this reason, in the present report the uncertainty for the emission factors is increased by half. This leads to an emissions uncertainty of about 75 % (and that uncertainty also has a normal distribution).

6.3.3.4   Source-specific quality assurance / control and verification (4.B, NMVOC)

With regard to source-specific QA/QC and verification, we refer to Chapter 6.1.6.

6.3.3.5   Source-specific recalculations (4.B, NMVOC)

In comparison to the NIR 2009, the following changes have resulted for 2007:

Table 113:   NMVOC emissions E_{NMVOC} from animal husbandry (manure management), (4s1.B, 4s2.B)

[Gg a^{-1} NMVOC, or Gg a^{-1} C]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, 2010	300.1	269.8	264.6	262.4	252.3	250.7	252.9	249.9	252.6	250.3
Total, 2009	327.3	286.4	281.2	281.1	270.8	270.2	272.0	269.2	270.7	269.7
[Gg a^{-1} NMVOC, or Gg a^{-1} C]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Total, 2010	246.4	249.0	243.9	242.3	237.7	239.7	234.3	239.0	240.1	
Total, 2009	269.0	270.2	264.1	263.8	258.5	262.7	258.3	262.7		

In light of the calculation method used, the lower values for 2008, throughout, in the present NIR 2010 are due to lower NH$_3$-emissions results. Cattle account for about one-third of the difference between the NMVOC sum in 2010 and the NMVOC sum in 2009, while swine

account for about two-thirds. Among cattle, the NMVOC emissions increase calculated for dairy cows is more than offset by a reduction for heifers and fattening bulls. In the swine category, in spite of an increase in the NMVOC emissions calculated for sows and weaners, a considerable reduction results, as a result of a considerable decrease among fattening pigs.

In the cases involving higher NMVOC emissions (dairy cows, sows, weaners), the higher underlying NH_3 emissions are the result of higher N excretions (revisions of the animal models with regard to energy requirements).

The reduction in NMVOC emissions among heifers is due to lower N excretions (via NH_3). Those lower excretions result, in spite of increases in heifer weights, from elimination of errors in transferring data for ME content in feed and of conversion errors in calculation of the N ingested with feed.

For stud bulls, daily weight gains were calculated on the basis of an improved database. The new weight-gain figures are somewhat higher than the earlier figures. Since final weights have not changed, a shorter fattening period results. That has slightly lowered energy requirements as summed over the entire fattening period. And that result, in turn, has led to lower N excretions and, thus, to lower emissions of N species. This has entailed a slight decrease in NMVOC emissions tied to NH_3 emissions. New N_2O emission factors, higher than those formerly used, have had a similar effect; as a consequence of their use, less N is available for NH_3 emissions.

6.3.3.6   Planned improvements (4.B, NMVOC)

With regard to planned improvements, we refer to Chapter 6.3.2.6.

6.3.4 N_2O and NO emissions from manure management (4.B, N2O & 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)

Pursuant to key-source analysis, category 4.B N_2O emissions are not a key source. For this reason, a simple method (Tier -1 approach) may be used for calculation. Nonetheless, a more complex, so-called "detailed" procedure (EMEP term) is used with regard to the ammonia emissions calculated with the same data record. It corresponds to a Tier 2 approach. In such calculation, national – and, in some cases, regional – data for N excretion are used.

Calculation of N_2O and NO emissions from manure management is based on the N-flow concept (DÄMMGEN & HUTCHINGS, 2005: Figure 3). The key elements of that substance-flow procedure include consideration of N losses via NH_3 emissions, which losses are calculated in accordance with the methods specified by EMEP/CORINAIR (EMEP, 2006, B1090). N_2 emissions are also taken into account as losses from the overall N balance.

Use of the N-flow concept requires determination of excreted N quantities ($m_{excreted}$). In the process, a distinction is made between organic N and easily converted TAN (total ammoniacal nitrogen). TAN occurs in the urine of mammals. For purposes of inventory calculation, TAN is considered to be equal to the N content in urine. Poultry excrete uric acid nitrogen (UAN), which in the inventory is treated in the same manner as TAN.

For dairy cows, N excretions are calculated as a function of milk yield, milk-protein levels, weight, number of births per year and feed composition. This calculation procedure also yields the pertinent TAN excretions.

For male fattening cattle and young female cattle, N excretions are calculated as a function of weight gain, final weight and feed characteristics. For calves, mother cows and stud bulls, national data from the literature are used. For swine, N excretions are determined from animal yields (for sows: number of weaners per year; for weaners and fattening pigs: weight gains) as well as from weights and feed composition.

For laying hens, pullets, broilers, 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 a factor.

For all other animals, N-excretion figures were taken from the German literature.

N excretions have to be broken down into in-pasture and in-stall excretions, since only in-stall excretions can enter into calculation of N_2O emissions. N excretions during pasturing are taken into account under 4.D. To take account of grazing periods and animals' behaviour, excretion amounts are divided into amounts in pastures and amounts in stalls. In the N-flow concept, and for cattle, sheep and horses, the duration of grazing (pasture) periods, the average grazing duration per day and the average time spent in milking stalls are used to divide excrement into pasture and stall portions.

Emissions of all N species in pastures occur simultaneously. Calculations are carried out in accordance with IPCC (2006) and EMEP (2006).

In stalls, TAN losses occur through NH_3 emissions. The N in the remaining TAN is the source of emissions of NH_3, N_2O, NO and N_2 from storage. In principle, the relevant emissions levels are a function of type of storage and of temperature.

With regard to storage, a distinction is made between solid and liquid farm manure. The storage procedures and floating-cover designs commonly used in Germany are taken into account. Relevant, complete-coverage data are available for both cattle and swine farms. Daily application is not commonly practiced in Germany; open lagoons are not used. Farm manures are not used for extraction of thermal energy.

The N_2O emission factor given in IPCC (2006) refers to the amount of N that is stored.

A more detailed description of the relevant methodological aspects is provided by HAENEL et al. (2010).

6.3.4.2.2   *Activity data and additional information (4.B(b))*

With regard to animal head counts, we refer to Chapter 6.1.3.2. The N excretions per animal place and year are given in Table 114. The annual total N excretions calculated for the various relevant manure-management systems are listed in Table 115 through Table 117.

Table 114:   N excretions per animal place and year (4.B(b))

[kg place⁻¹ a⁻¹]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	106.7	110.9	115.4	118.1	115.1	116.6	118.4	119.2	121.4	122.7
Other cattle	37.1	38.1	39.2	39.7	39.6	40.2	40.7	40.8	41.0	41.2
Swine	9.9	10.1	10.1	10.1	10.2	10.3	10.3	10.4	10.4	10.2
Sheep	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
Goats	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
Horses	48.4	48.4	48.5	48.5	48.4	48.4	48.3	48.3	48.3	48.5
Mules/asses	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4
Buffalo	0.0	0.0	0.0	0.0	0.0	0.0	82.0	82.0	82.0	82.0
Poultry	0.68	0.68	0.69	0.68	0.67	0.66	0.66	0.67	0.68	0.65
[kg place⁻¹ a⁻¹]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
Dairy cows	124.7	127.5	128.1	129.7	130.4	131.9	132.7	134.2	132.5	
Other cattle	41.4	41.3	41.0	41.0	41.1	41.1	41.1	41.2	40.8	
Swine	10.2	10.2	10.2	10.2	10.1	10.1	10.1	10.1	10.2	
Sheep	7.5	7.5	7.4	7.6	7.5	7.5	7.4	7.4	7.4	
Goats	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	
Horses	48.5	48.0	48.0	48.1	48.1	48.1	48.1	48.0	48.0	
Mules/asses	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	33.4	
Buffalo	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	82.0	
Poultry	0.67	0.70	0.67	0.67	0.74	0.75	0.74	0.77	0.77	

Table 115:   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 cows	368.1	339.0	340.1	344.0	430.1	432.1	436.1	424.8	416.1	422.6
Other cattle	287.0	254.0	248.5	242.4	239.4	238.6	236.0	226.3	223.6	223.5
Swine	245.6	210.5	214.0	211.8	219.0	213.4	218.5	224.6	239.7	237.7
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	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**	
Dairy cows	412.0	419.7	410.4	410.8	404.8	405.0	392.7	396.2	405.3	
Other cattle	220.0	222.8	210.1	203.9	194.6	192.0	189.4	188.8	190.0	
Swine	233.4	233.5	236.8	239.8	232.6	243.3	239.5	246.0	243.2	
Sheep	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Goats	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Horses	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Mules/asses	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Buffalo	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.06	
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	

Table 116:   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 cows	191.2	176.1	169.1	171.0	97.5	97.9	98.4	95.9	93.9	87.1
Other cattle	134.9	122.3	110.9	111.0	113.1	115.8	116.7	113.7	113.4	115.0
Swine	60.0	53.1	53.4	51.5	32.9	31.9	31.8	32.6	34.1	29.3
Sheep	7.0	6.1	5.8	5.9	5.8	5.9	5.8	5.6	5.6	5.7
Goats	0.67	0.64	0.67	0.68	0.71	0.74	0.78	0.86	0.93	1.00
Horses	16.3	16.3	17.6	17.6	19.8	19.8	21.6	21.6	21.6	24.4
Mules/asses	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
Buffalo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
Poultry	77.5	77.9	71.0	70.8	73.6	73.0	74.5	75.0	76.7	77.0
[Gg a⁻¹]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
Dairy cows	84.9	86.2	84.2	83.5	82.3	82.3	79.8	80.6	82.5	
Other cattle	114.0	113.8	107.1	104.0	100.5	99.3	97.6	97.0	97.5	
Swine	28.4	28.6	28.7	28.6	27.8	28.7	28.2	28.8	27.9	
Sheep	5.8	5.9	5.8	5.7	5.7	5.6	5.4	5.4	5.2	
Goats	1.04	1.19	1.19	1.19	1.19	1.26	1.34	1.34	1.34	
Horses	24.4	26.0	26.0	27.1	27.1	25.8	25.8	27.8	27.8	
Mules/asses	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	
Buffalo	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.06	0.06	
Poultry	78.8	85.1	81.7	83.1	91.9	90.8	88.9	97.7	97.4	

Table 117:   Total annual N excretions during pasturing (4.B(b))

[Gg place⁻¹]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	118.7	109.3	109.7	111.0	79.6	80.0	80.4	78.3	76.7	74.8
Other cattle	65.4	62.2	66.3	67.8	71.3	74.6	76.9	76.3	77.4	79.0
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Sheep	17.9	15.4	14.8	14.9	14.9	15.0	14.8	14.4	14.4	14.8
Goats	0.33	0.31	0.33	0.34	0.34	0.36	0.38	0.42	0.45	0.49
Horses	7.5	7.5	8.1	8.1	9.1	9.1	9.9	9.9	9.9	11.3
Mules/asses	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Buffalo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
[Gg place⁻¹]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
Dairy cows	72.9	74.1	72.4	72.5	71.5	71.5	69.3	69.3	70.9	
Other cattle	78.8	79.0	74.9	72.7	70.7	70.2	69.3	68.8	69.4	
Swine	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Sheep	14.6	14.9	14.5	14.8	14.5	14.2	13.5	13.3	12.7	
Goats	0.51	0.58	0.58	0.58	0.58	0.62	0.65	0.65	0.65	
Horses	11.3	12.0	12.0	12.5	12.5	11.9	11.9	12.8	12.8	
Mules/asses	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	
Buffalo	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	
Poultry	NO	NO	NO	NO	NO	NO	NO	NO	NO	

6.3.4.2.3   *Calculated N₂O 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 and NO emissions (83 % in 1990, and a decrease to 77 % in 2008). While the N_2O-emissions levels hardly changed at all from 1990 to 2008, a considerable reduction (about 37 %) occurred in the area of solid-manure systems.

Table 118: N_2O emissions from manure management, by animal categories (4.B)

[Gg a^{-1} N$_2$O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	3.744	3.403	3.378	3.425	3.425	3.437	3.463	3.379	3.310	3.299
Other cattle	3.661	3.193	3.006	2.966	3.047	3.072	3.064	2.959	2.926	2.930
Swine	1.134	1.054	1.084	1.066	1.081	1.049	1.072	1.103	1.170	1.124
Sheep	0.059	0.051	0.049	0.049	0.049	0.050	0.049	0.048	0.048	0.048
Goats	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005
Horses	0.172	0.172	0.186	0.186	0.209	0.209	0.228	0.228	0.228	0.257
Mules/asses	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Buffalo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0002
Poultry	0.123	0.123	0.113	0.110	0.115	0.114	0.116	0.117	0.119	0.120
[Gg a^{-1} N$_2$O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows	3.226	3.274	3.207	3.195	3.146	3.148	3.055	3.079	3.135	
Other cattle	2.882	2.895	2.734	2.655	2.547	2.517	2.475	2.456	2.478	
Swine	1.095	1.095	1.105	1.122	1.083	1.138	1.120	1.156	1.136	
Sheep	0.049	0.049	0.049	0.048	0.048	0.047	0.046	0.046	0.044	
Goats	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	
Horses	0.257	0.274	0.274	0.286	0.286	0.272	0.272	0.293	0.293	
Mules/asses	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	
Poultry	0.124	0.134	0.128	0.131	0.144	0.142	0.139	0.153	0.152	

Table 119: N_2O emissions from manure management, by management systems (4.s2.B)

[Gg a^{-1} N$_2$O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid-manure-based	4.545	4.148	4.070	4.059	4.873	4.856	4.885	4.788	4.773	4.798
Straw-based	4.352	3.853	3.751	3.749	3.059	3.081	3.113	3.052	3.033	2.989
[Gg a^{-1} N$_2$O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Liquid-manure-based	4.698	4.755	4.630	4.604	4.479	4.513	4.404	4.449	4.493	
Straw-based	2.946	2.975	2.875	2.839	2.784	2.761	2.713	2.743	2.757	

The following table lists the NO emissions calculated for manure management overall.

Table 120: N_2O emissions (E_{NO}) from manure management

[Gg a^{-1} NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NO}	1.213	1.091	1.066	1.065	1.082	1.082	1.091	1.069	1.065	1.062
[Gg a^{-1} NO]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
E_{NO}	1.042	1.054	1.023	1.015	0.990	0.992	0.971	0.981	0.989	

6.3.4.2.4   *Emission factors (4.B, N$_2$O & NO)*

Pursuant to IPCC (2000, 2006), the input data for N_2O-emissions calculation must be obtained through statistical surveys and through measurements. In the process, framework conditions such as the effectiveness of the relevant surface, the ventilation situation and the temperature for manure storage must be taken into account. The entire data-collection, data-review and documentation process is, thus, considerably involved. Germany lacks pertinent data records. IPCC (2006) also contains default values for N_2O emission factors (IPCC, 2006: p. 10.62, Table 10.21). The relevant values are given in Table 121. Since the N-flow concept – which Germany uses – also takes N_2 emissions into account, the emission factors for those emissions are also listed.

Table 121:   Partial emission factors for N_2O, NO and N_2 emissions from manure storage (with regard to excreted N) (4.B(b))

Species	Farm manure	Emission factor [kg kg^{-1} N]
N_2O emissions	Liquid manure with floating cover	0.005
	Liquid manure without floating cover	0.000
	Liquid manure below slatted floor	0.002
	Solid manure (no turning)	0.005
	Poultry, solid manure or faeces	0.001
NO emissions	Liquid manure with floating cover	0.0005
	Liquid manure without floating cover	0.0000
	Liquid manure below slatted floor	0.0002
	Solid manure (no turning)	0.0005
	Poultry, solid manure or faeces	0.0001
N_2 emissions	Liquid manure with floating cover	0.015
	Liquid manure without floating cover	0.0000
	Liquid manure below slatted floor	0.006
	Solid manure (no turning)	0.015
	Poultry, solid manure or faeces	0.003

The emission factors for NO and N_2 were derived from the N_2O emission factors, in accordance with findings of experiments carried out in the UK (JARVIS & PAIN, 1994):

$$EF_{N2O} = 10\ EF_{NO} = 1/3\ EF_{N2}$$

The same factors are used in the UK, Switzerland and Denmark.

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, we refer to Chapter 6.1.5 (total uncertainty of the German GG inventory). All the time series are consistent.

6.3.4.4   Source-specific quality assurance / control and verification (4.B, N_2O & NO)

With regard to source-specific QA/QC and verification, we refer to Chapter 6.1.6.

6.3.4.4.1   Comparison with results of other countries (4.B, N_2O & NO)

A comparison of "implied emission factors" for N_2O emissions, comparing IEF of Germany with those of neighbouring countries and of the UK, for 2007 (submission 2009 for 2007; UNFCCC 2009) (no Figure), shows that all other countries use the IPCC default emission factors of 1996 (0.001 for landscape management liquid manure and 0.02 for solid manure). Germany, on the other hand, uses the IPCC default emission factors of 2006 (cf. Table 121), which more accurately reflect the situation prevailing in Germany (for justification of the use of the new factors, cf. also Chapter 19.4.1 the Annex). In Germany, use of the new factors leads to an IEF for liquid manure of 0.00341 kg kg^{-1} N and an IEF for solid manure of 0.00516 kg kg^{-1}. The reason why the IEF for solid manure is higher than the highest partial emission factor in Table 121 is that, in determining N_2O emissions, Germany considers both the nitrogen in N excretions and the nitrogen in straw bedding, while the IEF is calculated only on the basis of the N quantities excreted in solid-manure systems.

For dairy cows, a comparison of N excretions (Table 122) with those in neighbouring countries shows that Germany, as a result of the recalculations, now has the second-highest N excretions, after Denmark. In the other-cattle category, only Switzerland has considerably lower N excretions. The N excretions for swine are in the range seen in the data of Denmark,

Switzerland and the UK. 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 German value is approximately similar to the value calculated for Germany for the laying-hens category. The IPCC default value (1996) is 0.60 kg place^{-1} a^{-1}.

Table 122:   N excretions per animal place, for dairy cows, other cattle, swine and poultry, in various countries (in Germany, for 2008; in other countries, for 2007)

	Dairy cows [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	96.48	45.87	14.06	0.55
Belgium				
Czech Republic	100.0	70.00	20.00	0.60
Denmark	137.58	44.93	8.96	0.59
Germany	**132.48**	**40.78**	**10.16**	**0.77**
France	100.00	57.25	16.40	0.60
Netherlands				
Poland	70.00	50.00	20.00	0.60
Switzerland	107.47	30.44	10.42	0.49
UK	111.84	48.85	11.18	0.49

Source (except for figures for Germany): UNFCCC 2009

6.3.4.5   Source-specific recalculations (4.B, N$_2$O & NO)

In comparison to the NIR 2009, the following main changes have resulted for 2007:

- Throughout the entire report period, higher N excretions were calculated for dairy cows (1990: about 13 %; 2007: about 7 %). This is due to the revision of the dairy-cow model (cf. Chapter 6.1.3).
- Throughout the entire report period, lower N excretions resulted for other cattle (1990: about -13 %; 2007: about -19 %). Those changes occurred primarily as a result of elimination of a conversion error in calculation, for heifers, of N intake via feed.
- The N excretions for swine are lower overall throughout the entire report period (1990: about -23 %; 2007: about -23 %). This is due to revision of the various swine models (cf. Chapter 6.1.3).
- Slightly higher N excretions resulted for poultry. Those increases resulted from elimination of a transfer error within the broiler model.

Table 123:   Comparison of N excretions per animal place as reported in 2010 and as reported in 2009 (4.B)

[kg place^{-1} a^{-1}]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows, 2010	106.7	110.9	115.4	118.1	115.1	116.6	118.4	119.2	121.4	122.7
Dairy cows, 2009	94.1	96.6	98.9	103.0	103.9	105.2	105.2	105.6	107.4	109.7
Other cattle, 2010	37.1	38.1	39.2	39.7	39.6	40.2	40.7	40.8	41.0	41.2
Other cattle, 2009	42.6	42.6	44.5	45.5	44.8	45.8	47.3	47.5	48.3	48.6
Swine, 2010	9.9	10.1	10.1	10.1	10.2	10.3	10.3	10.4	10.4	10.2
Swine, 2009	12.9	12.7	12.8	12.9	13.2	13.3	13.3	13.4	13.4	13.3
Poultry, 2010	0.68	0.68	0.69	0.68	0.67	0.66	0.66	0.67	0.68	0.65
Poultry, 2009	0.68	0.68	0.68	0.68	0.67	0.66	0.66	0.66	0.68	0.64
[kg place^{-1} a^{-1}]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Dairy cows, 2010	124.7	127.5	128.1	129.7	130.4	131.9	132.7	134.2	132.5	
Dairy cows, 2009	112.1	114.9	115.3	118.2	119.0	120.8	121.5	123.7		
Other cattle, 2010	41.4	41.3	41.0	41.0	41.1	41.1	41.1	41.2	40.8	
Other cattle, 2009	49.1	49.4	49.0	49.1	49.2	49.7	49.9	50.3		
Swine, 2010	10.2	10.2	10.2	10.2	10.1	10.1	10.1	10.1	10.2	
Swine, 2009	13.2	13.2	13.2	13.2	13.1	13.1	13.2	13.2		
Poultry, 2010	0.67	0.70	0.67	0.67	0.74	0.75	0.74	0.77	0.77	
Poultry, 2009	0.66	0.69	0.66	0.67	0.74	0.75	0.73	0.76		

For 1990, N_2O emissions from manure management show a slight increase for liquid-manure-based systems, and a decrease of about 9 % for straw-based systems. For 2007, there is a slight emissions decrease for liquid-manure-based systems and a decrease of about 15 % for straw-based solid-manure systems (cf. Table 124). The overall emissions decrease must be understood as the result of the lower – overall – calculated N excretions. The majority of the emissions reductions for solid-manure systems can be ascribed to a transfer error in the old fattening-bull model.

Table 124:   Comparison of N_2O emissions from manure management, as reported in 2010 and as reported in 2009, by systems (4.s2.)

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Liquid-manure-based, 2010	4.545	4.148	4.070	4.059	4.873	4.856	4.885	4.788	4.773	4.798
Liquid-manure-based, 2009	4.497	4.081	4.040	4.111	4.801	4.814	4.883	4.816	4.845	4.879
Straw-based, 2010	4.352	3.853	3.751	3.749	3.059	3.081	3.113	3.052	3.033	2.989
Straw-based, 2009	4.758	4.074	3.933	3.927	3.444	3.450	3.481	3.388	3.379	3.349
[Gg a^{-1} N_2O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Liquid-manure-based, 2010	4.698	4.755	4.630	4.604	4.479	4.513	4.404	4.449	4.493	
Liquid-manure-based, 2009	4.804	4.871	4.749	4.605	4.502	4.547	4.454	4.512		
Straw-based, 2010	2.946	2.975	2.875	2.839	2.784	2.761	2.713	2.743	2.757	
Straw-based, 2009	3.308	3.353	3.233	3.329	3.241	3.238	3.200	3.239		

6.3.4.6   Planned improvements (4.B, N_2O & NO)

With regard to planned improvements, we refer to Chapter 6.3.2.6.

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

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
Agricultural soil, direct soil emissions (CRF 4.D.1)	l / t	N_2O	2.69 %	3.17 %	Rising
Agricultural soil, indirect emissions (CRF 4.D.3)	l / -	N_2O	0.61 %	0.69 %	Rising

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	IE	NO	NO	NO	NO	C/D	C/D	NO	C	NO
EF uncertainties in %						-80/ +400				
Distribution of uncertainties						L				
EF-determination method						C/D/T 1/T2				

With regard to *direct and indirect N₂O emissions*, the source category *Agricultural soils* is a key source in terms of emissions level. With regard to *direct emissions*, it is also a key source in terms of trend.

Indirect N_2O emissions from agriculture come from leaching and surface run-off from fertilised areas (including spreading of sewage sludges) as well as from atmospheric deposition of NH_3 and NO_x from agricultural sources.

Use of lime fertiliser and urea fertiliser releases CO_2. The relevant emissions are not reported in CRF Sector 4. They do, however, enter into calculation of the greenhouse-gas inventory's total uncertainty with regard to German agriculture (cf. Chapter 6.1.5).

Table 104 of the German NIR 2009 presents a description of CH_4 consumption by agricultural soils and crops. Those results were not entered into the CRF tables (NO), because the area concerned is not an anthropogenic sink. In fact, the sink strength of natural CH_4 consumption is reduced via N fertilisation. In preparation of the IPCC Good Practice Guidance, no consensus was reached regarding this point (communication of Annette Freibauer, co-ordinating first author of the relevant section of the IPCC Good Practice Guidance). For this reason, as of the present inventory CH_4 consumption will no longer be described.

6.5.2 Methodological issues (4.D)

6.5.2.1 Methods

The emission factors used in last year's inventory (NIR 2009 für 2007) were in accordance with IPCC 2006. In keeping with the objections raised by experts conducting the Centralized Review 2009, those emission factors have been largely replaced with emission factors pursuant to IPCC 1996. Relevant details are provided in Chapter 19.4.1 in the Annex. In previous calculation of N_2O and NO emissions resulting from manure application, the activity rate was figured on the basis of the N quantity remaining after manure application, i.e. the computation included deduction of application-related NH_3 emissions. As of this inventory, in conformity with the Guidelines the activity rate will be figured on the basis of that N quantity that is actually applied (i.e. the computation will not include deduction of application-related NH_3 emissions).

A more detailed description of the relevant calculation procedure is provided by HAENEL et al. (2010). The following chapters outline the most important relevant aspects.

6.5.2.1.1   *Treatment of N₂O from agricultural soils by IPCC and EMEP*

Microbial reactions (nitrification and denitrification) with nitrogen compounds lead to emissions of N_2O. The IPCC methods assume that nitrification and denitrification reactions increase as more N enters into the soil. For this reason, N inputs play an important role in determination of N-species emissions. The extent of such reactions depends on a number of other soil parameters, however (water-filled pore space, temperature, C content), that are not covered by the IPCC methods. The improved EMEP procedure (EMEP, 2003) requires the use of detailed soil data that is currently not available. For this reason, N_2O emissions from the area of agricultural soils were calculated in accordance with the IPCC methods.

6.5.2.1.2   *Direct N₂O emissions from agricultural soils (4.Ds1.2, 4.Ds1.3)*

Due to a lack of detailed emission factors, Germany uses the simple Tier 1 method (IPCC, 2006: 11.6 ff.). For calculation, the emissions are assumed to be proportional, on the average, to N discharges into the system. Two emission factors are used: $EF = 0.0125$ kg kg^{-1} N (IPCC, 1996, Table 4-18) for emissions via N inputs from mineral fertiliser and farm manure, crop residues, sewage sludge and N fixing via legumes, and $EF = 8$ kg ha^{-1} a^{-1} N (IPCC 2000, Table 4.17) for emissions from cultivation of organic soils.

N inputs from mineral fertilisers are taken from official statistics. Mineral fertiliser sales (for each German Land) serve as the basis for determining activity data. Under the assumption that no type of fertilisation was preferred over others, fertiliser inputs were calculated for each administrative district for 1999 and 2003, and for each German state (Land) for all other years. Separate calculations were carried out for cropland and grassland. The cropland area also includes the vegetable cultivation area.

The inputs from farm manure result from calculation of N flows in manure management. The emission factor for N_2O-N is 0.0125 kg kg^{-1} N IPCC (1996), Table 4-18. In N_2O-emissions calculation in last year's inventory, the activity data were defined as those N quantities that result from manure application, *after deduction* of NH_3 emissions. The procedure has now been converted to "*before deduction*", and this has resulted in increased N inputs into soil via manure management.

To calculate N_2O emissions from crop residues, one must know the N quantities remaining in the soil. Those quantities are calculated on the basis of the relevant cultivation areas, crop yields and crop-specific N residues. The calculation procedure used is described in IPCC (2006: 11.13) as a Tier 2 procedure ($EF = 0.0125$ kg kg^{-1} N_2O-N).

N_2O emissions from cultivation of organic soils are calculated in accordance with the simpler method, i.e. in proportion to the relevant area. Since no statistical data on use of such soils are available, the areas in question have been estimated via superpositioning of land-use maps and soil maps. In keeping with IPCC (2006: Table 11.1) and IPCC (2000, Table 4.17), an emission factor of 8 kg ha^{-1} a^{-1} N_2O-N is used. The areas of the cultivated organic soils differ slightly from the corresponding area data used in last year's inventory. The reason for this is that a constant area was assumed, due to a lack of relevant data. As of this year's inventory, updated data are used for the years as of 2006.

N_2O emissions from animal excrement in connection with grazing also have to be reported as part of direct emissions from soils. Only Tier 1 procedures for this are available (EMEP (2003: B1020-9) and IPCC (2006: p. 11.6 ff). Previously, two emission factors were differentiated that are to be applied to the excreted N quantity: EF = 0.02 kg kg^{-1} N_2O-N for cattle, swine, buffalo and poultry; EF = 0.01 kg kg^{-1} N_2O-N for sheep, goats and horses. As of the present inventory, and in conformance with IPCC (1996, Table B-1), only a single factor, EF = 0.02 kg kg^{-1} N_2O-N, is used for all animal categories.

6.5.2.1.3   *Indirect N_2O emissions from agricultural soils (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 run-off and leaching. No indirect N_2O emissions from disposal of wastewater in surface waters occur, since such disposal does not occur in Germany (NO).

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 all NH_3-N and NO-N emissions:

- NH_3-N emissions from use of mineral fertilisers
- NO-N emissions from use of mineral fertilisers
- NH_3-N emissions from manure management
- NO-N emissions from manure management
- NH_3-N emissions from legume cultivation
- NH_3-N emissions from grazing
- NO-N emissions from grazing
- NO-N emissions from crop residues

Emissions from manure management also include emissions resulting from the nitrogen introduced with straw bedding, as well as emissions caused by imports of farm manure. Spreading of sewage sludge is not taken into account, since no NH_3 and NO emissions are calculated for that activity.

In principle, the German procedure for calculating deposition-related N_2O emissions is in line 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 and NO-N emissions from straw bedding, legume cultivation, crop residues and imported farm manure. Furthermore, since that equation is not consistent with the definition of *Frac*$_{GASM}$ in CRF Table 4.Ds2 (cf. Chapter 6.5.2.1.8), it can be used only as an approximation in checking of calculated German N_2O emissions (cf. Chapter 6.5.2.3).

The activity data are the N quantities emitted and then deposited via NH_3 and NO. With regard to the relevant activity data and mineral fertilisers, we refer to Chapters 6.5.2.1.4. NH_3 and NO emissions from manure management are calculated on the basis of the N-flow concept (cf. Chapter 6.3.4.2). They also include emissions resulting from imports of farm manure. NH_3 emissions from legume cultivation are calculated from the emission factor (0.01 kg kg^{-1} NH_3-N, EMEP, 2003-B1020-12) and the quantity of bound nitrogen, which is determined on the basis of the cultivation areas and the species-specific fixed N quantities. The NO emissions from above-ground and below-ground crop residues (including non-removed vegetable harvests) are calculated on the basis of the emission factor (cf. Chapter 6.5.2.1.4) and the N quantities contained in the crop residues that remain in fields. Those N

quantities are determined from the relevant cultivation areas, yields and specific N content of residues. Those quantities do not include the N quantity removed from the relevant area in straw in straw bedding.

The indirect N_2O emissions resulting from leaching and surface run-off can be determined, via a simplified Tier 1 procedure (IPCC, 2006: p. 11.21), as the product of the N_2O-N conversion factor, 44/28, N inputs into the soil, the relative share of the N input affected by leaching and surface run-off ($Frac_{LEACH}$; cf. Chapter 6.5.2.1.8) and the emission factor (0.0075 kg kg^{-1} N, IPCC, 2006, Table 11.3). Pursuant to IPCC (2006)-11.21, N inputs into the soil must be understood to include contributions from application of mineral fertilisers, farm manure and sewage sludge, from crop residues (including the N quantity fixed via legumes), from grazing and from mineralisation of organic soils. The German inventory does not take account of mineralisation of organic soils, however, since no data for that area are available.

With regard to the activity data, cf. the remarks made above relative to indirect N_2O emissions from deposition of reactive nitrogen apply.

6.5.2.1.4   *NO emissions*

NO emissions are calculated via an approach similar to that uses for calculation of N_2O emissions (cf. Chapters 6.5.2.1.2 and 6.5.2.1.3), where the relevant emission factors are available (cf. the table below).

Table 125:   Emission factors EF_{NO} for NO emissions from agricultural soils

	EF_{NO} kg kg^{-1} NO-N]	Remark
Mineral fertiliser	0.012	STEHFEST & BOUWMAN (2006)
Farm manure	0.012	STEHFEST & BOUWMAN (2006)
Crop residues	0.007	EMEP (2003), B1020-12
Grazing	0.02	Annahme: $EF_{NO} = EF_{N2O}$ (EMEP, 2003, B1020-11,12)

CO_2 emissions from urea use

CO_2 emissions from urea use are not reported under CRF Sector 4. They are mentioned in the present area, however, since they enter into calculation of the greenhouse-gas inventory's total uncertainty in the area of German agriculture (cf. Chapter 6.1.5).

Urea is applied both in solid form, as a sole fertiliser, and as a liquid fertiliser, in combination with ammonium nitrate. The relevant quantities sold are reported by the Federal Statistical Office as N quantities. Urea N is assumed to account for 50 %, by weight, of the N in relevant ammonium-nitrate solutions.

Calculation of CO_2 emissions from urea use is based on the following reaction between urea ((NH_2)$_2$CO) and water (H_2O):

$$(NH_2)_2CO + H_2O \rightarrow 2\ NH_3 + CO_2$$
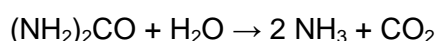
This reaction is complete. The emission factor for CO_2 is thus 44/28, with respect to the N in urea.

The urea-synthesis process can lead to binding of CO_2. That sink is reported under the sector "Industrial Processes and Product Use". In Germany, urea is used in a combination of ammonia syntheses, via a synthesis gas process (such as the Kellogg process) for ammonia

production and a high-pressure process for urea production (such as the stamicarbon process). The eductants used in the process are natural gas, air and water. The reaction between NH_3 and CO_2, leading to urea, consumes more CO_2 than is released in NH_3 synthessis. Urea synthesis must thus be considered a sink for CO_2. At the same time, it can be shown that complete hydrolysis, following use of urea as a fertiliser, releases ten times as much CO_2 as is bound in the overall process.

6.5.2.1.5   CO₂ emissions from application of fertiliser lime

CO_2 emissions from fertiliser lime use are not reported under CRF Sector 4. They are mentioned in the present area, however, since they enter into calculation of the greenhouse-gas inventory's total uncertainty in the area of German agriculture (cf. Chapter 6.1.5).

"Fertiliser lime" includes all carbonates of calcium and magnesium, either as pure substances or as additives. Fertiliser lime within the meaning of this inventory thus also includes the $CaCO_3$ quantities in calcium ammonium nitrate. Those quantities are also taken into account in the inventory.

The activity consists of the product quantities sold annually; those data are taken from official statistics. Lime-containing fertilisers and magnesium carbonates are normally reported as quantities of CaO, while calcium ammonium nitrate is reported as a quantity of N.

The relevant calculation is carried out pursuant to EMEP(2003)-B1060-6. From the formal relationship

$$CaCO_3 \rightarrow CaO + CO_2$$
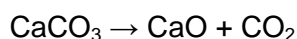
one obtains the emission factor $EF_{CO2\ (CaO)}$, 44/56, with respect to the quantity CaO concerned.

CO_2 emissions from calcium ammonium nitrate (CAN) are calculated on the basis of the weight fraction for $CaCO_3$, 0.229 kg kg^{-1}. That value is based on information from YARA, a producer (YARA, 2009), to the effect that CAN contains 27 % N. From that figure, the molar masses of the two CAN components NH_4NO_3 and $CaCO_3$ can be used to calculate those components' shares of CAN's total weight (77.1 % and 22.9 %). That, in turn, points to a CO_2 weight fraction of 10.1 %. From that figure, finally, one obtains the emission factor $EF_{CO2\ (N)}$, 37.2 %, for the N quantity contained in CAN.

6.5.2.1.6   NMVOC emissions from agricultural soils and crops

Levels of NMVOC emissions from plants were estimated using the procedure set forth in the CORINAIR manual (EMEP, 2006). The present inventory uses the more comprehensive set of emission factors given by KÖNIG et. al. (1995). At present, NMVOC can be calculated solely for crop cultivation and grassland. The activity figure used is the crop-cultivation and grassland area.

6.5.2.1.7   Frac_GASF and Frac_GASM

$Frac_{GASF}$ is calculated in accordance with the definition in CRF-4.Ds2.

With regard to $Frac_{GASM}$, it must be noted that the definition given in CRF-4.Ds2 ("Fraction of livestock N excretion that volatilizes as NH_3 and NO_x") does not agree with the definition

implied by Equation 11.9 in IPCC (2006)-11.21. When one solves that equation for $Frac_{GASM}$, one obtains:

Equation 4:   Derivation of $Frac_{GASM}$ from Equation 11.9 in IPCC (2006)-11.21

$$Frac_{GASM,\,Eq.\,11.9} = \frac{E_{N2O\text{-}N} / EF_4 - F_{SN} \cdot Frac_{GASF}}{F_{ON} + F_{PRP}}$$

With

$Frac_{GASM}$, Eq. 11.9	$Frac_{GASM}$ value from Equation 11.9 in IPCC (2006)-11.21 (in Gg Gg-1)
$EN_2O\text{-}N / EF_4$	Total emissions of N2O-N via deposition of reactive nitrogen from emissions of NH3-N and NO-N from cultivated soils (in Gg a-1 N2O-N)
$FSN \cdot Frac_{GASF}$	Emissions of N2O-N via deposition of reactive nitrogen from emissions of NH3-N and NO-N from application of mineral fertiliser (in Gg a-1 N2O-N)
FON	N quantity from manure management, composting, sewage sludge and other organic N inputs into the soil (in Gg a-1 N)
$FPRP$	N quantity deposited on pastures and relevant installation sites (in Gg a-1 N)

The difference in the numerator corresponds to the indirect N_2O emissions resulting from animal excretions only if N contributions from straw bedding, legume cultivation, crop residues and imported farm manure are not taken into account. Because it includes N contributions that are not the result of animal excretions, the numerator does not accord with the definition of $Frac_{GASM}$ given in CRF-4.Ds2.

In a departure from the definition given in CRF-4.Ds2, the $Frac_{GASM}$ reported by Germany also includes the NH_3 and NO emissions resulting from nitrogen introduced via straw bedding and farm-manure imports. Those nitrogen quantities are included in the N-flow concept (cf. Chapter 6.3.4.2) and thus must be taken into account. These considerations lead to the following modified definition of $Frac_{GASM}$ as reported by Germany.

Equation 5:   Derivation of $Frac_{GASM}$ from Equation 11.9 in IPCC (2006)-11.21

$$Frac_{GASM} = \frac{E_{NH3\text{-}N,\,MM} + E_{NH3\text{-}N,\,grazing} + E_{NO\text{-}N,\,storage} + E_{NO\text{-}N,\,application} + E_{NO\text{-}N,\,grazing}}{m_{excr} + m_{straw} + m_{import}}$$

With

$Frac_{GASM}$	Nitrogen fraction from animal excrement, straw bedding (straw) and farm-manure imports that is emitted as NH3-N and NO-N (in Gg Gg^{-1})
$E_{NH3\text{-}N,\,MM}$	Emissions of NH3-N from manure management (in Gg a^{-1} NH3-N)
$E_{NH3\text{-}N,\,grazing}$	Emissions of NH3-N from grazing (in Gg a^{-1} NH3-N)
$E_{NO\text{-}N,\,storage}$	Emissions of NO-N from manure storage (in Gg a^{-1} NO-N)
$E_{NO\text{-}N,\,application}$	Emissions of NO-N as a result of manure application, including farm-manure imports (in Gg a^{-1} NO-N)
$E_{NO\text{-}N,\,grazing}$	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)
m_{import}	N quantity contained in farm-manure imports (in Gg a^{-1} N)

Because the relevant input data vary by time and place, $Frac_{GASM}$ is not a constant.

Since Equation 11.9 in IPCC (2006: 11.21) does not represent all components that contribute to indirect N_2O emissions (cf. Chapter 6.5.2.1.3), and since Germany uses a modified definition of $Frac_{GASM}$, Equation 11.9 in IPCC (2006: 11.21) may be used only as an approximation in checking the indirect N_2O emissions (CRF-4.Ds1.3.1) reported in the German inventory. In this regard, cf. Chapter 6.5.2.3.

6.5.2.1.8   The other Frac values

$Frac_{BURN}$ and $Frac_{FUEL}$ are not reported (NO).

In keeping with the definition in CRF-4.Ds2, $Frac_{GRAZ}$ is calculated as the ratio of N excreted during grazing to total N excretions.

For $Frac_{LEACH}$, the German inventory, in accordance with IPCC (2006: 11.21f), uses a constant value of 0.30 kg kg^{-1} N. It should be noted that the calculation of indirect N_2O emissions from leaching and surface run-off (CRF-4.Ds1.3.2) does not take account of mineralisation of organic soils; cf. Chapter 6.5.2.1.3.

$Frac_{NCRBF}$ describes the N fraction in dry matter of N-fixing plants, without taking harvest products into account. 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.

$Frac_{NCR0}$ describes the N fraction in dry matter of non-N-fixing plants, without taking harvest products into account. It is determined as a weighted average for grain, rape, sugar and fodder beets, potatoes, grass and vegetables (not including peas and beans).

Since the relevant definition in IPCC (2006: 11.15) is not unambiguous, $Frac_R$ and $Frac_{Remove}$ are calculated in accordance with the definition in CRF-4.Ds2, i.e. 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, lupines and grasses. Root crops and vegetables are not taken into account (the latter is not included for reasons of inadequate data). The straw quantities that are used for straw bedding are also not considered as harvest products.

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.

N quantities input via imports of farm manure are not listed separately; they are included in the figures for N from spreading of farm manure (Table 126).

Table 126:   N inputs into soils (4.Ds1.1.1 to 4.Ds1.1.4)

[Gg a-1 N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Mineral fertiliser	2163.6	2011.5	1927.2	1810.1	1612.0	1787.3	1769.1	1757.1	1787.2	1901.9
Farm manure	1187.1	1073.9	1052.5	1048.1	1059.9	1058.9	1064.1	1044.0	1046.1	1047.0
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	1085.6	1034.5	948.6	1046.5	943.6	992.7	1055.3	1090.6	1078.5	1080.5
[Gg a-1 N]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
Mineral fertiliser	2013.6	1847.0	1791.7	1787.8	1827.8	1778.4	1783.7	1599.8	1807.2	
Farm manure	1032.3	1050.4	1024.3	1015.3	999.9	1002.7	981.2	997.4	1005.4	
N fixing, legumes	95.6	102.3	97.5	95.5	91.8	94.7	92.7	83.2	76.4	
Crop residues	1059.9	1082.6	1032.3	934.7	1158.7	1129.0	1064.2	1177.0	1256.5	

Table 127:   Total area of cultivated organic soils (4.Ds1.1.5)

[1000 ha]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
org. soils	1303	1303	1303	1303	1303	1303	1303	1303	1303	1303
[1000 ha]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
org. soils	1303	1303	1303	1303	1303	1303	1297	1289	1285	

Table 128:   N excretions $N_{excr, graz}$ during grazing (4.Ds1.2)

[Gg a-1N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Nexcr, graz	216.2	198.9	203.9	205.6	178.7	181.4	185.8	181.5	180.0	182.7
[Gg a-1N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Nexcr, graz	179.3	182.4	175.3	174.2	170.6	168.1	163.9	164.9	166.7	

Table 129:   Quantity $N_{reac, em}$ of emitted reactive N (4.Ds1.3.1)

[Gg a-1N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Nreac, em	573.1	519.7	506.2	506.5	492.8	500.2	502.7	497.0	501.5	507.1
[Gg a-1N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Nreac, em	503.8	512.6	501.9	498.0	497.4	491.8	488.1	491.0	498.5	

Table 130:   N losses N_{leach} via leaching and surface runoff (4.Ds1.3.2)

[Gg a-1N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Nleach	1286.3	1187.5	1133.6	1128.1	1047.8	1108.8	1123.7	1124.4	1130.7	1158.4
[Gg a-1N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Nleach	1173.8	1141.9	1103.2	1073.3	1135.5	1117.5	1092.3	1076.7	1152.6	

Table 131:   N quantities input into soil via sewage sludge, N_{sew} (4.Ds1.4)

[Gg a-1N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Nsew	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
[Gg a-1N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Nsew	33.0	29.9	28.2	29.3	28.3	27.4	27.0	26.0	26.0	

The NH_3 and NO emissions on which calculation of indirect N_2O emissions from deposition of reactive nitrogen are based are summarised in Table 132. The nitrogen fractions required for N_2O calculation are obtained by multiplication by 14/17 in the case of NH_3 and by 14/30 in the case of NO.

Table 132:   Calculated sum, as given in 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}N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NH3}	641	581	566	568	554	561	564	558	562	568
E_{NO}	117	107	103	102	94	100	100	100	101	104
[Gg a^{-1}N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
E_{NH3}	562	575	563	559	558	552	548	554	560	
E_{NO}	106	102	99	97	101	99	98	95	101	

The activity data presented in the following tables are provided to facilitate understanding of the CO_2-emissions figures listed in Chapter 6.5.2.3, which are reported under CRF 5(IV).

Table 133:   Activity data for CO_2 emissions from fertiliser lime: quantities of fertiliser lime sold, in Gg CaO

[Gg a-1 CaO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CaO	2868.0	2125.5	1526.2	1551.8	1329.4	1615.7	1666.6	1758.1	2029.0	2066.4
[Gg a-1 CaO]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
CaO	2331.5	1999.4	2120.8	1957.7	1980.2	1855.5	1801.4	2079.4	2122.1	

Table 134:   Activity data for CO_2 emissions from calcium ammonium nitrate (CAN): quantities of CAN sold, in Gg N

[Gg a-1 CaO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N	1348.4	1263.0	1196.0	1148.9	992.5	1090.6	1047.7	1001.2	983.8	992.1
[Gg a-1 CaO]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
N	1057.3	896.1	851.1	823.0	835.3	831.9	805.0	660.3	809.0	

Table 135:   Quantities of N discharged into the soil via urea (including urea fraction in ammonium-nitrate solutions), N_{urea}

[Gg a^{-1}N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
N_{urea}	305.2	276.0	253.2	287.0	265.7	303.7	306.0	315.7	328.5	356.2
[Gg a^{-1}N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
N_{urea}	368.2	407.9	410.7	403.1	427.3	380.5	416.0	407.9	412.3	

The time series presented in the following tables, for the relevant fraction quantities (*Frac* quantities; cf. Chapters 6.5.2.1.7 and 6.5.2.1.8) were calculated for the German inventory. With regard to the definition of $Frac_{GASM}$, cf. Equation 4 in Chapter 6.5.2.1.7; as to interpretation of $Frac_{GASM}$, we refer to the pertinent remarks in Chapter 6.5.2.3. 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 136: $Frac_{GASF}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{GASF}$	0.040	0.039	0.038	0.042	0.043	0.044	0.044	0.045	0.045	0.046
	2000	2001	2002	2003	2004	2005	2006	2007	2008	
$Frac_{GASF}$	0.045	0.050	0.051	0.051	0.051	0.049	0.052	0.055	0.051	

Table 137: $Frac_{GASM}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{GASM}$	0.288	0.290	0.288	0.288	0.284	0.285	0.283	0.285	0.288	0.285
	2000	2001	2002	2003	2004	2005	2006	2007	2008	
$Frac_{GASM}$	0.286	0.286	0.287	0.287	0.289	0.291	0.291	0.291	0.291	

Table 138: $Frac_{GRAZ}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{GRAZ}$	0.132	0.135	0.140	0.142	0.125	0.127	0.128	0.128	0.127	0.129
	2000	2001	2002	2003	2004	2005	2006	2007	2008	
$Frac_{GRAZ}$	0.129	0.129	0.128	0.127	0.127	0.125	0.125	0.124	0.124	

Table 139: $Frac_{NCRBF}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{NCRBF}$	0.0498	0.0503	0.0491	0.0484	0.0484	0.0467	0.0457	0.0450	0.0438	0.0429
	2000	2001	2002	2003	2004	2005	2006	2007	2008	
$Frac_{NCRBF}$	0.0437	0.0417	0.0423	0.0422	0.0421	0.0440	0.0451	0.0461	0.0462	

Table 140: $Frac_{NCR0}$ (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_{NCR0}$	0.0263	0.0263	0.0271	0.0264	0.0269	0.0262	0.0259	0.0252	0.0253	0.0248
	2000	2001	2002	2003	2004	2005	2006	2007	2008	
$Frac_{NCR0}$	0.0247	0.0240	0.0249	0.0256	0.0235	0.0242	0.0245	0.0244	0.0231	

Table 141: $Frac_R$ ($Frac_{Remove}$) (4.Ds2)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$Frac_R$	0.583	0.579	0.582	0.577	0.580	0.578	0.579	0.575	0.575	0.572
	2000	2001	2002	2003	2004	2005	2006	2007	2008	
$Frac_R$	0.574	0.571	0.572	0.576	0.567	0.569	0.571	0.567	0.566	

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 142.

Table 142: N_2O and NO emissions E_{N2O} and E_{NO} from agricultural soils (4s1, 4s2)

[Gg a^{-1} N$_2$O], [Gg a^{-1} NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{N2O}	137.8	128.3	123.5	123.1	115.5	121.0	122.4	122.4	123.0	125.6
E_{NO}	115.4	106.1	101.9	100.4	92.7	98.2	99.1	98.9	99.7	102.5
[Gg a^{-1} N$_2$O], [Gg a^{-1} NO]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
E_{N2O}	126.9	124.4	120.8	118.2	123.6	121.8	119.6	118.1	124.8	
E_{NO}	104.2	101.0	97.7	95.9	99.6	98.0	96.4	93.5	100.2	

A reduction of N_2O emissions in the first half of the 1990s is clearly apparent. Since the end of the 1990s, N_2O and NO emissions have remained at basically the same level. For 2008, a share of 28.5 % of N_2O emissions from soils can be allocated to use of mineral fertilisers in the soil; 19.8 % can be allocated to crop residues; 15.8 % can be allocated to application of farm manure; 13.0 % can be allocated to cultivation of organic soils; and 10.6 % can be allocated to indirect emissions as a result of leaching. The remaining emissions consist of emissions from grazing, sewage sludge, legumes and indirect emissions from deposition of reactive N species.

Table 143 shows the indirect N_2O emissions resulting from deposition of reactive N species, as calculated for the German inventory using the method described in Chapter 6.5.2.1.3, i.e. a method whereby, in contrast to the procedure in IPCC (2006)-11.21, NH_3-, N-, and NO-N emissions from litter, legume cultivation, crop residues and imported farm manure are taken into account.

Table 143:   Indirect N_2O emissions $E_{N2O,\ dep}$ resulting from deposition of reactive N species, as calculated for the inventory

[Gg a^{-1} N$_2$O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$E_{N2O,\ dep}$	9.00	8..17	7.95	7.96	7.74	7.86	7.90	7.81	7.88	7.97
[Gg a^{-1} N$_2$O]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
$E_{N2O,\ dep}$	7.92	8.05	7.89	7.82	7.82	7.73	7.67	7.72	7.83	

When deposition-related indirect N_2O emissions are calculated instead pursuant to IPCC (2006)-11.21, using that source's Equation 11.9, the German $Frac_{GASM}$ defined via Equation 5 and calculated in Table 137 yield N_2O-emissions values that diverge somewhat from those in Table 143. Table 143 shows the relationships between those values and those in Table 144.

The reasons for the discrepancies relative to fraction quantity 1 are that Equation 11.9 in IPCC (2006)-11.21 a) does not take account of emissions of reactive nitrogen from litter, legume cultivation, crop residues and imported farm manure; and b) also applies $Frac_{GASM}$ to sewage-sludge emissions, which has a (partly) offsetting effect. (Cf. Chapter 6.5.2.1.7 regarding inconsistencies in the definition of $Frac_{GASM}$ in IPCC, 2006.)

Table 144:   Ratio X_G of deposition-related N_2O emissions, as calculated pursuant to Equation 11.9 (IPCC, 2006-11.21), with $Frac_{GASM}$ as per Chapter 6.5.2.2, to the values in Table 143

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
X_G	1.000	1.005	1.005	1.005	0.999	1.009	1.011	1.012	1.008	1.006
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
X_G	1.007	1.002	0.999	1.005	1.002	1.002	1.001	1.000	1.000	

Table 145 shows estimates of (non-methane) volatile organic compounds from plant residues.

Table 145:   NMVOC emissions E_{NMVOC} from crop cultivation and grassland (not including vegetable cultivation) (4s1.D, 4s2.D)

[Gg a^{-1} NMVOC]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NMVOC}	1.32	1.70	1.68	1.69	1.70	1.70	1.54	1.64	1.76	1.93
[Gg a^{-1} NMVOC]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
E_{NMVOC}	1.84	1.91	2.07	2.00	2.06	2.13	2.22	2.35	2.19	

The CO_2-emissions results listed below are not reported under CRF Sector 4. They do, however, enter into calculation of the greenhouse-gas inventory's total uncertainty with regard to German agriculture (cf. Chapter 6.1.5).

Table 146: CO_2 emissions $E_{CO2, liming}$ from use of fertiliser lime and calcium ammonium nitrate

[Gg a^{-1} CO$_2$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$E_{CO2, liming}$	2753.6	2139.1	1643.9	1646.4	1413.5	1674.8	1698.7	1753.2	1959.2	1991.6
[Gg a^{-1} CO$_2$]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
$E_{CO2, liming}$	2224.0	1903.2	1981.8	1843.3	1865.5	1766.4	1713.9	1878.0	1967.1	

Table 147: CO_2 emissions $E_{CO2, urea}$ from urea use

[Gg a^{-1} CO$_2$]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
$E_{CO2, urea}$	479.6	433.7	397.9	451.0	417.5	477.2	480.9	496.1	516.2	559.8
[Gg a^{-1} CO$_2$]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
$E_{CO2, urea}$	578.5	641.1	645.4	633.4	671.5	598.0	653.8	641.0	647.9	

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 sets 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 quality assurance / control and verification (4.D)

With regard to source-specific QA/QC and verification, we refer to Chapter 6.1.6.

For purposes of verification, the following table compares the N_2O emission factors used in the 2008 German inventory with those of neighbouring countries, and of the UK, for 2007

(Submission 2009 for 2007; UNFCCC 2009). Since Germany is now using the default emission factors of the IPCC (1996) (cf. Chapter 6.5.2), there are hardly any differences between the two groups of factors. One exception is seen in the emission factor for leaching, for which Germany uses the default emission factor of IPCC (2006) (and is the only country to do so; for a justification, cf. Chapter 19.4.1 in the Annex).

Table 148:　　Comparison of the N_2O emission factors used in the German inventory with those of neighbouring countries (those of Germany, for 2008; those of other countries, for 2007)

[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	0.0100	0.0200
Belgium	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.0100	0.0250
Czech Republic	0.0125	0.0125	0.0125	0.0125	NO	0.0200	0.0100	0.0250
Denmark	0.0125	0.0125	0.0125	0.0125	2.86	0.0200	0.0100	0.0250
Germany	**0.0125**	**0.0125**	**0.0125**	**0.0125**	**8.00**	**0.0200**	**0.0100**	**0.0075**
France	0.0125	0.0125	0.0125	0.0125	NO	0.0200	0.0100	0.0250
Netherlands	0.0106	0.0200	0.0100	0.0100	4.70	0.0165	0.0100	0.0250
Poland	0.0089	0.0100	0.0100	0.0100	8.00	0.0200	0.0100	0.0250
Switzerland	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.0100	0.0250
UK	0.0125	0.0125	0.0125	0.0125	8.00	0.0200	0.0100	0.0250

* Units: kg ha-1 N_2O
Source (except for figures for Germany): UNFCCC 2009

Table 149 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 results of countries that either are neighbouring countries or have agricultural practices that are comparable to those of Germany.

The spread seen in the case of $Frac_{GASF}$ can be explained as the result of differences in urea fractions. This possibility cannot be comprehensively assessed, however, since the distribution of fertiliser quantities among individual crops is not known.

Regarding problems relative to a consistent definition of $Frac_{GASM}$, cf. Chapter 6.5.2.1.7.

The spread in $Frac_{Remove}$ could be due to differences in interpretation of calculation methods.

Table 149:　　Comparison of the *Frac* values used in the German inventory with those of neighbouring countries (those of Germany, for 2008; those of other countries, for 2007)

[kg kg^{-1}]	$Frac_{GASF}$	$Frac_{GASM}$	$Frac_{GRAZ}$	$Frac_{LEACH}$	$Frac_{NCR0}$	$Frac_{NCRBF}$	$Frac_{Remove}$
Austria	0.035	0.20	0.14	0.30	0.009	0.026	0.34
Belgium							
Czech Republic	0.100	0.20	0.14	0.30	0.03	0.015	0.15
Denmark	0.019	0.20	0.09	0.33			0.24
Germany	0.051	0.291	0.124	0.30	0.023	0.046	0.566
France	0.100	0.20	0.41	0.30		0.03	
Netherlands							
Poland	0.100	0.20	0.05	0.30	0.01	0.05	
Switzerland	0.067	0.33	0.12	0.20	0.008	0.029	0.67
UK	0.100	0.20	0.52	0.30	0.015	0.03	0.45
IPCC(1996)-4.94 IPCC(2006)-11.24	0.100	0.20		0.30	0.015	0.03	

Source (except for figures for Germany): UNFCCC 2009

6.5.4   Uncertainties and time-series consistency (4.D)

With regard to the uncertainties in the area of CO_2 and N_2O emissions from enteric fermentation, we refer to Chapter 6.1.5 (total uncertainty of the German GG inventory).

In keeping with EMEP(2003)-B1010-26, an uncertainty factor of 10 is used for NO emissions from use of mineral fertilisers and farm manure.

According to EMEP (2003)-1020-15, the uncertainty factor for NO emissions from grazing could well be 5 or higher. That figure has been adopted for NO emissions from crop residues, since no special uncertainty data are available for that area.

EMEP(2003)-B1020-27 gives a factor of 30 for the uncertainty of NMVOC emissions. In light of the relatively low estimate for the uncertainty of the activity data (< 5 %), that uncertainty is determined primarily by the uncertainty of the emission factors. Consequently, the uncertainty for the emission factors, like that for the emissions themselves, may be assumed to be on the order of 30.

The calculated time series are consistent.

6.5.5   Source-specific recalculations (4.D)

In comparison to the NIR 2009, the following main changes have resulted for 2007 (cf. also Table 150):

- The N inputs into the soil, from manure management, are higher throughout (1990: about 17 %; 2007: 12 %). The main reason for this is that in this year's inventory, for the first time, the inputs prior to deduction of NH_3 emissions were used as the activity (cf. Chapter 6.5.2.1.2). The lower N_2O emissions from storage are another reason (cf. Chapter 6.3.4.5); they translated into more remaining N for manure application. Yet another, much less significant, reason is that mules and asses were taken into account for this first time this year.
- The N inputs into the soil from crop residues are somewhat more than twice as high throughout. This is the result of an erroneous calculation in last year's inventory. In that inventory, the underlying relative N content figures for crops were erroneously applied to the dry weight, instead of to the fresh weight. Correction of that error has yielded considerably larger N quantities – and, thus, higher emissions.
- As of 2006, the areas of the cultivated organic soils differ slightly from the corresponding area data used in last year's inventory (cf. Chapter 6.5.2.1.2).
- In general, lower values were obtained for N excretions $N_{excr, graz}$ during grazing (1990: about -2.5 %; 2007: about -9 %). The main reason for this is that an error in calculation of N excretions for heifers was eliminated (cf. Chapter 6.3.4.5). Another reason is that an error was eliminated in calculation of the percentage distribution of N excretions among grazing, straw-based systems and liquid-manure-based systems for dairy cows. In the last submission, that error had led to excessive shares for grazing excretions. The higher overall N excretions of dairy cows resulting from the use of the new dairy-cow model (cf. Chapter 6.3.4.5) tend to offset the effects of the corrections.

- The quantity $N_{reac,\,em}$ of emitted reactive N is about 3 % to 4 % lower. This is tied primarily to NH_3 emissions from animal husbandry, which account for about 70-80 % of emitted reactive N from agriculture. NH_3 emissions from animal husbandry decreased by about 7 – 8 %, with regard to last year's calculations, as a result of recalculation of N excretions for cattle and swine (cf. also Chapter 6.3.4.5).

- The N losses N_{leach} from leaching and surface run-off are about 20 % to 24 % higher. The primary reasons for this are that, in calculation of N losses, N inputs from grazing were taken into account for the first time and that N inputs from crop residues doubled (see above). Yet another important aspect is the higher N input from farm manure (see above).

- The N quantity input into soils via sewage sludge, N_{sew}, is slightly higher for 1990, and about 8 % lower for 2007. This is due to the use of new sewage-sludge data provided by the Federal Environment Agency.

- The N_2O emissions from the area of agricultural soils are noticeably higher (1990: about 16 %; 2007: about 15 %). A similar effect is seen in the NO emissions.

Table 150:   Comparison of N inputs into soil as reported in 2010 and as reported in 2009 (4.D)

[Gg a^{-1} N]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Manure, 2010	1187.1	1073.9	1052.5	1048.1	1059.9	1058.9	1064.1	1044.0	1046.1	1047.0
Manure, 2009	1016.9	896.4	881.9	888.7	914.7	901.8	922.7	908.2	920.3	913.0
Crop residues, 2010	1085.6	1034.5	948.6	1046.5	943.6	992.7	1055.3	1090.6	1078.5	1080.5
Crop residues, 2009	456.1	470.1	422.3	460.2	440.4	476.8	493.9	533.4	532.2	550.1
Grazing, 2010	216.2	198.9	203.9	205.6	178.7	181.4	185.8	181.5	180.0	182.7
Grazing, 2009	220.0	201.4	204.5	210.2	186.5	190.6	194.4	189.9	190.6	192.7
$N_{reac,\,em}$, 2010	573.1	519.7	506.2	506.5	492.8	500.2	502.7	497.0	501.5	507.1
$N_{reac,\,em}$, 2009	594.0	526.7	513.3	517.5	504.5	512.5	515.8	510.2	512.8	519.8
N_{leach}, 2010	1286.3	1187.5	1133.6	1128.1	1047.8	1108.8	1123.7	1124.4	1130.7	1158.4
N_{leach}, 2009	1035.2	952.6	909.0	889.9	840.6	892.6	899.6	904.7	918.2	948.0
N_{sew}, 2010	27.4	27.4	26.2	26.2	26.2	35.3	35.3	34.1	31.6	31.5
N_{sew}, 2009	27.2	27.2	26.0	26.0	26.0	35.0	35.0	33.8	31.6	31.0
[Gg a^{-1} N]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Manure, 2010	1032.3	1050.4	1024.3	1015.3	999.9	1002.7	981.2	997.4	1005.4	
Manure, 2009	900.3	919.21	898.9	895.9	878.1	888.4	873.7	888.2		
Crop residues, 2010	1059.9	1082.6	1032.3	934.7	1158.7	1129.0	1064.2	1177.0	1256.5	
Crop residues, 2009	536.3	575.0	524.8	4.77.2	615.3	577.1	549.3	563.8		
Grazing, 2010	179.3	182.4	175.3	174.2	170.6	168.1	163.9	164.9	166.7	
Grazing, 2009	190.2	194.0	186.9	186.1	183.1	182.6	178.7	180.9		
$N_{reac,\,em}$, 2010	503.8	512.6	501.9	498.0	497.4	491.8	488.1	491.0	498.5	
$N_{reac,\,em}$, 2009	518.2	528.7	517.6	515.6	512.6	510.6	508.6	510.8		
N_{leach}, 2010	1173.8	1141.9	1103.2	1073.3	1135.5	1117.5	1092.3	1076.7	1152.6	
N_{leach}, 2009	966.2	947.3	911.1	895.9	936.6	918.7	906.1	862.7		
N_{sew}, 2010	33.0	29.9	28.2	29.3	28.3	27.4	27.0	26.0	26.0	
N_{sew}, 2009	32.8	29.6	28.5	28.9	28.3	28.3	28.3	28.3		

All in all, these changes in the activity data, in conjunction with use of the IPCC default emission factors from 1996 (instead of the previously used emission factors from 2006), lead to considerable increases (31 % to 36 %) of N_2O emissions from agricultural soils (cf. Table 151).

Table 151:   Comparison of N₂O emissions from agricultural soils as reported in 2010 and as reported in 2009 (4.D)

[Gg a⁻¹ N₂O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E$_{N2O}$ total, 2010	137.8	128.3	123.5	123.1	115.5	121.0	122.4	122.4	123.0	125.6
E$_{N2O}$ total, 2009	101.2	94.7	91.7	90.5	86.1	90.3	90.8	90.9	91.7	94.1
Mineral fertilisers, 2010	42.5	39.5	37.9	35.6	31.7	35.1	34.7	34.5	35.1	37.4
Mineral fertilisers, 2009	34.0	31.6	30.3	28.4	25.3	28.1	27.8	27.6	28.1	29.9
Manure, 2010	23.3	21.1	20.7	20.6	20.8	20.8	20.9	20.5	20.5	20.6
Manure, 2009	16.0	14.1	13.9	14.0	14.4	14.2	14.5	14.3	14.5	14.3
Legumes, 2010	2.8	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.3	2.1
Legumes, 2009	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crop residues, 2010	21.3	20.3	18.6	20.6	18.5	19.5	20.7	21.4	21.2	21.2
Crop residues, 2009	7.2	7.4	6.6	7.2	6.9	7.5	7.8	8.4	8.4	8.6
Organic soils, 2010	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
Organic soils, 2009	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
Grazing, 2010	6.8	6.3	6.4	6.5	5.6	5.7	5.8	5.7	5.7	5.7
Grazing, 2009	5.9	5.4	5.5	5.6	5.0	5.1	5.2	5.1	5.2	5.1
Ind., deposition, 2010	9.0	8.2	8.0	8.0	7.7	7.9	7.9	7.8	7.9	8.0
Ind., deposition, 2009	9.3	8.3	8.1	8.1	7.9	8.1	8.1	8.0	8.1	8.2
Ind., leaching, 2010	15.2	14.0	13.4	13.3	12.3	13.1	13.2	13.3	13.3	13.7
Ind., leaching, 2009	12.2	11.2	10.7	10.5	9.9	10.5	10.6	10.7	10.8	11.2
[Gg a⁻¹ N₂O]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
E$_{N2O}$ total, 2010	126.9	124.4	120.8	118.2	123.6	121.8	119.6	118.1	124.8	
E$_{N2O}$ total, 2009	95.6	93.8	91.0	89.9	92.8	91.3	90.5	87.6		
Mineral fertilisers, 2010	39.6	36.3	35.2	35.1	35.9	34.9	35.0	31.4	35.5	
Mineral fertilisers, 2009	31.6	29.0	28.2	28.1	28.7	27.9	28.0	25.1		
Manure, 2010	20.3	20.6	20.1	19.9	19.6	19.7	19.3	19.6	19.7	
Manure, 2009	14.1	14.4	14.1	14.1	13.8	14.0	13.7	14.0		
Legumes, 2010	1.9	2.0	1.9	1.9	1.8	1.9	1.8	1.6	1.5	
Legumes, 2009	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Crop residues, 2010	20.8	21.3	20.3	18.4	22.8	22.2	20.9	23.1	24.7	
Crop residues, 2009	8.4	9.0	8.2	7.5	9.7	9.1	8.6	8.9		
Organic soils, 2010	16.4	16.4	16.4	16.4	16.4	16.4	16.3	16.2	16.2	
Organic soils, 2009	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3		
Grazing, 2010	5.6	5.7	5.5	5.5	5.4	5.3	5.2	5.2	5.2	
Grazing, 2009	5.0	5.1	4.9	4.9	4.8	4.8	4.7	4.8		
Ind., deposition, 2010	7.9	8.1	7.9	7.8	7.8	7.7	7.7	7.7	7.8	
Ind., deposition, 2009	8.1	8.3	8.1	8.1	8.1	8.0	8.0	8.0		
Ind., leaching, 2010	13.8	13.5	13.0	12.7	13.4	13.2	12.9	12.7	13.6	
Ind., leaching, 2009	11.4	11.2	10.7	10.6	11.0	10.8	10.7	10.2		

6.5.6   Planned improvements (4.D)

In some areas of the present inventory, the resources for data outside of official statistics are still unsatisfactory. This reflects a difficulty seen in inventories of past years. Efforts continue to obtain the relevant data by expanding pertinent agricultural statistics or by conducting suitable surveys. Such efforts are proceeding on the basis of, inter alia, co-operation agreements with the *Federal Statistical Office* and the *Association for Technology and Structures in Agriculture* (KTBL).

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)

Information relative to key-source analysis for LULUCF is presented in Chapter 1.5.2.

The source categories Forest land (5.A), Cropland (5.B), Grassland (5.C), Settlements (5.E) and Other land (5.F) are key sources of CO_2 emissions, in terms of both emissions level and trend.

7.2   Forest land (5.A)

7.2.1   Source category description (5.A)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS									
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS/T2 [67]									

The source categories *Forest Land remaining Forest Land* (5.A.1) und *Land converted to Forest Land* (5.A.2) are key sources for CO_2 emissions pursuant to GPG-LULUCF (IPCC, 2003).

In the Good Practice Guidance for Land use, Land-use Change and Forestry (GPG-LULUCF, IPCC, 2003), in the official reporting tables for the greenhouse-gas inventories sent to the Climate Secretariat and in the "Common Reporting Format" (CRF), the category "forest" 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 created, via afforestation or natural succession, on areas previously used for other purposes).

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 report year. It differs from the total forest area in that it does not include new forest land, which is considered in a separate category (see below).

7.2.1.2   Land converted to forest land (5.A.2)

Forest is created through succession, afforestation and reforestation; new forest areas begin storing C equivalents as soon as they are converted. Pursuant to IPCC GPG-LULUCF (2003), new forest remains for at least 20 years within this category, after which it is transferred to the "forest land remaining forest land" category.

It must be remembered that the C stocks of previous land uses are deducted. The relevant figures were calculated by the Johann Heinrich von Thünen Institute's Institute of Agricultural Climate Research (vTi-AK). Relevant information is provided in Chapters 7.3 through 7.7.

---

[67] The figure "CS/T2" refers to determination of stock changes in biomass. Under Tier 1, changes in dead wood, ground cover and soil are estimated as "0".

7.2.2   Information about the approaches used to determine forest area and about the land-use databases used (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, forest-floor litter and dead wood; and for calculation of carbon stocks and stock changes at various times:

- Federal Forest Inventory 1 (Bundeswaldinventur; BWI 1)
- Federal Forest Inventory 2 (Bundeswaldinventur; BWI 2)
- Inventurstudie 2008 (IS08; Inventory Study)
- Datenspeicher Waldfonds (DSW)
- Bodenzustandserhebung im Wald 1 (BZE 1; survey of soil condition in forests)
- GSE Forest Monitoring68 (GSE)
- Amtliches Topographisch-Kartographisches Informationssystem (ATKIS; Official topographic-cartographic information system)
- Bodenübersichtskarte der Bundesrepublik Deutschland 1:1.000.000 (BÜK 1000; overview soil map for the Federal Republic of Germany)
- Forest-fire statistics of the Federal Republic of Germany
- Fertiliser statistics of the Federal Statistical Office

7.2.2.1   Federal Forest Inventory, Inventurstudie 2008 and Datenspeicher Waldfonds

The Federal Forest Inventory (Bundeswaldinventur – BWI) is a terrestrial random-sampling inventory with permanently marked sampling points in a 4 km x 4 km basic grid whose resolution, at the request of the Länder, can be increased on a regional basis[69].

The first Federal Forest Inventory (BWI 1) 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 Federal Forest Inventory (BWI 2) was carried out in the period 2001 to 2003 (sample year 2002), as a repeat inventory in the old German Länder and as a first inventory in the new German Länder (BMVEL, 2001; BMELV, 2005).

In 2008, in order to obtain current forest-condition data as of the beginning of the commitment period under the Kyoto Protocol, the Inventurstudie 2008 (IS08), an interim inventory based on the Federal Forest Inventory, was carried out over an 8 km x 8 km sampling grid (SCHWITZGEBEL et al. 2007, BMELV 2008).

The Datenspeicher Waldfonds (DSW) contains complete-coverage forestry data for the territory of the former GDR until 1993. Its data were collected periodically and updated annually, on the basis of growth models and of implementation and change reports of the country's forestry operations (BML, 1994).

---

[68] GSE =GMES Services Elements

  GMES = Global Monitoring for Environment and Security

[69] Further information: http://www.bundeswaldinventur.de

7.2.2.2　　Forest soil-condition survey

The Bodenzustandserhebung (BZE; soil-condition survey) is a nation-wide survey of the condition of soils in forests. The BZE collects data on the basis of an 8 km x 8 km grid. It was carried out between 1986 and 1992 (BZE 1). Further information is provided in "Deutscher Waldbodenbericht 1996 - Ergebnisse der bundesweiten Bodenzustandserhebung in Wald (BZE) 1987 – 1993" (WOLFF & RIEK 1996; presentation of results) and "Bodenzustandserhebung im Wald (BZE II) Arbeitsanleitung für die Außenaufnahmen" (WELLBROCK et al. 2006; guide for sampling).

7.2.2.3　　GSE Forest Monitoring

In the GSE Forest Monitoring project, maps of forest cover in 1990, and of changes in forest cover until 2002 and 2005, were prepared for the new German Länder. (GSE, 2009). 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 ATKIS data, aerial photographs, topographic maps and elevation models. The surveyed structures had to have a minimum area of 0.5 hectares. 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.

7.2.2.4　　Official Topographic-Cartographic Information System (ATKIS)

The Official Topographic-Cartographic Information System (Amtliches Topographisch-Kartographisches Informationssystem), a system for digital management of results of topographic land surveys and of official topographic maps, has been developed by the surveying authorities of the Länder and by the Federal Agency for Cartography and Geodesy (BKG). It is constantly being refined, and it is updated by the Länder surveying authorities in keeping with the availability of pertinent land-use-change data. A more detailed description is provided in Chapter 19.5.2.1.1.

7.2.3　　*Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.A)*

The basis for reporting for the period 1990 to 2007 is the forest definition used by the Federal Forest Inventory (BMVEL, 2001):

"Forest" within the meaning of the FFI 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, landings, rides located in the forest, 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.

For the 2008 report year, the forest area was determined with ATKIS data of 2008, and land conversions to forest land were determined with ATKIS data of 2007 and 2008. This approach was necessary for the purpose of ensuring area consistency with agricultural areas. In the ATKIS object-type catalogue, the "forest" object type is defined as follows: Area covered with forest plants (forest trees and forest shrubs). The inclusion criterion with regard to area size is >= 0.1 ha.

It must be noted that, pursuant to IPCC GPG-LULUCF (2003), new forest remains for at least 20 years in the "new forest" category before it is transferred to the "forest land remaining as forest land" category. Since no afforestation-area data for all of Germany (i.e. both the old German Länder and the new German Länder) are available for the period prior to 1990, new forest land can be taken into account only as of that year. For this reason, the areas that are converted to forest (= new forest), within the various land-use classes, have been growing continually.

7.2.3.1   Determination of forest land, and of relevant changes, in the old German Länder

The first Federal Forest Inventory, from 1987, collected data in the territory of the old German Länder. In the second BWI, in sample year 2002, the sampling points included in the first BWI were re-sampled, and the forest areas of the new German Länder were surveyed for the first time. This has made it possible to quantify forest changes, including conversion from/to other land-use classes, in the old German Länder. For the new German Länder, the relevant data begin with forests' status as of 2002, and thus it is not yet possible to derive changes in forest areas.

The development of the total forest area, and of the various individual change classes, were derived via interpolation for the period 1987 to 2002, on the basis of the data from BWI 1 and BWI 2. During that period, the same rate of change is assumed for each year, and offsetting developments are not taken into account. The resulting changes are extrapolated until 2007. As of 2008, annually available ATKIS data serve as the basis for determining changes.

In BWI 2, no land-use changes in the class "Other Land converted to Forest Land" were included. Only with the ATKIS data can relevant figures be provided for 2008 (cf. Table 152).

Table 152:   Forest areas and area changes, in the old German Länder

Year	Forest Area [ha]	Forest Land remaining Forest Land [ha]	Cropland converted to Forest Land [ha]	Grassland converted to Forest Land [ha]	Wetlands converted to Forest Land [ha]	Settlements converted to Forest Land [ha]	Other Land converted to Forest Land [ha]
1990	7,881,966	7,873,030	1,977	3,669	1,081	2,209	0
1991	7,885,538	7,867,666	3,955	7,338	2,161	4,418	0
1992	7,889,110	7,862,301	5,932	11,007	3,242	6,627	0
1993	7,892,681	7,856,937	7,910	14,675	4,323	8,836	0
1994	7,896,253	7,851,572	9,887	18,344	5,404	11,045	0
1995	7,899,824	7,846,208	11,865	22,013	6,484	13,254	0
1996	7,903,396	7,840,843	13,842	25,682	7,565	15,463	0
1997	7,906,968	7,835,479	15,820	29,351	8,646	17,672	0
1998	7,910,539	7,830,114	17,797	33,020	9,727	19,881	0
1999	7,914,111	7,824,750	19,775	36,689	10,807	22,090	0
2000	7,917,682	7,819,385	21,752	40,357	11,888	24,299	0
2001	7,921,254	7,814,021	23,730	44,026	12,969	26,508	0
2002	7,924,825	7,808,656	25,707	47,695	14,050	28,717	0
2003	7,928,397	7,803,292	27,685	51,364	15,130	30,926	0
2004	7,931,969	7,797,927	29,662	55,033	16,211	33,135	0
2005	7,935,540	7,792,563	31,640	58,702	17,292	35,344	0
2006	7,939,112	7,787,198	33,617	62,370	18,373	37,553	0
2007	7,942,683	7,781,834	35,595	66,039	19,453	39,762	0
2008	7,919,954	7,652,105	40,394	76,198	20,219	45,677	4,022

7.2.3.2   Determination of forest land, and of relevant changes, in the new German Länder

The GSE maps show the land-use changes in the new German Länder in the period 1990 to 2005. A single exception applies with regard to the eastern part of the State of Saxony – it was included only for the period 1990-2002. As of 2005, the deviations resulting from the land-use changes were addressed with the help of ATKIS data. In a procedure similar to that used for the old German Länder, a constant annual rate of change was assumed for the individual years in question, and it was calculated via interpolation for the period between 1990 and 2005 (2002) and via extrapolation for the period between 2005 (2002) and 2007. As of 2008, the changes are determined on the basis of ATKIS data.

Table 153:   Forest areas and area changes, in the new German Länder

Year	Forest Area [ha]	Forest Land remaining Forest Land [ha]	Cropland converted to Forest Land [ha]	Grassland converted to Forest Land [ha]	Wetlands converted to Forest Land [ha]	Settlements converted to Forest Land [ha]	Other Land converted to Forest Land [ha]
1990	2,953,400	2,942,456	223	925	40	129	9,626
1991	2,964,801	2,942,913	447	1,851	79	259	19,253
1992	2,976,201	2,943,369	670	2,776	119	388	28,879
1993	2,987,602	2,943,826	894	3,701	158	518	38,505
1994	2,999,003	2,944,283	1,117	4,627	198	647	48,131
1995	3,010,404	2,944,739	1,341	5,552	237	777	57,758
1996	3,021,805	2,945,196	1,564	6,478	277	906	67,384
1997	3,033,205	2,945,653	1,788	7,403	316	1,036	77,010
1998	3,044,606	2,946,109	2,011	8,328	356	1,165	86,637
1999	3,056,007	2,946,566	2,234	9,254	395	1,294	96,263
2000	3,067,408	2,947,023	2,458	10,179	435	1,424	105,889
2001	3,078,808	2,947,479	2,681	11,104	474	1,553	115,515
2002	3,090,209	2,947,936	2,905	12,030	514	1,683	125,142
2003	3,101,610	2,948,393	3,128	12,955	554	1,812	134,768
2004	3,113,011	2,948,849	3,352	13,881	593	1,942	144,394
2005	3,124,411	2,949,306	3,575	14,806	633	2,071	154,021
2006	3,135,812	2,949,763	3,798	15,731	672	2,201	163,647
2007	3,147,213	2,950,220	4,022	16,657	712	2,330	173,273
2008	3,212,582	2,943,606	11,163	32,098	1,967	10,528	180,226

7.2.4   Methodological issues

7.2.4.1   Changes in 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 federal forest inventories (key dates: 1 October 1987 and 1 October 2002). Between BWI 1 and 2, C stocks increased by 1.22 MgC/ha*a 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 Federal Forest Inventory II (BWI II) were compared with data from the Datenspeicher Waldfonds database, given the lack of an initial inventory comparable to BWI I. The comparison showed a marked net increase in C stocks, amounting to 2.52 MgC/ha*a. As of 2002, data from the BWI 2 inventory and the Inventurstudie 2008 study are available for calculation of changes in stocks for Germany as a whole. On the basis of that information, a C-stocks increase of 0.44 MgC/ha*a was calculated.

Overall, the forests of the Federal Republic of Germany are thus a net sink for carbon.

7.2.4.1.2   New forest land

With regard to new forest land, an individual-tree calculation was carried out on the basis of the BWI 1 and 2 inventories. Only trees in the old German Länder were taken into account, since the BWI 1 inventory was carried out only there. The carbon stocks were calculated for

each LULUCF class and then, at the end of the process, combined within one new-forest class. The stocks of earlier-use classes were deducted – and thus taken into account.

Since it was not possible, for the new German Länder, to derive new-forest wood stocks 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 2008. In the year in which a land area is converted to forest, the increase in C stocks for the area amounts to 0.36 MgC/ha*a; in subsequent years, it amounts to 1.54 MgC/ha*a. The reason for the difference is that earlier uses are taken into account.

Those two factors for the increase in C stocks have to be corrected in the next annual reporting due to an error (cf. planned improvements in chapter 7.2.8.1).

7.2.4.1.3   *Derviation of stock changes via the "stock-change method" (difference method)*

The Federal Forest Inventories provide an outstanding database for calculating C stocks and their changes. They provide such good data for calculation – measuring about 230,000 trees in key year 1987 (BWI 1) and some 377,000 trees in key year 2002 (BWI 2) – that it was possible to use the "stock-change method" instead of the "default method" (incremental extrapolation, as carried out for previous inventories) (IPCC, 2003: p. 3.24). The BWI data have been supplemented with repeat-survey data for some 83,000 trees, from the Inventurstudie 2008.

No biomass functions are available that are generally valid for central European conditions and that are suitable for application to the inventory's measured data (a function for spruce is one exception). These functions directly yield tree dry masses, usually with the input quantities breast-height diameter (BHD) and height (H). Unfortunately, findings from existing biomass studies are based only on small numbers of random samples, and they represent only local growth and site conditions, along with relevant variations in management. Use of such findings, therefore, would tend to distort estimates of biomass.

For this reason, a procedure was applied whereby the standing-timber 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 standing timber volumes, linear regression equations are used that describe the relationship between the above-ground standing-timber volume and the above-ground tree wood volume. These equations (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 trees' above-ground mass was calculated from tree wood volume, via volume density data. To that end, the density data of KOLLMANN (1982) were used, since they include ranges and thus support error determination. Since above-ground expansion of standing-timber volume into tree wood volume was carried out, the various wood categories can be separated in order to take the higher volume densities of branches (HAKKILA, 1972)

into account. That separation was carried out for the densities pursuant to KOLLMANN (1982).

The underground living biomass was taken into account via stock-mass relationships. To this end, the above-ground biomass, broken down by tree species, was extrapolated to hectare values for each random-sample point. From those values, the corresponding root biomass values were derived with the help of the IPCC default values (IPCC-GPG, 2003 Table 3A.1.8).

For the new German Länder, forest-establishment data are available in aggregated form, in the Datenspeicher Waldfonds database. For this reason, the C-balancing method pursuant to BURSCHEL et al. (1993), in conjunction with volume densities pursuant to KOLLMANN (1982), was used for relevant C-stock determination.

For use of the stock-change method, the relevant living biomass was divided into the categories of standing-timber 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 6 and Equation 7 for C-stock determination via the stock-change method were thus converted into the form exhibited by Equation 8. The first part of Equation 8 (standing timber, branch wood) was applied to each tree, while the second part was applied to plantations. The total value was then extrapolated from the plantation values.

Equation 6

$$\Delta C = (C_{t2} - C_{t1})/(t_2 - t_1)$$

Equation 7

$$C = (D * rd * BEF) * (1 + R) * CF$$

Equation 8

$$C = (D * rd_{stamm} + D * rd_{ast} + (VEF - 1)) * (1 + R) * CF$$

where:

C	= carbon stock
t	= time at which an inventory is taken
D	= standing-timber volume
rd_{stamm}	= stem wood density
rd_{ast}	= branch wood density
BEF	= biomass-expansion factor
VEF	= volume-expansion factor[70]
R	= root / sprout relationship
CF	= carbon content

7.2.4.1.4   *Conversion to above-ground individual-tree biomass*

The standing-timber volume D of each individual tree is derived, with the help of the BWI-volume function, via the parameters breast-height diameter (BHD), tree height (H) and

---

[70] 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 / standing-timber volume".

diameter at a height of 7 m (D7). The standing-timber volume D is converted to biomass (in tonnes) via volume-density values rd$_{stamm}$ for each relevant tree-species group. The volume-density values are derived, via the formula

Equation 9

$$r = r_0 (1 - \beta_V / 100)$$

where:

r	= volume density
r_0	= raw density
β_V	= volume-loss measure

as a function of the volume-loss measure, and from the raw densities given in KOLLMANN (1982). The raw densities pursuant to KOLLMANN (cf. Table 154) give 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 that results via conversion of standing-timber volume into biomass. Table 154 lists volume 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 154:   Volume densities *rd* in [g/cm³], as given by IPCC, KOLLMANN and KNIGGE & SCHULZ

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	(sonstige)	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
Nadelbäume	(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	exelsior	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
Laubbäume	(other)	0.58	0.64	0.56	0.61	0.38	13.7

The standing-timber volume *D* was expanded into 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 10

$$VEF = B/D = (a + bD)/D$$

The parameters *a* and *b* for calculation of *VEF* are listed in Table 155.

Table 155:   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 standing-timber 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 standing-timber 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 156 shows average values for 8 conifers, 8 ring-porous deciduous trees and 4 scattered-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 156:   Volume densities for branch wood

	Stem wood [g/cm^3]	Branch wood [g/cm^3]	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 B_o for a given individual tree, therefore, is obtained as the sum of the standing-timber biomass and the branch-wood biomass, via the following equation:

Equation 11

$$B_o = D * rd_{stamm} + D * (1 - \frac{a + bD}{D}) * rd_{ast}$$

7.2.4.1.5   Below-ground individual-tree biomass

In contrast to derivation of above-ground biomass, the root dry substance was not calculated via a volume and the basic density; instead, it was established directly from the above-ground mass. Dry-root substance was estimated using the root/shoot ratio, at the plantation level, with values from Table 3A.1.8 IPCC GPG-LULUCF (2003) (cf. Table 157). To obtain plantation values, the above-ground biomass, differentiated by tree-species groups, was extrapolated 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.

While the function of DIETER & ELSASSER (2002) offers another way of calculating the underground biomass, that function was not used, because it does not include error determination. A comparative calculation is provided in Chapter 19.5.1.1.1.

Table 157:   Root/shoot-ratio at the plantation level, pursuant to IPCC (2003)

Vegetation type	Above-ground biomass in [t/ha]	Mean	SD	lower range	upper range
Conifer plantation	<50	0.46	0.21	0.21	1.06
Conifer plantation	50-150	0.32	0.08	0.24	0.50
Conifer plantation	>150	0.23	0.09	0.12	0.49
Oak forest	>70	0.35	0.25	0.20	1.16
Other broadleaf	<75	0.43	0.24	0.12	0.93
Other broadleaf	75-150	0.26	0.10	0.13	0.52
Other broadleaf	>150	0.24	0.05	0.17	0.30

7.2.4.1.6   *Conversion of individual-tree biomass into carbon*

For converstion of biomass to C stocks, the IPCC default value, 0.5 (IPCC GPG, 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 in conifers. The relative standard error for carbon content in wood is given by BURSCHEL et al. (1993) as 1-2 %; WEISS et al. (2000) use 2 %. Overall, therefore, 0.5 gC/g, with a relative standard error of ±2 %, seems appropriate as a good assumption for mean C content.

7.2.4.1.7   *Algorithms for extrapolation to obtain relevant status in 1987, 2002 and 2008*

At this juncture, we present the extrapolation procedures to be used in connection with a stratified sampling plan oriented to the values "standing-timber stocks", "biomass" and "carbon" at a given time. Stratification is required, since some Länder have increased the density of their sampling networks. The relevant approach uses "sampling strata". The relevant statuses are calculated for 1987, 2002 and 2008. The extrapolation algorithms used for different study units (entire territory of Germany, different regions (east/west) and different LULUCF and ARD classes) are identical.

The Federal Forest Inventory uses cluster sampling. The smallest sampling unit is the cluster. It can vary in size, in such a manner that a cluster can contain from 1 to 4 sampling points. For each cluster c located within a stratum l, the local density (Y) must be calculated first:

Equation 12

$$Y_{lc} = \frac{\sum_{m=1}^{M} I_{l,c,m} Y_{l,c,m}}{M_{l,c}}$$

where $M_{l,c}$ = number of sampling points in cluster c in stratum l. The estimator for stratum l is then obtained as follows:

Equation 13

$$\hat{\overline{Y}}_l = \frac{\sum_{c_l=1}^{C_l} M_{l,c} Y_{lc}}{\sum_{c_l=1}^{C_l} M_l}$$

The global estimator for a given value, throughout all strata ($\hat{Y}_{st}$) is the average of the individual stratum estimators, weighted with the area shares for the strata:

Equation 14

$$\hat{\overline{Y}}_{st} = \sum_{l=1}^{L} \frac{\lambda(U_l)}{\lambda(U)} \hat{\overline{Y}}_l$$

The total status estimate is obtained by multiplying the global estimator by the total area *λ(U)*.

Equation 15

$$\hat{Y}_{st} = \hat{\overline{Y}}_{st} \lambda(U)$$

The (forest-) area-oriented mean is defined as the quotient estimator ($\hat{R}_{st}$); it is obtained as follows:

Equation 16

$$\hat{R}_{st} = \frac{\hat{Y}_{st}}{\lambda(U_{Wald})}$$

7.2.4.1.8   Algorithms for extrapolating change 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 extrapolation only those cluster sampling points were used that were included at both times. The change estimate is thus based on the difference between the two status estimates. At the stratum level, the total change is estimated as follows:

Equation 17

$$\hat{G}_l = Y_l^{(t2)} - Y_l^{(t1)}$$

The total change throughout all strata for a given study unit is estimated in the manner used in Equation 14. The estimated total change is calculated via Equation 15. The change in the area-oriented average is determined via:

Equation 18

$$\hat{R}_{st}^{(t1,t2)} = R_{st}^{(t2)} - R_{st}^{(t1)}$$

7.2.4.1.9   Interpolation between time periods to obtain estimates of annual changes

The Federal Forest Inventory is carried out periodically. Consequently, annual rates of change – "emission factors" – have to be obtained via interpolation between two time

periods. For the time periods between BWI 1 (1987) and BWI 2 (2002) and the Inventurstudie 2008 study, 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-oriented average and the number of years *a* within the relevant inventory interval:

Equation 19

$$EF = \hat{R}_{st}^{(t1t2)} / a$$

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 basis for calculating C stocks in dead wood consists of the data in BWI 2 (BMELV 2005) and the Inventurstudie 2008. The terrestrial survey used for BWI 2 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 (BHD); and trunks with either a height of at least 50 cm or a cut-surface diameter of at least 60 cm (BMVEL 2001). The data survey in the Inventurstudie 2008 included all dead-wood objects with a thicker-end diameter of at least 10 cm (BMELV 2008). 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.

For purposes of reporting the dead-wood pool pursuant to IPCC (2003), the applicable dead-wood-stock relationship between the 10 cm and 20 cm survey limits was determined from the dead-wood data collected in the Inventurstudie. Under the assumption that that relationship applied also at the time of BWI 2, the dead-wood stocks from the 10 cm survey limit upward were derived for the year 2002. The biomass of the dead wood stocks from BWI 2 (2002) and the Inventurstudie (2008), for the various relevant decomposition classes, was determined with the volume density figures pursuant to FRAVER et al (2002) for conifers, and with the volume density figures pursuant to MÜLLER-USING & BARTSCH (2009) for deciduous trees. The annual C-stock change in dead wood was calculated pursuant to Equation 3.2.12 (IPCC 2003). It amounts to about 0.09 MgC/ha*a.

7.2.4.2.2   *New forest land*

No dead wood accumulation occurs in new-forest areas, since the relevant surveys cover only dead wood objects wth a diameter of at least 10 cm. The BWI 2 data indicate that the mean BHD of a 20-year-old plantation is no more than 10 cm, throughout all tree species.

7.2.4.3   Forest-floor litter and mineral soils

7.2.4.3.1   *Forest land remaining forest land*

The C stocks in the soil and forest-floor litter were extrapolated on the basis of the "Bodenzustandserhebung im Wald" (BZE) nation-wide survey of forest-soil condition. The first survey of soil condition (Bodenzustandserhebung) was carried out from 1986 to 1992. Because the Länder are currently processing the data from the second survey of soil condition, the Länder were not able to deliver all BZE 2 data by the time of reporting. Under

its regular schedule, the BZE 2, which is being carried out independently of any greenhouse-gas monitoring, will present its national report in 2013. Along with the problem of incomplete data, a number of methodological issues remain to be clarified, especially issues relating to collection and processing of ground-cover data and to derivation of dry raw densities of mineral soils (VOLZ et al. 2008). With a view to showing that the soil and litter are not C sources, a ground-cover and soil status calculation, using the existing data, was carried out for both inventories. The results, which are presented in Table 158, indicate that any possibility of a C source can be ruled out. For the aforementioned reasons, no calculation of C-stock changes between BZE 1 and BZE 2 was carried out.

For greenhouse-gas inventories, it was assumed that stocks under existing forest do not change (corresponds to "Tier 1").

Table 158:   C stocks in forest-floor litter and mineral soils, from BZE 1 and BZE 2 (provisional)

	BZE 1		BZE 2 (provisional)	
	Litter	**Mineral soil [0-30cm]**	**Litter**	**Mineral soil [0-30cm]**
Stocks [t]	215,815,933	699,321,779	372,172,262	969,583,443
Stocks [t]	915,137,712		1,341,755,705	

7.2.4.3.2   *New forest land*

The C-stock changes in mineral soils of new forest areas were calculated for 2008 by the Johann Heinrich von Thünen Institute's Institute of Agricultural Climate Research (vTI-AK; cf. Chapter 7.3.4.2.). The emission factors, which are presented in Table 159, were also used for relevant calculations for the years 1990 to 2007.

Table 159:   Emission factors for mineral soils in land-use classes involving conversion to forest land, for the year 2008

Land-use change	Emission factor [MgC/ha*a]
Cropland converted to Forest Land	-0.51014
Grassland converted to Forest Land	0
Wetlands converted to Forest Land	0.09852
Settlements converted to Forest Land	0
Other Land converted to Forest Land	-0.02215

For calculation of the forest-floor litter, the status data of BZE 1 and the provisional status data of BZE 2 were used. The average carbon stocks in ground cover, so the result, are 26.25 MgC/ha.

Forest-floor litter forms only gradually in new forest areas. It was assumed that it takes 100 years for average carbon stocks to form in litter. An annual carbon build-up of 0.2625 MgC/ha*a was assumed. That is an extremely conservative estimate, since it is likely that the average stocks emerge within a shorter time. Future studies are expected to yield more precise data.

7.2.4.4   **Organic soils**

7.2.4.4.1   *Forest land remaining forest land*

The carbon-stock changes of organic soils were estimated with the aid of the IPCC (2003) values from Table 3.2.3. For this process, it is assumed that all organic sites are affected by

drainage and that the drainage is solely responsible for the changes. For organic forest soils, carbon emissions of 0.68 MgC/ha*a, and nitrous oxide (N_2O) emissions of 0.6 kg/ha*a, were calculated. The areas covered by organic soils were determined via a georeferencing procedure, with overlaying of BÜK 1000 and ATKIS data (cf. also Chapter 19.5.2.1.3).

7.2.4.4.2   New forest land

The carbon-stock changes in organic soils of new forest areas were calculated for 2008 by the Johann Heinrich von Thünen Institute's Institute of Agricultural Climate Research (vTI-AK; cf. Chapter 7.3.4.2). The C emissions amount to 0.034 MgC/ha*a. The same annual change was also assumed for the years 1990 to 2007.

7.2.4.5   Other greenhouse-gas emissions from forests

Forests in Germany are not normally given nitrogen fertilisers. In CRF Table 5(I), therefore, this activity has been marked "NO" (not occurring).

7.2.4.5.1   Liming

Figures for CO_2 emissions from liming of forest floors are provided in category 5.G. (Other). They range between 65 (2008) and 208 (1992) Gg CO_2 per year, and are tending to decrease.

The liming data were derived from the total-fertilisers calculation. They describe producers' and importers' deliveries to wholesalers and end users (STATISTISCHES BUNDESAMT, 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).

7.2.4.5.2   Forest fire

In forest fires ("wildfires"), both CO_2 and other greenhouse gases (CO, CH_4, N_2O and NO_x) are released. 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). No controlled burning of biomass takes place in Germany's managed forests.

Emissions of other greenhouse gases are calculated with Equation 3.2.20 (IPCC 2003). The data on areas affected by forest fires in the period 1990 to 2008 have been taken from the forest-fire statistics maintained by the Federal Agency for Agriculture and Food (BLE; Waldbrandstatistik – BLE 2008). The mean above-ground biomass was derived for each individual year via linear extrapolation and interpolation between the national forest inventories of 2002 (Federal Forest Inventory 2002 – Bundeswaldinventur 2) and 2008 (Inventurstudie 2008). Pursuant to KÖNIG (2007), 80% of the forest fires 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 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 forest-fire 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 0.03 and 0.43 Gg, and the N_2O emissions range between 0.0005 and 0.0067 Gg. These emissions levels were exceeded in 1992 (CH_4: 1.33 Gg; N_2O: 0.021 Gg), which had an extremely warm summer that was responsible for an above-average burn area of some 4,908 ha. The complete time series for the other greenhouse gases resulting from forest fires is presented in the relevant CRF tables.

7.2.4.5.3   Drainage

No area data are available with regard to drainage of mineral soils. It may be assumed that no such drainage occurs. 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 7.2.4.4.

7.2.4.5.4   Conversion of forest land to cropland

The vTI's Institute of Agricultural Climate Research (vTI-AK) is responsible for determination of N_2O emissions in connection with land-use changes leading to cropland. The relevant procedure is described in Chapter 19.5.2.5. Table 160 shows the N_2O emissions for conversion of forest land to cropland, for mineral and organic soils.

Table 160: N_2O emissions from conversion of forest land to cropland

Time period [year]	N_2O emissions [kg/ha*a]	
	Mineral soils	Organic soils
1990-2000	0.10	4.53
2001-2005	0.15	4.54
2006	0.26	4.53
2007	0.16	4.53
2008	0.13	4.56

7.2.5   Uncertainties and time-series consistency (5.A)

In calculation of carbon stocks, various errors occur, mostly as a result of uncertainties. Errors are derived using practical approaches, and thus such derivation provides only an approximation of the actual errors at work. The calculation does not take account of every possible error source (deviation of allometry, model errors in standing-timber calculation, measurement errors). Correlations between individual terms were neglected.

With the available data, the following error sources can be quantified:

- Uncertainties in estimation of areas affected by land-use changes
- Uncertainties in conversion of standing-timber volume into tree wood volume
- Uncertainties related to the volume densities for specific tree-species groups
- Uncertainties in derivation of the below-ground biomass
- Uncertainties in the carbon-conversion factor
- Random-sampling errors.

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 Inventurstudie 2008 found that such errors can be neglected. A detailed consideration of the measurement errors in the Inventurstudie 2008 project is provided in Chapter 19.5.1.2.1.

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 20)

Equation 20

$$U = \frac{\sqrt{\sum_i (U_i x_i)^2}}{\sum_i x_i}$$

where:

U	= total uncertainty
U_i	= uncertainty for measured value i
x_i	= quantity of measured value i

On the other hand, when two values are multiplied or divided, the errors for the two values propagate themselves multiplicatively - cf. Equation 21:

Equation 21

$$U = \sqrt{\sum_i (U_i)^2}$$

7.2.5.1   Uncertainties in estimation of land-use-change areas

Until 2008, derivation of areas, for different LULUCF classes, had to be carried out separately for the new German Länder and the old German Länder. In the period 1987 to 2002, two Federal Forest Inventories were carried out in the old German Länder. In the process, at each relevant time, the applicable land-use class was determined for each cluster sampling point in forest land and each cluster sampling point in non-forest land. That sampling provided a basis for determining land-use changes for the old German Länder, differentiated by LULUCF classes and including error estimation.

For the new German Länder, the results of the project "GSE Forest Monitoring" (GSE, 2009) were available for the period 1990 to 2005. With the help of analyses of satellite-based remote-sensing data, change analyses with regard to land cover / land use were carried out and verified with accepted statistical methods. The results for the individual Länder were then aggregated. The area-estimation errors were weighted by area and then summed separately by LULUCF classes (cf. Table 161).

Table 161: Area and sampling-error estimates relative to the LULUCF classes, on the basis of BWI 1 and BWI 2, in the old German Länder and between 1987 and 2002

LULUCF classes	BWI, 1987 – 2002		GSE, 1990 – 2005		LC/LU change for Germany as a whole	
	Area [ha]	SE [%]	Area [ha]	SE [%]	Area [ha]	SE [%]
Forest Land remaining Forest Land	7,599,965	0.93	2,948,849	1.12	10,548,814	0.74
Forest Land converted to Cropland	5,290	26.51	335	1.98	5,625	24.93
Forest Land converted to Grassland	24,634	14.18	1,280	2.08	25,913	13.48
Forest Land converted to Settlements	39,688	11.14	4,700	7.24	44,388	9.99
Forest Land converted to Wetlands	9,133	24.85	1,618	11.18	10,751	21.18
Forest Land converted to Other Land	0	nd	25,858	5.37	25,858	5.37
Cropland converted to Forest Land	28,425	13.59	3,352	2.91	31,776	12.16
Grassland converted to Forest Land	52,974	8.61	13,881	3.13	66,854	6.85
Settlements converted to Forest Land	28,967	13.32	1,942	3.86	30,909	12.49
Wetlands converted to Forest Land	16,469	15.92	593	8.25	17,062	15.37
Other Land converted to Forest Land	0	nd	144,394	5.52	144,394	5.52
KP Aforestation	126,834	5.98	164,161	2.30	290,995	5.18
KP Deforestation	78,744	7.92	33,790	4.87	112,534	7.21

From the Inventurstudie 2008, for the period 2002 to 2008, it was possible to make land-use-change estimates solely for the classes *forest land remaining forest land* and *KP Deforestation*. The error for the class *KP Deforestation* was transferred to the LC/LU classes involving conversion of forest into a different form of land use. The land-use changes in those LC/LU classes in which aforestation took place were linearly extrapolated from the earlier period into and through the year 2007 (cf. Table 162).

Table 162: Area and sampling-error estimates relative to the LULUCF classes, on the basis of BWI 2 and IS08, for Germany and between 2002 and 2008

LULUCF classes	Old German Länder		New German Länder		Germany	
	Area [ha]	SE [%]	Area [ha]	SE [%]	Area [ha]	SE [%]
Forest Land remaining Forest Land	7,619,762	2.06	3,038,641	3.46	10,658,404	1.77
KP Deforestation	33,864	27.36	8,041	44.69	41,905	23.72

With a view to obtaining an additive area set relative to those LC/LU classes that do not involve forest, and whose data are obtained from CORINE and ATKIS, as of 2008 the LULUCF areas have been extracted from the complete-coverage, Germany-wide ATKIS system.

7.2.5.2   Uncertainties in conversion of standing-timber volume into tree wood volume

The natural variability of above-ground allometry has not been included. This error cannot be calculated, since the original figures of GRUNDNER & SCHWAPPACH (1952) are not

available. The tables contain only averaged values. These smoothed values systematically underestimate the actual variance. This error consideration thus calculates only the error for conversion of standing-timber volume into tree wood volume. The standard deviation of the residues of the models is shown in Table 163.

Table 163:   Relative standard error of the VEF models

Model		mean (tree wood)	s(residues)	se [%]
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 164 shows the uncertainties that arise in the volume expansion. The uncertainties are included only for those cells of the table in which it was possible to estimate the C stocks directly.

Table 164:   Uncertainties arising in the volume expansion

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	2.99	2.84	2.18	2.90	1.70	1.70	1.76	1.71
Forest Land converted to Cropland	2.12	–	–	–	–	–	–	–
Forest Land converted to Grassland	2.81	–	–	–	–	–	–	–
Forest Land converted to Settlements	2.14	–	–	–	–	–	–	–
Forest Land converted to Wetlands	3.08	–	–	–	–	–	–	–
Forest Land converted to Other Land	–	–	–	–	–	–	–	–
Cropland converted to Forest Land	–	2.11	–	–	–	–	–	–
Grassland converted to Forest Land	–	2.07	–	–	–	–	–	–
Settlements converted to Forest Land	–	2.00	–	–	–	–	–	–
Wetlands converted to Forest Land	–	1.04	–	–	–	–	–	–
Other Land converted to Forest Land	–	–	–	–	–	–	–	–
KP Aforestation	–	2.70	–	–	–	–	–	–
KP Deforestation	2.14	2.45	–	–	2.23	–	1.93	–

7.2.5.3   Uncertainties for volume densities for specific tree-species groups

Wood volume densities differ from species to species and can fluctuate within one and the same tree. KOLLMANN (1982) gives variation ranges for raw densities. With the help of these variation ranges, the standard deviation can be estimated pursuant to SACHS (1984). For left-leaning and right-leaning distributions (approximations of triangular distributions) of volume 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 volume density, since no relevant data are available. In this case, it was assumed that this error would not affect the volume-density range.

Table 165:   Relative standard error of volume densities

Tree species	Average raw density	min. raw density	max. 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%
Ash (ALH)	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 (ALN)	0.41	0.37	0.52	0.04	8.71%
Fir	0.41	0.32	0.71	0.09	22.65%

For secondary 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 166 shows the uncertainties that arise in the volume expansion. The uncertainties are included only for those cells of the table in which it was possible to estimate the C stocks directly.

Table 166:   Uncertainties arising in connection with use of volume 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
Forest Land converted to Cropland	13.70	–	–	–	–	–	–	–
Forest Land converted to Grassland	8.65	–	–	–	–	–	–	–
Forest Land converted to Settlements	7.92	–	–	–	–	–	–	–
Forest Land converted to Wetlands	24.49	–	–	–	–	–	–	–
Forest Land converted to Other Land	–	–	–	–	–	–	–	–
Cropland converted to Forest Land	–	8.05	–	–	–	–	–	–
Grassland converted to Forest Land	–	7.76	–	–	–	–	–	–
Settlements converted to Forest Land	–	6.83	–	–	–	–	–	–
Wetlands converted to Forest Land	–	6.65	–	–	–	–	–	–
Other Land converted to Forest Land	–	–	–	–	–	–	–	–
KP Aforestation	–	6.96	–	–	–	–	–	–
KP Deforestation	8.21	9.23	–	–	24.46	–	8.93	–

7.2.5.4   Uncertainties in 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 157). That source also uses quantity-weighted error extrapolation. 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. This made it possible to derive the total errors for conifers, oak and other deciduous trees (broadleaves). The cells of Table 167 show the results – the values for the state in which it was possible to estimate C stocks directly.

Table 167:   Uncertainties arising in use of root/shoot ratios

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	23.1	–	26.24	26.13	19.15	18.48
Forest Land converted to Cropland	32.36	–	–	–	–	–	–	–
Forest Land converted to Grassland	24.19	–	–	–	–	–	–	–
Forest Land converted to Settlements	22.43	–	–	–	–	–	–	–
Forest Land converted to Wetlands	32.34	–	–	–	–	–	–	–
Forest Land converted to Other Land	–	–	–	–	–	–	–	–
Cropland converted to Forest Land	–	29.27	–	–	–	–	–	–
Grassland converted to Forest Land	–	26.61	–	–	–	–	–	–
Settlements converted to Forest Land	–	25.24	–	–	–	–	–	–
Wetlands converted to Forest Land	–	17.95	–	–	–	–	–	–
Other Land converted to Forest Land	–	–	–	–	–	–	–	–
KP Aforestation	–	24.79	–	–	–	–	–	–
KP Deforestation	23.09	22.51	–	–	35.27	–	19.20	–

7.2.5.5   Random-sampling error

The Federal Forest Inventory is a random-sample inventory. Rather than a basic totality of samples, it includes only a random set 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 values. The variance of a measured value in a stratum *l* is estimated via the following relationship:

Equation 22

$$v\left\langle \hat{\hat{Y}}_l \right\rangle = \frac{1}{c_l(c_l-1)} \sum_{c_l=1}^{C_l} \left(\frac{M_{l,c}}{E\left\langle M_{l,c}\right\rangle}\right)^2 (Y_{l,c} - \hat{\hat{Y}}_l)^2$$

where:

v	= variance
Y	= measured value
c	= number of clusters
E	= expected value
M	= number of sampling points per cluster

The variance of the overall mean, throughout all strata, is defined as follows:

Equation 23

$$v\left\langle \hat{\bar{Y}}_{st} \right\rangle = \sum_{l=1}^{L} (\frac{\lambda(U_l)}{\lambda(U)})^2 v\left\langle \hat{\bar{Y}}_l \right\rangle \cong \sum_{l=1}^{L} (\frac{n_l}{n})^2 v\left\langle \hat{\bar{Y}}_l \right\rangle$$

where

$$n = \sum_{l=1}^{L} n_l = \sum_{l=1}^{L} c_l E\left\langle M_{l,c} \right\rangle = \sum_{c_{l=1}}^{C_l} M_{l,c}$$

The estimated variance of the change $v\left\langle \hat{\bar{G}}_l \right\rangle$ between two inventories whose sampling elements were repeatedly surveyed is calculated as follows:

Equation 24

$$v\left\langle \hat{\bar{G}}_l \right\rangle = v\left\langle \hat{\bar{Y}}_l^{(2)} \right\rangle + v\left\langle \hat{\bar{Y}}_l^{(1)} \right\rangle - 2r_{y^2y^1} \sqrt{v\left\langle \hat{\bar{Y}}_l^{(2)} \right\rangle} \sqrt{v\left\langle \hat{\bar{Y}}_l^{(1)} \right\rangle}$$

With $r_{y^2y^1} = \dfrac{s_{y^2y^1}}{s_{y^2y^1}}$ as a correlation coefficient and:

Equation 25

$$s_{y^2y^1} = \frac{1}{c_l(c_l-1)} \sum_{c_{l=1}}^{C_l} (\frac{M_{lc}}{E\left\langle M_{l,c} \right\rangle})^2 (Y_{lc}^{(2)} - \hat{\bar{Y}}_l^{(2)})(Y_{lc}^{(1)} - \hat{\bar{Y}}_l^{(1)})$$

The variance of the area-based mean (ratio estimator) $v\left\langle \hat{R}_{st} \right\rangle$ from $\hat{\bar{Y}}_{st} / \hat{\bar{X}}_{st}$ is estimated as follows:

Equation 26

$$v\left\langle \hat{R}_{st} \right\rangle = \frac{1}{(\hat{\bar{X}}_{st})^2} \sum_{l=1}^{L} w_l^2 \frac{\sum_{c_{l=1}}^{C_l} (\frac{M_{lc}}{E\left\langle M_{l,c} \right\rangle})^2 (y_{lc} - \hat{R}_{st} x_{lc})^2}{c_l(c_l-1)}$$

where:

w_l　　　　　　= weight of stratum l
X_{st}　　　　　= measured value

The variance in the change of a ratio estimator ($v\left\langle \hat{\bar{G}}_{R_{st}} \right\rangle$) is defined as follows:

Equation 27

$$v\left\langle \hat{\bar{G}}_{Rst} \right\rangle = v\left\langle \hat{R}_{st}^{(2)} \right\rangle + v\left\langle \hat{R}_{st}^{(1)} \right\rangle - 2\,\text{cov}\left\langle \hat{R}_{st}^{(2)}, \hat{R}_{st}^{(1)} \right\rangle$$

For each LULUCF class in which biomass estimates are carried out, therefore, the precision of the estimates can be calculated with the estimation procedures presented here, on the basis of the Federal Forest Inventory.

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", BML, 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 on the sub-area were determined, in the framework of the forest-establishment procedure, with a mean standard error of ±12.5 %." Assuming that that error has had a systematic impact on extrapolation, a value of ±12.5 % may be assumed for tree-species groups.

Table 168:   Random-sampling error for above-ground biomass

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	1.07	1.04	2.34	12.50	3.91	3.84	2.01	2.00
Forest Land converted to Cropland	55.12	–	–	–	–	–	–	–
Forest Land converted to Grassland	45.42	–	–	–	–	–	–	–
Forest Land converted to Settlements	18.73	–	–	–	–	–	–	–
Forest Land converted to Wetlands	69.85	–	–	–	–	–	–	–
Forest Land converted to Other Land	–	–	–	–	–	–	–	–
Cropland converted to Forest Land	–	26.46	–	–	–	–	–	–
Grassland converted to Forest Land	–	15.37	–	–	–	–	–	–
Settlements converted to Forest Land	–	20.9	–	–	–	–	–	–
Wetlands converted to Forest Land	–	28.42	–	–	–	–	–	–
Other Land converted to Forest Land	–	–	–	–	–	–	–	–
KP Aforestation	–	10.47	–	–	–	–	–	–
KP Deforestation	16.33	44.95	–	–	77.3	–	39.03	–

Table 169:   Random-sampling error for below-ground biomass

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	1.05	1.03	2.18	12.50	3.84	3.80	1.98	1.97
Forest Land converted to Cropland	55.59	–	–	–	–	–	–	–
Forest Land converted to Grassland	43.11	–	–	–	–	–	–	–
Forest Land converted to Settlements	18.49	–	–	–	–	–	–	–
Forest Land converted to Wetlands	64.93	–	–	–	–	–	–	–
Forest Land converted to Other Land	–	–	–	–	–	–	–	–
Cropland converted to Forest Land	–	25.41	–	–	–	–	–	–
Grassland converted to Forest Land	–	14.80	–	–	–	–	–	–
Settlements converted to Forest Land	–	20.93	–	–	–	–	–	–
Wetlands converted to Forest Land	–	28.31	–	–	–	–	–	–
Other Land converted to Forest Land	–	–	–	–	–	–	–	–
KP Aforestation	–	10.23	–	–	–	–	–	–
KP Deforestation	16.01	2.45	–	–	77.86	–	38.50	–

7.2.5.6   Error budget

Finally, the error sources and error frameworks described in the previous sections are combined to a form a total error budget. For the old German Länder, and for the period 1987 – 2002, a complete budget can be prepared. The relevant error values are listed in Table 170, while the total error budget is presented in Table 240 through Table 242 in Chapter 19.5.1.2.2. For the period 2002 – 2008, the data permit only an error calculation for the class *Forest Land remaining Forest Land* (cf. Table 171). The complete error budget is shown in Table 243 in Chapter 19.5.1.2.2. With data from the BWI 3 inventory, which is expected to be concluded in 2012, it will be possible to close the remaining gaps. In the 2002 - 2008 period, the C-stock change in the LULUCF class *Forest Land remaining Forest Land* shows a significant increase, amounting to 2.71 m³/ha.

Table 170:   Total error in estimation of C stocks and C-stock changes between 1987 and 2002 in the old German Länder

LULUCF class	1987		2002		1987-2002	
	error total [%]	error emission factor [%]	error total [%]	error emission factor [%]	error total [%]	error emission factor [%]
Forest Land remaining Forest Land	9.64	9.68	9.09	9.14	7.14	7.20
Forest Land converted to Cropland	45.48	52.64	–	–	45.48	52.64
Forest Land converted to Grassland	36.75	39.39	–	–	36.75	39.39
Forest Land converted to Settlements	17.21	20.5	–	–	17.21	20.50
Forest Land converted to Wetlands	59.08	64.10	–	–	59.08	64.10
Forest Land converted to Other Land	–	–	–	–	–	–
Cropland converted to Forest Land	–	–	22.83	26.57	22.83	26.57
Grassland converted to Forest Land	–	–	15.21	17.48	15.21	17.48
Settlements converted to Forest Land	–	–	18.54	22.83	18.54	22.83
Wetlands converted to Forest Land	–	–	23.26	28.18	23.26	28.18
Other Land converted to Forest Land	–	–	–	–	–	–
KP Aforestation	–	–	11.98	13.4	11.98	13.40
KP Deforestation	15.67	17.60	–	–	15.67	17.60

Table 171:   Total error in estimation of C stocks and C-stock changes between 2002 and 2008 in Germany

LULUCF class	2002		2008		2002-2008	
	error total [%]	error emission factor [%]	error total [%]	error emission factor [%]	error total [%]	error emission factor [%]
Forest Land remaining Forest Land	7.58	7.62	7.33	7.36	29.68	29.69

7.2.5.7   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   Source-specific quality assurance / control and verification (5.A)

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The estimates of carbon stocks, at the various relevant times, and the estimates of carbon-stock changes are based on extrapolations that were carried out at the Institute of Forest Ecology and Forest Inventory of the Johann Heinrich von Thünen Institute (vTI-WOI) and that use data from the Federal Forest Inventories and from the Inventurstudie 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 were calculated at the Institute for World Forestry of the Johann Heinrich von Thünen Institute (vTI-WFW) with a programme developed under PostGreSQL. The results of the two sets of calculations agree.

For the first time, extensive error analysis was carried out, and an attempt was made to quantify all existing sources of error. At the conclusion of the error-analysis process, a summarising global error budget was prepared.

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 input data is the responsibility of the relevant data administrators.

7.2.7   *Source-specific recalculations (5.A)*

In the GSE Forest Monitoring project, maps of forest cover in 1990, and of changes in forest cover until 2002 and 2005, were prepared for the new German Länder. With that data set, it became possible, for the first time, to identify areas relative to the land-use classes, and to determine the changes in those areas, for all of Germany. For this reason, the areas were recalculated and supplemented as necessary. Organic soils were identified with the aid of the BÜK 1000 overview map set.

With the additional data available from the Inventurstudie 2008 (IS08) project, which was carried out in 2008, the carbon-stocks changes in biomass were recalculated (cf. Table 172 and Table 173). Inclusion of dead wood in the IS08 survey made it possible to calculate relevant change and, thus, to add dead-wood-change values to the tables.

Table 172:   Recalculations of C storage in biomass, for the class "forest land remaining forest land"

Year	Biomass, submission 2010 [GgC]	Biomass, submission 2009 [GgC]	Difference [GgC]
1990	17,053.00	20,199.14	-3,146.14
1991	17,047.59	20,199.14	-3,151.55
1992	17,042.19	20,199.14	-3,156.95
1993	17,036.79	20,199.14	-3,162.35
1994	17,031.38	20,199.14	-3,167.76
1995	17,025.98	20,199.14	-3,173.16
1996	17,020.58	20,199.14	-3,178.56
1997	17,015.17	20,199.14	-3,183.97
1998	17,009.77	20,199.14	-3,189.37
1999	17,004.37	20,199.14	-3,194.77
2000	16,998.96	20,199.14	-3,200.18
2001	16,993.56	20,199.14	-3,205.58
2002	4,754.32	20,199.14	-15,444.82
2003	4,752.16	20,199.14	-15,446.98
2004	4,749.99	20,199.14	-15,449.15
2005	4,747.82	20,199.14	-15,451.32
2006	4,745.65	20,199.14	-15,453.49
2007	4,743.48	20,199.14	-15,455.66
2008	4,733.88		

With the help of the status data from the BZE federal survey of soil condition, it was possible to determine C emissions from forest-floor litter in connection with deforestation, and the vTI-AK institute supplied relevant data on soil C emissions. Those data were also supplemented as necessary.

Table 173:   Recalculation of C storage in biomass, for the class "new forest land"

Year	Biomass, submission 2010 [GgC]	Biomass, submission 2009 [GgC]	Difference [GgC]
1990	7.16	91.62	-84.46
1991	37.85	122.20	-84.35
1992	68.55	152.73	-84.18
1993	99.24	183.27	-84.03
1994	129.93	213.82	-83.89
1995	160.63	244.36	-83.73
1996	191.32	274.92	-83.60
1997	222.02	305.45	-83.43
1998	252.71	335.99	-83.28
1999	283.40	366.55	-83.15
2000	314.10	397.10	-83.00
2001	344.79	427.64	-82.85
2002	375.48	458.19	-82.71
2003	406.18	488.74	-82.56
2004	436.87	518.94	-82.07
2005	467.56	549.74	-82.18
2006	498.26	580.02	-81.77
2007	528.95	611.47	-82.51
2008	575.63		

7.2.8   Planned improvements (source-specific) (5.A)

Complete GIS-based determination of land-use changes, via use of spatially oriented data (ATKIS®), was carried out in 2008. As a result, as of 2008 area consistency with the agriculture sector has been achieved, for the first time. At the same time, the aforestation and deforestation areas determined with ATKIS are larger, by a factor of 3.2 and 4.6, respectively, than the corresponding areas determined via the inventory data. Independent expert assessments indicate that the inventory results reflect the real situation more accurately. The overestimation of the area changes via ATKIS could be the result of updating, which is currently in progress, and of the higher accuracy requirements applying to the ATKIS data. A project is to be carried out to determine whether areas can be determined more precisely with the help of other data sources.

The C stocks in the soil and ground cover were extrapolated on the basis of the "Bodenzustandserhebung im Wald" (BZE) nation-wide survey of forest-soil condition. The data for the first BZE soil-condition survey was collected in the period from 1986 to 1992. Currently, the data for the second BZE soil-condition survey are being processed by the Länder. This is the reason why the Länder were not able to deliver all of the BZE 2 data by the time of reporting. Along with the problem of incomplete data, a number of methodological issues remain to be clarified, especially issues relating to collection and processing of ground-cover (litter) data and to derivation of dry raw densities of mineral soils. Such open issues are to be clarified by the next report, or in the next few years. When complete BZE 2 data become available, they are to be used to calculate changes in soil and forest-floor litter. An error budget is to be prepared relative to the carbon-stocks and carbon-stock-change

calculations. An effort is being made to use an improved soil map (with a scale at least as fine as: 1: 200,000) in assigning areas to mineral-soil and organic-soil categories.

7.2.8.1   New forest land

Latest calculations show a corrected factor fort he increase in C-Stocks which could not be included in the current inventory and the data tables due to time constraints. The corrected increase in C stocks for the area amounts to 0.67 MgC/ha*a; in subsequent years, it amounts to 2.89 MgC/ha*a. The change is due to consideration of the areas' earliers use. The time series of the biomass change on afforestation areas will be recalculated in the on the basis of these factors in the next annual reporting.

7.3   Cropland (5.B)

The total CO_2 emissions from cropland cultivation amounted to 29,285.4 Gg in 2008. Of that figure, a total of 23,452.6 Gg CO_2 were released from agriculturally used bogs. 5,335.8 Gg CO_2 were released from mineral soils, as a result of conversion to cropland or of conversion from perennial to annual crops (or vice-versa). A total of 497.04 Gg CO_2 came from biomass.

An additional 1,967.2 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.

N_2O releases as a result of conversion of grassland, settlement land, wetlands, other lands and forest land to cropland have been calculated as amounting to 2.4 Gg N_2O, or 740.1 Gg CO_2 equivalents.

7.3.1   Source category description (5.B)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS/M					D				
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS/M[71]					CS/T1				

The source categories *Cropland remaining Cropland* (5.B.1) und *Land converted to Cropland* (5.B.2) are key sources for CO_2 emissions pursuant to GPG-LULUCF (IPCC, 2003).

7.3.2   Information regarding the methods used in determining land areas and regarding the land-use databases used (5.B)

The following data sources were used for determination of cropland areas, for determination of any land-use changes, for allocation of natural and administrative parameters, for development of emission factors for soils and biomass and for calculation of carbon stocks in soils and biomass at various times: digital maps, remote-sensing data, data from official German statistics, results of forest inventories and data from the literature (cf. Chapter 19.5.2.1).

A "wall-to-wall" approach developed in recent years was used in identification of land-use categories and land-use changes. For identification and spatial allocation of land-use categories, digital maps and data records were correlated, throughout the entire area under consideration and in a GIS-technology framework. Via comparison with data records of

---

[71] The entry "CS/M" refers to determination of changes in biomass stocks and in soil. Under Tier 1, changes in dead wood and forest-floor litter were estimated to be 0.

various relevant years, land-use changes throughout Germany were identified. All such data was georeferenced.

The procedures for determining outset parameters, as well as land areas and usage changes, are described in detail in the Annex, Chapter 19.5.2.1/19.5.2.2. The net changes between 1990 – 2000 were determined on the basis of CORINE Land Cover data; those for the period 2000 – 2007 were determined with the ATKIS® data records. The CORINE and ATKIS® databases were then normed, for the various individual years, so that they could be compared. The norming was carried out on the basis of the area sums in the digital database for Germany's administrative boundaries, in ATKIS® (vg250). Via overlaying with digital map data, the georeferenced land-use-change areas that had been obtained via intersection were assigned soil data and biomass data (cf. also Chapter 19.5.2.3 in the Annex).

7.3.3 Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.B)

Pursuant to IPCC GPG LULUCF (2003), carbon-stock changes in soil and biomass stocks are reported under the category "cropland". The "dead organic substance" pool, along with the relevant values for above-ground and below-ground biomass, has been reported in all categories in which it can be determined. The land area subsumed under "cropland" consists of:

- **Cropland with annual crops**
  For purposes of biomass determination, annual crops were divided as follows: wheat, rye, summer and winter barley, oats, triticale, feed plants, silo corn, potatoes, sugar beets and non-food crops – especially winter rape.
- **Cropland with perennial crops:**
  Breakdown for purposes of biomass determination: long-lived crops (fruit crops, osiers, poplars, Christmas tree farms, nurseries).

The basis for reporting under "cropland" consists of the definitions in the object-type key for the basic digital landscape model (Basis-DLM) in the "**A**mtliches **T**opographisch-**K**artographisches **I**nformations **S**ystem" (ATKIS®; "official topographic-cartographic information system" of the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV)); in the use-type keys of the AdV – "Verzeichnis der flächenbezogenen Nutzungsarten im Liegenschaftskataster und ihrer Begriffsbestimmungen" (AdV, 1991; "directory of area-based use types in the property cadastre"); and in the "Nomenklatur der Bodenbedeckungen" ("groundcover nomenclature") of the CORINE LAND COVER project (STATISTISCHES BUNDESAMT, 1989). Table 245 in Chapter 19.5.2.1.2 shows the manner in which different systems classify the various object types within land-use categories.

The land-use categories "Forest Land" and "Other Land" were restructured for purposes of the report. In the framework of Kyoto reporting, which is being carried out for the first time, the restructuring was necessary because the ATKIS® system had to be brought into line with the Federal Forest Inventory's definition of "forest". The object type "wood" ("Gehölze"; B-DLM object type 4108), which was previously reported under "Forest Land", is now reported under "Other Land". Due to limitations of time and resources, it has not yet been possible to recalculate this change for the period 1990 – 2007. As a result, in all land-use and land-use-changes categories in which "Forest Land" and "Other Land" appear, shifting occurs with

respect to earlier years. It manifests itself as follows: values that are linked with "Forest Land" are smaller, and values that are linked with "Other Land" are larger. This inconsistency has no impacts on the overall result, however.

7.3.4   *Methodological issues (5.B)*

7.3.4.1   **Mineral soils**

For each sub-area, the carbon-stock changes in mineral soils were calculated as the difference between the final carbon stock (after the use change) and the initial carbon stock (before the use change). The final carbon stock was determined by multiplying the area affected by a use change with the carbon stock – corrected via an emission factor – for the relevant land-use class.

The equation is as follows:

$$\Delta C = C_f - C_i = A * EF * C - A * C$$

where:

ΔC: change in carbon stocks as a result of the use change
   in t / circle * monitoring period
C_f: final soil carbon stock in t
C_i: initial soil carbon stock in t
A: area on which land-use change has occurred, in ha
EF: dimensionless emission factor
C: polygon-specific carbon stock, in t/ha

The carbon-stock changes in the soils and in biomass were estimated with the help of specially developed programmes that calculate the stocks for the various sub-areas and years, assign the stocks to the relevant CRF categories, sum the stocks on a nation-wide basis and then output them in conformance with the CRF tables (cf. Chapter 19.5.2.3, in the Annex). The N_2O emissions as a result of conversion of land to cropland (CRF Table 5 (III)) were determined pursuant to GPG (2003). The changes in N stocks in the soil were calculated from the carbon-stock changes for the relevant areas, using applicable C/N ratios.

7.3.4.2   **Organic soils**

The carbon-stock differences for organic soils were estimated on the basis of values from the literature. In a CarboEurope study, BYRNE et al. (2004) report figures of 0.82 – 6.58 t C ha^{-1}a^{-1} for carbon emissions from organic grassland soils, and figures of 1.09 – 10.6 t C ha^{-1}a^{-1} for emissions from cropland soils. At an average of 4.09 t 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 und ZEITZ (1999), MEYER (1999) and AUGUSTIN (2001) report losses in grassland areas ranging from 2.46 – 7.63 t C ha^{-1}a^{-1}, and HÖPER (2002) reports a range of 4.6 – 16.5 t C ha^{-1}a^{-1}, with bogs used as cropland reaching 10.6 – 16.5 t C ha^{-1}a^{-1}. The report uses an emission factor of 5 t C ha^{-1}a^{-1} for grassland and a figure of 11 t C ha^{-1}a^{-1} for cropland; these figures are based primarily on data collected in Germany. The organic-soil areas in question, and the relevant uses, were determined via a georeferencing procedure involving intersection of BÜK 1000 and ATKIS$^{®}$ data.

7.3.4.3   Biomass

The carbon-stock changes in biomass are estimated by subtracting the biomass carbon stock before the use change from the stock after the use change, with reference to the area affected by the change:

$$\Delta C_{Bio} = C_{Bio}f - C_{Bio}i = A * EF_{final} - A * EF_{initial}$$

where:

ΔC_{Bio}:	change in carbon stocks in biomass in $t*polygon^{-1}*monitoring\ period^{-1}$
$C_{bio}f$:	final biomass carbon stock in t
$C_{bio}i$:	initial biomass carbon stock in t
A:	area on which land-use change has occurred, in ha
EF_{final}:	plant-specific biomass carbon stock in t/ha (after use change)
$EF_{initial}$:	plant-specific biomass carbon stock in t/ha (before use change)

Biomass carbon stocks were mathematically combined pursuant to GPG-LULUCF (IPCC, 2003) (cf. also Chapter 19.5.2.3.2 in the Annex). The present report uses biomass emission factors for each of the years since 1989. Specially developed programmes (cf. Chapter 19.5.2, in the Annex) were used for combination, category-oriented summation and output of the data in keeping with the CRF categories.

7.3.5   *Uncertainties and time-series consistency (5.B)*

The uncertainties for determination of land-use changes via ATKIS® are very small (cf. Chapter 19.5.2.6, in the Annex), since the procedure chosen is a "wall-to-wall" method. Any errors that occur in the process are based in the original data. The data precision is given as ± 3 m (BKG). The errors from rounding and combining figures, following use of the programmes for area classification and emissions estimation, are very small. They amount to 0.002 % - 0.9 % (median of 0.01 %) of the affected sub-areas.

Since the agency that administrates ATKIS® does not archive older versions, an annually based time series is available for the ATKIS® system only as of 2005. On the other hand, reporters have access to a consistent ATKIS® version for the year 2000, and that version is a suitable basis for reporting for the period as of 2000. For determination of land-use changes for the period 1990 – 2000, CORINE Landcover data were used. Those data were normed, with the help of the administrative-boundaries database in ATKIS®, and brought into line with ATKIS®. At the same time, the CORINE Landcover data have considerably lower resolution, and selection of land-use categories in that system exhibits shortcomings (Gensior, 2003). As a result, the data show a clear discontinuity with regard to consistency. With regard to the 2005 – 2008 time series, the relevant time series that had a gap in the last report has now been completed, and the results for 2006 and 2007 have also been recalculated. Apart from the inconsistency in 2000, the time series now has only the inconsistency in 2008 – the result of a methodological transition – with regard to the categories "Forest Land" and "Other Land" (cf. Chapter 7.3.2). That inconsistency has no impact on the overall result, however, since the applicable calculation algorithms were not changed. The sole change was to assign the results of the "wood" ("Gehölze") object to the category "Other Land", instead of to the "Forest Land" category as had been done in the past. For this reason, no changes occurred with regard to the uncertainties.

In estimation of soil carbon losses, the stock changes range between 45 % - 53 % of the reported mean value. The curve adjustments for determination of emission factors are highly

significant; they explain 93.6 % (grassland/forest/untilled land to cropland) and 68.2 % (cropland to grassland/forest/untilled land) of the variance (cf. Chapter 19.5.2.5).

As a result of the procedure used for estimating N_2O, the errors occurring in determination of carbon stocks propagate themselves. In addition, the uncertainty increases via use of the default procedure, which is based on assumptions that need to be scientifically improved. At present, it is not possible to determine the uncertainties more precisely, since all parameters that actually influence N_2O formation and release vary strongly from area to area and, pursuant to GPG (2003), are not to be used in determination of uncertainties.

7.3.6   Source-specific quality assurance / control and verification (5.B)

Quality control and quality assurance (pursuant to Tier 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

The data sources used to prepare this inventory fulfill the checking criteria of the QSE manual for data sources (and yet are still inadequate; cf. Chapter 19.5.2.7). 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. No special third-party QA/QC checking is carried out.

7.3.7   Source-specific recalculations (5.B)

This year's report includes completely recalculated data for the years 2006 and 2007. In last year's report, those years were reported in combination, due to calculation-capacity limitations. In addition, the data for the category "Forest land converted to cropland" were recalculated, since this year's report includes deforestation emission factors from forestry-sector reporting (cf. Chapter 19.5.1.3). In addition, the emissions from liming were recalculated, to take account of adjustment of the values for calcium ammonium nitrate. As a result of data correction, the tables for the periods 1990 – 2000 and 2000 – 2007 are consistent (with a discontinuity in 2000; cf. Chapter 19.5.2.6.1, in the Annex) and nearly complete.

7.3.8   Planned improvements (source-specific) (5.B)

Complete GIS-based determination of land-use changes, via use of spatially oriented data (ATKIS®), has been carried out. At the same time, there is a lack of field-based data relative to biomass and management methods. In addition, the data-consistency discontinuity resulting from the differences between the CORINE and ATKIS® databases is problematic. Furthermore, the scale for the soil data is too large, and the emission factors for the various soils are too imprecise.

For this reason, the following improvements are to be carried out for the next report or in the coming years:

- Recalculation of all years in the period 1990 – 2007, using the new allocation algorithm for the NIR 2011
- GIS-based use of InVeKoS data, for identification of management and biomass (NIR 2012/13)

- Use of an improved soil map, for both organic and mineral soils (and with a target scale of at least: 1: 200,000; NIR 2013)
- Improvement of the emission factors used for soils:
  - For organic soils: via complete-coverage measurements, carried out in a preliminary study;
  - For mineral soils: via development of improved response functions (for NIR 2011); a soil-carbon inventory of non-forest soils; and a research project on carbon-stocks changes in soils following land-use changes (results of projects available for NIR 2013/14).
- Determination and use of more precise values for carbon stocks in perennial plants (preliminary study for fruit trees and grapevines) (NIR 2012)
- In the NIR 2011, reporting on "dead organic substance" is to be separate wherever possible
- Norming of CORINE data and harmonisation of that data with ATKIS® data, with the help of data from official statistics and other remote-sensing data, in order to reconstruct land uses in 1990 and to ensure consistency of time series

A detailed pertinent discussion is presented in Chapter 19.5.2.7 in the Annex.

7.4   Grassland (5.C)

he anthropogenic CO_2 emissions from grassland were placed at 15,521.3 Gg for the year 2008. A total of 12,880.9 Gg CO_2 were released via draining of organic grassland soils, while 6,517.9 Gg CO_2 were released via changes in biomass. During the same period, 3,877.55 Gg CO_2 were stored in mineral soils.

With regard to the relevant uncertainties and to liming, cf. Chapter 7.3 (CRF 5.B) and Chapters 19.5.2.4 and 19.5.2.6 in the Annex.

7.4.1   Source category description (5. C)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS/M									
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method	CS/ M[72]									

The source categories *Grassland remaining Grassland* (5.C.1) und *Land converted to Grassland* (5.C.2) are key sources of CO_2 emissions pursuant to GPG-LULUCF (IPCC, 2003).

In the area of "grassland", reporting has to cover carbon-stock changes in the relevant storage areas – soil, above-ground biomass and below-ground biomass of all meadow and pasture areas that cannot be considered cropland. In addition, this category also includes land that is covered with trees and shrubs but that does not fall within the definition of "forest", as well as natural grassland and recreational areas.

---

[72] The entry "CS/M" refers to determination of changes in biomass stocks and in soil. Under Tier 1, changes in dead wood and forest-floor litter were estimated to be 0.

7.4.2 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

Cf. Chapter 7.3.2

7.4.3 Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.C)

The basis for reporting under "grassland" consists of the definitions in the ATKIS® object-type key for the basic digital landscape model (Basis-DLM); in the use-type keys of the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV) – "Verzeichnis der flächenbezogenen Nutzungsarten im Liegenschaftskataster und ihrer Begriffsbestimmungen" (AdV, 1991; "directory of area-based use types in the property cadastre"); and in the "Nomenklatur der Bodenbedeckungen" ("groundcover nomenclature") of the CORINE LAND COVER project (STATISTISCHES BUNDESAMT, 1989). Table 245 in Chapter 19.5.2.1.2 shows the manner in which different systems classify the various object types within land-use categories.

7.4.4 Methodological issues (5. C)

Cf. Chapter 7.3.4

7.4.5 Uncertainties and time-series consistency (5. C)

Cf. Chapter 7.3.5

7.4.6 Source-specific quality assurance / control and verification (5. C)

Cf. Chapter 7.3.6

7.4.7 Source-specific recalculations (5. C)

Cf. Chapter 7.3.7

7.4.8 Planned improvements (source-specific) (5. C)

In addition the improvements set forth in Chapter 7.3.8, the following improvements will be carried out for the grassland sector in the coming years:

- Use of improved, up-to-date grassland-plowing data, via use of InVeKoS data (NIR 2012/2013)
- Determination of activity data and emission factors for rejuvenation-oriented tilling of permanent grassland (NIR 2012/2013)

7.5 Wetlands (5.D)

In 2008, a total of 2,596.8 Gg CO_2 were released from wetlands. This sum comprises 1,983.76 Gg CO_2 of emissions from peat extraction and use; 761.2 Gg of CO_2 emissions from biomass; and CO_2 additions of 148.1 Gg to mineral soils.

7.5.1 Source category description (5. D)

The source categories *Wetlands remaining Wetlands* (5.D.1) und *Land converted to Wetlands* (5.D.2) are key sources of CO_2 emissions pursuant to GPG-LULUCF (IPCC, 2003).

Reporting in this category primarily covers emissions from organic soils that are released during peat extraction. Reporting has to cover CO_2 losses from extraction areas, and during extraction, as well as emissions resulting from spreading of peat.

In addition, reporting covers changes in carbon stocks of above-ground and below-ground biomass, and of soils that, as a result of land-use changes, now have to be categorised as wetlands. In the wetlands category, reporting does not have to cover land uses per se, since the areas in question fall into one of the other use categories. In Germany, "wetlands" include the few non-drained semi-natural bogs that have been largely free of anthropogenic impacts. Reporting does not have to cover such areas.

Reporting also does not cover changes in the carbon cycles of "flooded lands", water-storage facilities (dams, reservoirs, etc.) and settling basins that are used for energy production, irrigation, shipping and recreation, and that are flooded or drained, or that otherwise have large water-level fluctuations. In terms of their total area, such areas are insignificant in Germany and do not have to be covered in Tier 1 reporting.

7.5.2   Information about the approaches used to determine land areas and about the land-use databases used

Cf. Chapter 7.3.2

7.5.3   Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.D)

Cf. Chapter 7.3.3

7.5.4   Methodological issues (5. D)

CO_2 emissions from peat extraction were calculated in keeping with the provisions of the IPCC Guidelines 2006. Due to a lack of country-specific emission factors, a Tier 1 procedure was used, in connection with the default factors of the IPCC (2006). The activity data on which the estimate is based were taken from official German statistics (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 3.1).

Carbon-stocks changes in soils, and in biomass, as a result of land-use changes, were calculated using the procedures and methods described in Chapter 0. The carbon stocks in above-ground and below-ground biomass were estimated at 30 t/ha for the relevant lands.

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).

7.5.5   Uncertainties and time-series consistency (5. D)

The statements made in Chapter 7.3.5 and Chapter 19.5.2.6 apply here as well, with regard to the quality of activity data for the categories of land use and land-use changes. 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. The extraction area has remained relatively unchanged, at about 35,000 ha. Similarly, the extracted quantities have

remained at a fairly constant level; over the past six years, they have averaged 8.26 million $m^3 \pm 2.1$ %. The largest uncertainties in this category occur via use of emission factors with error > 100 % (IPCC 2006).

7.5.6   Source-specific quality assurance / control and verification (5. D)

Cf. Chapter 7.3.6

7.5.7   Source-specific recalculations (5. D)

Cf. Chapter 7.3.7

7.5.8   Planned improvements (source-specific) (5. D)

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 19.5.2.7). 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 (NIR 2013).

A continuing effort is also being made to determine specific emission factors for biomass of German wetlands and to classify the relevant areas in a differentiated way (NIR 2013).

7.6   Settlements (5.E)

In 2008, CO_2 emissions from Germany's settlement and transport-infrastructure areas, as a result of land-use changes, amounted to 7,601.39 Gg. That figure represents the sum of loss of forest and wood biomass (5,239.5 Gg) and CO_2 emissions from organic soils (2,361.9 Gg).

IPCC 1996 does not prescribe any methods for determining GG emissions & storage for the area *Other Land remaining Other Land* (5.F.1). For this reason, it is not possible to include such emissions data in the CRF-Reporter software. Since Germany has determined CO_2 storage via biomass from *Other Land remaining Other Land* (5.F.1), as a substitute measure such storage is reported under 5.E.1 (148.37 Gg CO_2).

7.6.1   Source category description (5. E)

he source category *Land converted to Settlements* (5.E.2) is a key source of CO_2 emissions pursuant to GPG-LULUCF (IPCC, 2003).

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.

7.6.2   Information about the approaches used to determine areas and about the land-use databases used (5.E)

Cf. Chapter 7.3.2

7.6.3   Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.E)

Cf. Chapter 7.3.3

7.6.4   Methodological issues (5. E)

The activity data for estimation of CO_2 emissions for the category "Settlements" were taken from the B-DLM of the ATKIS[®] (AdV) system and from the BÜK 1000 overview map (BGR 1998).

In estimation of emissions from biomass and soils, elements that fall within the categories of open settlement areas and transport areas are of particular interest. No findings are available relative to development of organic materials in mineral soils of settlement areas. For this reason, in the underlying approach, it was assumed that conversion to settlement areas does not lead to any changes in soil carbon stocks, even in cases in which mineral soil is not sealed (Tier 1). With regard to organic soils in settlement areas, it is assumed that such soils are either sealed or "left in a natural state", and that thus they release no anthropogenically based emissions.

For this reason, reporting under "Settlements" covers only stock changes in biomass and in organic soils following conversion. Table 174 shows the defined object types for the "Settlements" category, as well as the weighted biomass shares assigned to these areas via expert judgement. For woodlands, the IPCC default value of 63 t/ha was used (IPCC 2003; 2006); for grass areas, the grassland value listed for the relevant district was used, in each case. Biomass production on municipal grass areas is lower than it is on managed grassland, and the per-area shares for the category "Settlements" were suitably lowered to take account of this. Land uses and land-use changes were determined, and the relevant soil data assigned, in keeping with the algorithms described in Chapter 0. In order to prevent double-counting, carbon emissions in connection with dead organic material (especially grass and tree cuttings) are not reported under "Settlements". Since in Germany such cuttings are normally composted, their emissions have to be reported under "Waste".

Table 174:   Object-type key, object type and weighted biomass – area percentage shares for defining sub-categories in the land-use category "Settlements"

Key	Object type	Wooded areas	Grassy areas
2000	**Settled areas**		
2100-2135	Structurally modified areas		
2201	Sports facilities	10 %	25 %
2202	Recreational facilities	40 %	20 %
2213	Cemetaries	40 %	10 %
2227	Greenswards/parks	50 %	20 %
2228	Camping areas	30 %	20 %
2300 – 2352	Buildings and other facilities		
3000	**Transport**		
3100 – 3205	Roads and railways		
3301	Airports		50 %
3302	Airfields		70 %
3400 – 3543	Ship-transport infrastructure and related facilities		

7.6.5   Uncertainties and time-series consistency (5. E)

With regard to the quality of activity data for the categories of land use and land-use changes, the statements made in Chapter 7.3.5 apply here as well. Since no data are available on the biomass of the various types of areas in question, the relevant figures had to be estimated via expert judgement. The error for the pertinent underlying default factors is estimated at 75 %. The carbon stocks in biomass were estimated on the basis of default factors (error: 75 %) or harvest statistics.

The consistency of the time series is assured only with regard to the ATKIS[®] data. No other data were collected.

7.6.6   Source-specific quality assurance / control and verification (5. E)

Cf. Chapter 7.3.6

7.6.7   Source-specific recalculations (5. E)

Cf. Chapter 7.3.7

7.6.8   Planned improvements (source-specific) (5. E)

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 (NIR 2013). (Compare Chapter 19.5.2.7).

7.7   Other land (5.F)

In 2008, a total of 5,227.8 Gg CO_2 were stored in "other land". That value is composed of storage of 5,001.5 Gg CO_2 in biomass, storage of 255.2 Gg CO_2 in mineral soils and emissions of 32.99 Gg CO_2 from organic soils. The increase in storage of CO_2 in "other land", with respect to previous reports, is due to methodological changes (cf. Chapter 7.7.2).

As noted in Chapter 7.6, in the CRF Reporter, CO_2 emissions & storage may not be entered under 5.F.1. Since Germany determines CO_2 storage via biomass in *Other Land remaining Other Land* (5.F.1), however, areas, emissions and storage in this source category are reported under 5.E.1. That allocation would seem to fit fairly well for the reported areas concerned (waste land and swaths/aisles (cf. the following chapter). The allocation is not as well suited for wood areas that do not fall within the "forest" category, since such areas definitely do not fit within any of the existing LULUCF source categories apart from 5.F..

7.7.1   Source category description (5. F)

The source category *Land converted to Other Land* (5.F.2) is a key source of CO_2 emissions pursuant to GPG-LULUCF (IPCC, 2003).

Reporting for the category "Other land" has to cover all of the carbon-stock changes in soils, biomass and dead organic material that do not fall under any of the other land-area report categories. Such areas include, for example, scree, glacier areas and open soil. In the present report, this category includes all areas that could not be assigned to a different category. Glacier areas, scree slopes and sand bars etc. are normally not managed by human beings, with the result that the relevant emissions do not have to be reported. For purposes of emissions calculation, therefore, conversions to vegetation-free areas, waste land, swaths/aisles and wood areas (cf. Chapter 7.7.2) are significant.

7.7.2   Information about the approaches used to determine areas and about the land-use databases used (5.F)

Cf. Chapter 7.3.2.

7.7.3   Land-use definitions and land-use classification systems, and their reflection in the LULUCF categories (5.F)

within the German LULUCF report system: "area currently not classifiable" (object number 4199), "vegetation-free area" (object number 4120), "waste land" (4110), "swath" (object number 4198) and "woods" (object number 4108). Areas are identified and classified in keeping with the algorithms described in Chapter 19.5.2.

Cf. also Chapter 7.3.3.

7.7.4   Methodological issues (5. F)

The land-use categories "Forest Land" and "Other Land" were restructured for purposes of the report. In the framework of Kyoto reporting, which is being carried out for the first time, the restructuring was necessary because the ATKIS® system had to be brought into line with the Federal Forest Inventory's definition of "forest". The object type "wood" ("Gehölze"; B-DLM object type 4108), which was previously reported under "Forest Land", is now reported under "Other Land". Due to limitations of time and resources, it has not yet been possible to recalculate this change for the period 1990 – 2007. As a result, in all land-use and land-use-changes categories in which "Forest Land" and "Other Land" appear, shifting occurs with respect to earlier years. It manifests itself as follows: values that are linked with "Forest Land" are smaller, and values that are linked with "Other Land" are larger. This inconsistency has no impacts on the overall result, however.

For emissions from mineral soils, the principles described in Chapter 19.5.2.3 were applied.

In the case of organic soils, it was assumed that soils that fall into one of the above object types, as a result of land-use changes, were previously subject to anthropogenic impacts; at least, they were drained. For this reason, the emission factor for grassland was used for CO_2 emissions of such areas following conversion to "other land".

The biomass of object types 4199 and 4110 was specified as 50 % grassland cover and 63 t/ha wood.

7.7.5   Uncertainties and time-series consistency (5. F)

Cf. Chapter 7.3.5. The time-series consistency with regard to previous years has been interrupted; as a result of time and capacity limitations, it has not yet been possible to carry out relevant recalculations, with the new object-type allocations, for the previous years.

7.7.6   Source-specific quality assurance / control and verification (5. F)

Cf. Chapter 7.3.6.

7.7.7   Source-specific recalculations (5. F)

Cf. Chapter 7.3.7

7.7.8   Planned improvements (source-specific) (5. F)

For waste land and woods/shrubbery, the newly determined emission factors from the preliminary study referred to in Chapter 19.5.2.7 will be used. Otherwise, the next report will present recalculations, with respect to the categories changes, for all years in the period 1990 – 2007.

If future versions of the CRF-Reporter software allow entry of CO_2 emissions & storage under 5.F.1, those emissions and storage will again be reported here, instead of under 5.E.1, the substitute location used this year (cf. Chapter 7.6).

No additional improvements are planned at present.

7.8   Other areas (5.G)

The following emissions are reported under 5.G:

- Nitrous oxide emissions tied to disruptions in connection with land-use changes to cropland, since CRF Reporter does not include N_2O emissions in sub-category 5.B.2.4 Settlement converted to Cropland.
- CO_2 emissions from liming of forest soils, since CRF Reporter allows only reporting of agricultural lime fertilisation.
- CO_2 emissions from application of urea fertilisers on cropland. Those emissions should normally be reported under source category 4. Since the IPCC 1996 Revised Guidelines do not cover emissions from use of urea fertilisers, however, such emissions cannot be included under that source category within CRF Reporter. Since reporting for source category 4 is largely in accordance with the IPCC Guidelines 2006, however, and since that category includes a method for determining such CO_2 emissions, we have applied that method and are reporting the emissions here.

8 WASTE AND WASTE WATER (CRF SECTOR 6)

8.1 Overview (CRF Sector 6)
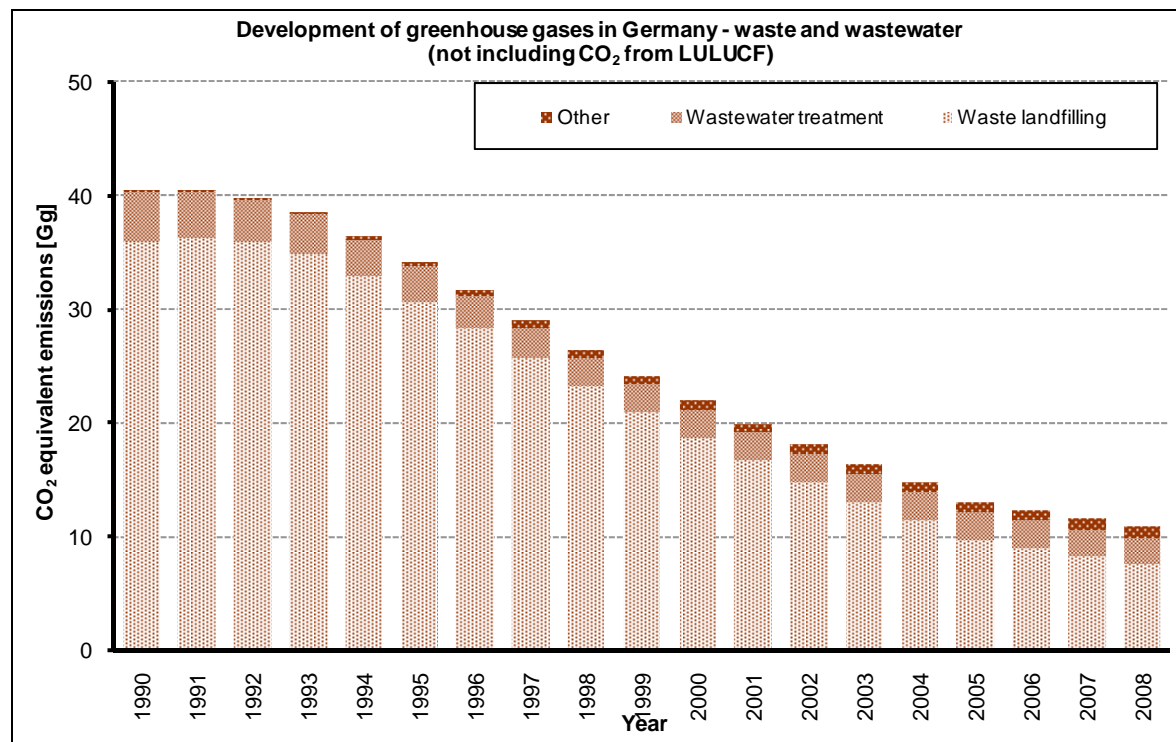
Figure 30:   Overview of greenhouse-gas emissions in CRF Sector 6

8.2 Solid waste disposal on land (6.A)

CRF 6.A					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 – contribution to total emissions**	**2008 – contribution to total emissions**	**Trend**
6.A.1 Solid waste disposal on land	l / t	CH$_4$	2.92 %	0.78 %	falling

Gas	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)		CS/D								
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method		T2								

The source category *Solid waste disposal on land* is a key source of CH$_4$ emissions in terms of both 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 31). 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 2006 ("Waste management, 2007") of 7 July 2009) are available for the period until 2006. Those figures were extrapolated linearly for the year 2007. 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 must be pre-treated via thermal or mechanical-biological processes. As landfill-gas formation from older landfill storage layers tapers off, landfill methane emissions will again decrease extensively, and thus methane emissions in 2012 are expected to be less than 10 % of the methane emissions of 1990.
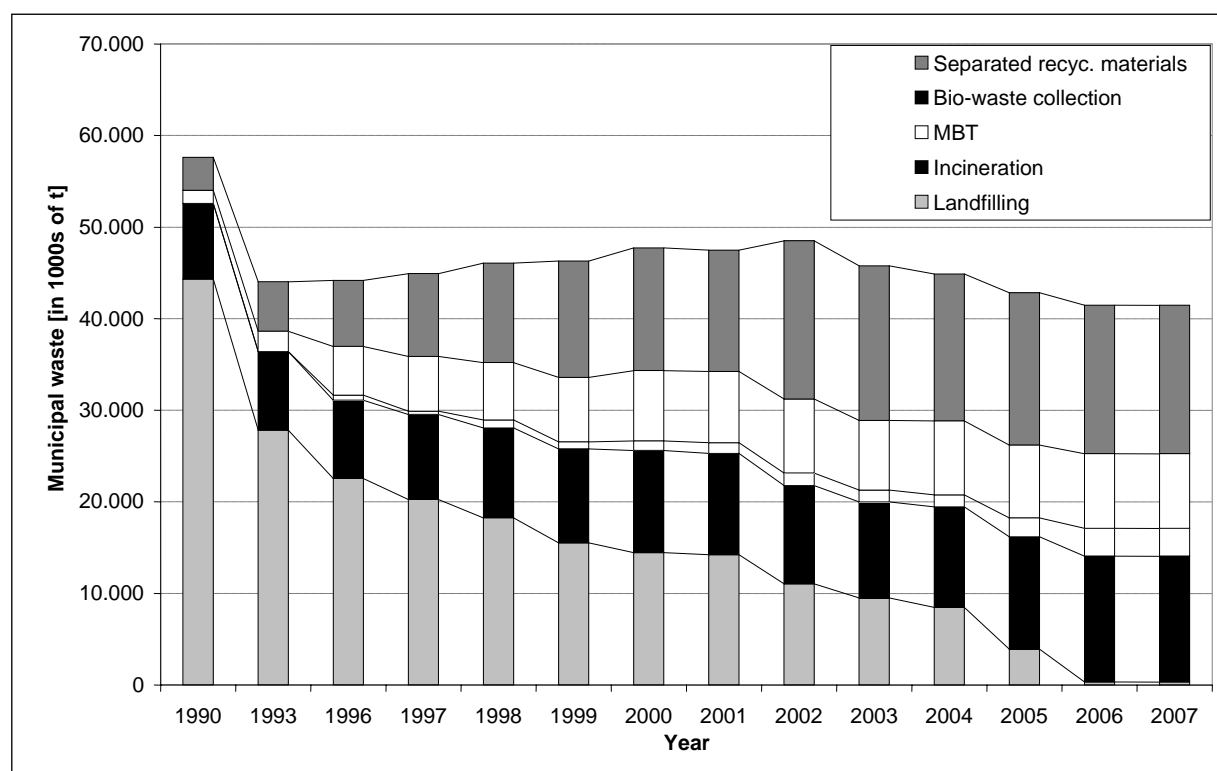
Figure 31:   Changes in pathways for management of household waste, 1990 to 2007, with intermediate years

By reducing landfill methane emissions from 1.7 million Mg in 1990 to less than 0.4 million Mg in 2007, 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 27 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 source. At present, this source category is a key source 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 28:[73]

Equation 28 *(IPCC Guidelines, Equation 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*
$DOC(x)$	= *Decomposable organic carbon in year x (relevant share)*
DOC_F	= *Fraction of converted DOC in landfill gas*
F	= *Fraction of CH_4 in landfill gas*
$16/12$	= *Conversion of C toCH_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 28.

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 29:

Equation 29 *(IPCC Guidelines, Equation 5.1)*:

CH_4 emitted in year t (Gg/year) = (CH_4 produced in year t – R(t)) • (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 settlement 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 DOCs.

---

73 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 municipal waste, industrial waste and landfilled sewage sludge.

Pertinent quantities of landfilled 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. Waste landfilled after 1 June 2005 must contain no biodegradable components; consequently, such waste no longer contributes to landfill-gas production. For this reason, in calculation of methane emissions from landfills, only waste storage until that date is considered. 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 32 and Figure 33). 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.

Composition of household waste
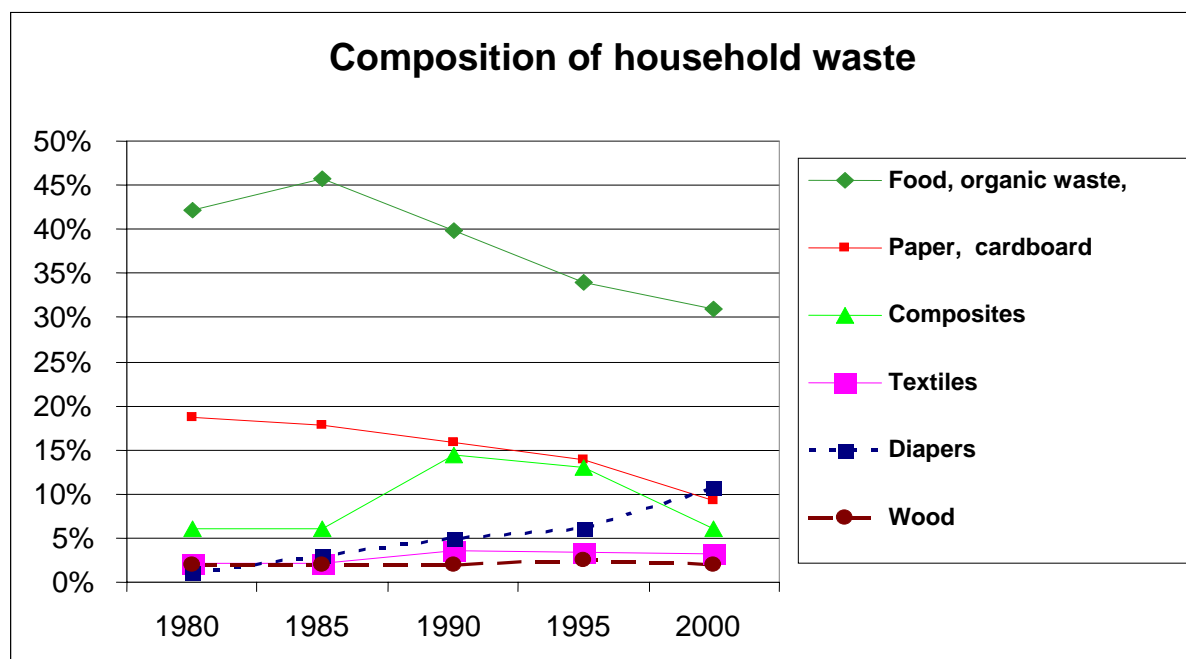
Figure 32:   Trends in waste composition (old German Länder) between 1980 and 2000

Composition of bulky waste
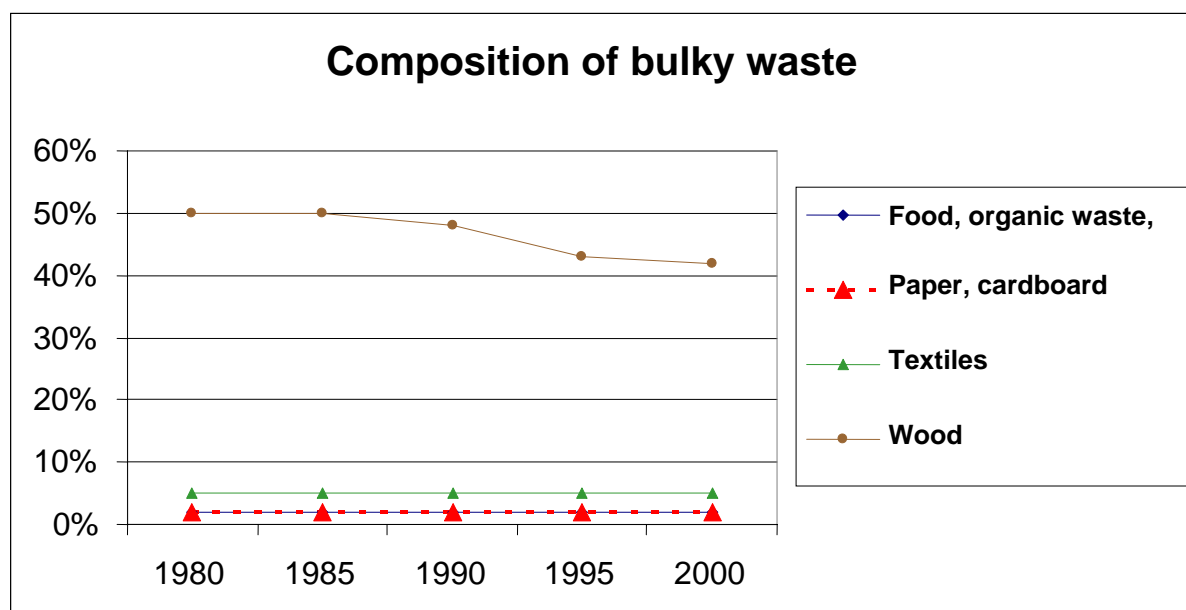
Figure 33:   Trends in bulky-waste composition (old German Länder) between 1980 and 2000

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*

Until 2005, both national data and IPCC default factors were used for DOC, the proportion of degradable organic carbon in waste. Table 175 below provides an overview of the DOC values used. For waste landfilled after 1 June 2005 (when landfilling of biodegradable waste was prohibited), a DOC of 0 % is assumed.

Table 175:   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

8.2.1.2.5   *DOC_F*

DOC_F, the DOC proportion 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 = proportion of CH_4 in landfill gas*

A value of 50%, the mean value in the IPCC default-value range, is assumed for F. This value was confirmed by a national research project (UBA, 1993).

8.2.1.2.7   *Half-life*

The calculation model is a multi-phase model that takes account of the different half-lives for the various different waste fractions. Table 176 shows the half-lives used for the pertinent waste fractions.

Table 176:   Half-lives of waste fractions

Type of waste	Half-life (years)
Food waste	4
Garden/park waste	7
Paper / cardboard	12
Wood	23
Textiles / diapers	12
Composite materials	12
Sewage sludge	4

8.2.1.2.8   Landfill-gas use

The "TA Siedlungsabfall" of 1993[74] made gas collection one of the prerequisites for licensing of landfills for municipal waste. Collection of gas from landfills began in the 1980s (MELCHIOR 2002); Melchior (2000) reports a gas-collection rate of 35 % for this period. To date, no detailed findings are available, at the federal level, from monitoring of gas usage from individual landfills. Landfill operators are required to report solely to Länder licensing authorities. The amended version of the Environmental Statistics Act (Umweltstatistikgesetz) of 2005 mandates that the Federal Statistical Office shall in future include and publish landfill-gas-collection data in its surveys, i.e. for future years it will be possible to replace this parameter with data from individual landfills. Data on gas collection in 1993 is available; it shows that 35 % of landfills were connected to a gas-collection system (UBA, 1994). In principle, collection did not begin until the 1980s. For 2004, it was assumed that gas was being collected in 95% of all landfills, and that collection efficiency amounted to 60%. For 1990, an efficiency of 45 % was assumed. These key figures were used as a basis for calculating the amounts of CH_4 that must be deducted as a result of use of generated methane gas.

Use of landfill gas for energy recovery is recorded and reported by the energy sector. Rough conversion of the assumptions noted here, into energy data, along with a comparison with various sources of data on use of landfill gas for energy recovery, showed that the method selected leads to conservative results and that publications on status of use of renewable energies show landfill-gas use in excess of the gas quantities taken into account for recent years in category 6.A. At the same time, the data from energy statistics are not based on data from all facility operators.

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 accepted 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.

---

[74] Technical instructions on recycling, treatment and other management of municipal waste (Third general administrative provision on the Waste Act (Abfallgesetz)) of 14 May 1993

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 and quality assurance (pursuant to Tier 1 & 2), 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.

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 national model's parameters and data into that FOD model. The same result was obtained.

8.2.1.5   Source-specific recalculations (6.A.1)

No recalculations are required. The emissions calculations for the period through the reported year 2005 are based on official data of the Federal Statistical Office. As a result of regulations in force since June 2005, landfilling of biodegradable waste is no longer permitted in Germany. Waste quantities landfilled after that time no longer contribute to methane formation and are thus not taken into account in emissions calculation.

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 negligibly low in comparison to total landfill-gas emissions. It is assumed that the low residual gas emissions of MBT waste are biologically oxidated nearly completely. The assessment also shows that the chronological emissions progression for stored MBT waste cannot be adequately described with the FOD model. As soon as landfill monitoring yields sufficient findings for development of a model for describing the actual emissions behaviour of MBT waste, the pertinent low emissions will also be taken into account in climate reporting.

8.3   Wastewater handling (6.B)

CRF 6.B

Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
6.B.2 - Domestic and commercial wastewater	- / t	CH$_4$	0.18 %	0.01	falling

The source category *Wastewater handling* is a key source, in terms of trend, of CH$_4$ emissions from municipal wastewater treatment.

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	CO$_2$	CH$_4$	HFC	PFC	SF$_6$	N$_2$O	NO$_X$	CO	NMVOC	SO$_2$
Emission factor (EF)	NA	NO	NO	NO	NO	NA	NO	NO	NO	NO
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method										

The source category "Methane emissions from industrial wastewater and sludge treatment" (6.B.1) is a key source only via the aggregated source category Wastewater handling (6.B). No calculations for this source category are carried out at present. In past years, data from municipal wastewater treatment (6.B.2) were listed in the above overview table, due to a transfer error. As a result, 6.B.1 was erroneously listed as a key source.

The composition of industrial wastewater, in contrast to that of household wastewater, varies greatly; it varies by industrial sector. In Germany, the biological stage of industrial wastewater treatment is partly aerobic and partly 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. As in treatment of municipal wastewater, treatment of industrial wastewater releases no methane emissions into the environment. The procedures used include aerobic treatment and anaerobic putrification; gas formed in the latter procedure is either used for energy recovery or is flared off. 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	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	NA	D/CS	NO	NO	NO	D/CS	NO	NO	NO	NO
EF uncertainties in %		- s. Text				- s. Text				
Distribution of uncertainties		L				L				
EF-determination method		D/CS				D				

The source category *Municipal wastewater treatment* is a key source.

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, 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; cf. Table 177. The average organic load is assumed to be 60 g BOD_5 per inhabitant. This value, the IPCC default value, is used in Germany as a statistical mean value.

Table 177:   Organic wastewater load in cesspools and septic tanks

Organic load [BOD_5 in kt/a]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cesspools and septic tanks	180.33	172.45	*164.57*	*156.69*	*148.80*	140.92	*105.41*	*69.90*	34.38	*31.06*
of these, in western Germany	91.69	87.45	*83.21*	*78.97*	*74.74*	70.50				
of these, in eastern Germany	88.65	85.01	*81.37*	*77.72*	*74.08*	70.43				
Organic load [BOD_5 in kt/a]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Cesspools and septic tanks	*27.74*	24.42	*23.20*	*21.98*	20.76	*19.54*	*18.32*	*17.10*	*15.88*	

Numbers in italics: Interpolated and extrapolated figures
(STATISTISCHES BUNDESAMT, Fachserie 19, Reihe 2.1, 2006)

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 sources, is not feasible, since the substance flows for cesspools and septic tanks are not separately recorded.

Table 178:   Methane emissions from cesspools and septic tanks

Methane emissions: [kt CH₄]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cesspools and septic tanks	54.10	51.74	49.37	47.01	44.64	42.28	31.62	20.97	10.31	9.32
Methane emissions: [kt CH₄]	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Cesspools and septic tanks	8.32	7.33	6.96	6.59	6.23	5.86	5.50	5.13	4.77	

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, which was published in 1991, 1995, 1998, 2001 and 2006 (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 complete 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 and between 2001 and 2004. The activity rates for 1990, on the other hand, were extrapolated from the 1991-1995 time series. The activity data for 2005 and 2008 were extrapolated from the 2001-2004 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)*

General quality control (in accordance with Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out. The relevant involved technical experts were unable to carry out quality assurance. The national co-ordinating agency (Single National Entity) carried out quality assurance.

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 respect to population figures, mechanical *dehydration* before and after treatment in the digestion tower currently represents the main treatment method (exception: small sewage-treatment plants in rural areas). 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 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 179 lists the emission factors for open sludge digestion and the methane emissions determined for that process.

Table 179:   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)[75]. The activity rates for the 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 this 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 sludge treatment)

General quality control (in accordance with Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out. The relevant involved technical experts were unable to carry out quality assurance. The national co-ordinating agency (Single National Entity) carried out quality assurance.

8.3.2.2.5   Source-specific recalculations (6.B.2 sludge treatment)

No recalculations are required.

---

75 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.

8.3.2.2.6   *Planned improvements (6.B.2 sludge treatment)*

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, municipal)

8.3.2.3.1   *Source category description (6.B.2 nitrous oxide, municipal)*

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.).

8.3.2.3.2   *Methodological issues (6.B.2 nitrous oxide, municipal)*

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 () (cf. Table 180). [76]
- In keeping with the FAO Statistical Yearbook 2007 – 2008[77] average protein intakes, per person and day, of 95 g (1994 – 1996), 97 g (1999 – 2001) and 99 g (2003 – 2005) are given for Germany (cf. Table 180).

Table 180:   Daily protein intake per person in Germany

	[g/inhabitant and day]									
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Protein intake	98	98	*97*	*96*	95	95	95	*96*	*96*	97
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	2008	
	97	97	*98*	99	99	99	*99*	*99*	*99*	

Numbers in italics: Extrapolated or automatically extended values
(FAO, FAO statistical yearbook 2004 & 2007 – 2008)

---

[76] FAO Statistical Yearbook 2004 Vol.1/1 http://www.fao.org/statistics/yearbook/vol_1_1/index.asp; September 2007

[77] FAO Statistical Yearbook 2007-2008 table D.1; http://www.fao.org/economic/ess/publications-studies/statistical-yearbook/fao-statistical-yearbook-2007-2008/d-consumption/en/; August 2009

Table 181:   Population in Germany

	[in thousands]									
Inhabitants	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	79,753	80,275	80,975	81,338	81,539	81,817	82,012	82,057	82,037	82,163
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
	82,260	82,440	82,537	82,532	82,501	82,438	82,315	82,218	82,002	

(STATISTISCHES BUNDESAMT, Statistisches Jahrbuch 2009)

The nitrous oxide emissions can be determined with the aid of Table 180 and Table 181 and the IPCC method; cf. Table 182.

$$N_2O_{(s)} = \Pr otein \; x \; Frac_{NPR} \; x \; NR_{PEOPLE} \; x \; EF_6$$

where:

$N_2O_{(s)} = N_2O \; emissions \; from \; human \; wastewater \; (kg \; N_2O - N/a)$

$\Pr otein = annual \; protein \, intake \; (kg/person/a)$

$NR_{PEOPLE} = Population \; of \; the \; country$

$EF_6 = emission \; factor \; (default \; 0.01 \; (\, 0.002 - 0.12 \,) \; kg \; N_2O - N/kg \; produced \; wastewater - N)$

$Frac_{NPR} = Nitrogen \; fraction \, in \, protein \; (default = 0.16 \, kg \; N/kg \; protein \,)$

Table 182:   Nitrous oxide emissions in Germany pursuant to IPCC method

	[t N$_2$O]									
N$_2$O emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	7,173	7,220	7,208	7,166	7,109	7,133	7,150	7,204	7,253	7,314
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
	7,323	7,339	7,423	7,498	7,496	7,490	7,479	7,470	7,450	

8.3.2.3.3   *Uncertainty and time-series consistency (6.B.2 nitrous oxide, municipal)*

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 2003-2005, were taken from the FAO Statistical Yearbook 2007-2008 Table D.1. The values for 1992 and 1993 are equivalent to the arithmetic mean of 1991 + 1994; the values for 1997 and 1998 are equivalent to the arithmetic mean of 1996 + 1999; the value for 2002 is equivalent to the arithmetic mean of 2001 + 2003. The activity rates as of 2006 are extrapolations of the data for 2005 published in the FAO Statistical Yearbook 2007/2008.

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.

8.3.2.3.4   Source-category-specific quality assurance / control and verification (6.B.2 nitrous oxide, municipal)

General quality control (in accordance with Tiers 1 & 2), in conformance with the requirements of the QSE manual and its associated applicable documents, has been carried out. The relevant involved technical experts were unable to carry out quality assurance. The national co-ordinating agency (Single National Entity) carried out quality assurance.

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)[78] 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[79] was derived.

The FAO database in the Statistical Yearbooks 2004 (Vol.1/1) and 2007–2008 (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-category-specific recalculations (6.B.2 nitrous oxide, municipal)

Recalculations were carried out for the years 1992-2007 (cf. the following Table), since the database was updated via the FAO Statistical Yearbook 2007-2008. In addition, the Statistisches Jahrbuch 2009 (STATISTISCHES BUNDESAMT*, Statistical Yearbook*) makes minor corrections in the population figures for the years 2006 and 2007.

---

78   The nutrition report is published every four years.

79   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).

Table 183: Recalculation of nitrous oxide emissions from municipal wastewater for the years 1992 to 2007

	Protein intake		Population		N$_2$O emissions				
	NIR 2009	NIR 2010	NIR 2009	NIR 2010	NIR 2009	NIR 2010	Change		
Units	g/inha-bitant and day	g/inha-bitant and day	inhabitants	inhabitants	Gg N$_2$O	Gg N$_2$O	Gg N$_2$O	Gg CO$_2$ equi.	in %
1992	99	97.00			7.357	7.208	-0.149	-46.1	-2.0 %
1993	99	96.00			7.390	7.166	-0.224	-69.4	-3.0 %
1994	99	95.00			7.408	7.109	-0.299	-92.8	-4.0 %
1995	99	95.00			7.433	7.133	-0.300	-93.1	-4.0 %
1996	99	95.00			7.451	7.150	-0.301	-93.3	-4.0 %
1997	99	95.67			7.455	7.204	-0.251	-77.8	-3.4 %
1998	99	96.33			7.453	7.253	-0.201	-62.2	-2.7 %
1999	99	97.00			7.465	7.314	-0.151	-46.7	-2.0 %
2000	99	97.00			7.474	7.323	-0.151	-46.8	-2.0 %
2001	100	97.00			7.566	7.339	-0.227	-70.4	-3.0 %
2002	100	98.00			7.575	7.423	-0.151	-47.0	-2.0 %
2003	100	99.00			7.574	7.498	-0.076	-23.5	-1.0 %
2004	100	99.00			7.571	7.496	-0.076	-23.5	-1.0 %
2005	100	99.00			7.565	7.490	-0.076	-23.5	-1.0 %
2006	100	99.00	82,315,000	82,314,900	7.554	7.479	-0.076	-23.4	-1.0 %
2007	100	99.00	82,218,000	82,217,800	7.545	7.470	-0.075	-23.4	-1.0 %

8.3.2.3.6 *Planned improvements (6.B.2 nitrous oxide, municipal)*

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.

CRF 6.D					
Key source by level (l) / trend (t)		Gas (key source)	1990 – contribution to total emissions	2008 – contribution to total emissions	Trend
- -		- -			

8.5.1 Other areas – composting facilities (6.D.1)

8.5.1.1 Source category description (6.D.1)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)		CS				CS				
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method		T1/CS				T1/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.

Table 184:   Quantities of waste placed in composting facilities

[in 1000s of 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**	
Waste quantity	9,030	9,244	9,459	9,304	9,191	9,207	8,960	9,329	9,329	

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 gases 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.

    EF-N_2O = 83 g N_2O/Mg kitchen waste
    EF-CH_4 = 2.5 kg CH_4/Mg kitchen waste

For plant waste, the same study obtained the following emission factors:

    EF-N_2O = 60.3 g N_2O/Mg plant waste
    EF-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 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 2007, 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.

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. This project, when completed, is expected to yield new emission factors for both gases.

8.5.2   *Other areas – mechanical-biological waste treatment (MBT) (6.D.2)*

8.5.2.1   Source category description (6.D.2)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)		CS				CS				
EF uncertainties in %										
Distribution of uncertainties										
EF-determination method		T1/CS				T1/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 retrofitted by no later than 1 March 2006.

Nearly all recently constructed new facilities were commissioned in 2005. Nearly all old facilities were brought into conformance with the 30th BImSchV in 2005, via expansions and operational upgrades. 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 for the first time 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 2007 and 2008, 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 contained inconsistencies that could not be 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 2007 3.7 million Mg/a of waste were treated mechanically and biologically. The corresponding figure obtained by the research project is 4.9 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.

Activity data

Since 1995, the Federal Statistical Office has regularly collected and published data on waste quantities managed in MBT systems. For 2007, 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 contained inconsistencies that could not be eliminated.

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 ammonia 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:

$EF-N_2O$ = 190 g N_2O/Mg waste
$EF-CH_4$ = 150 g CH_4/Mg waste

For closed mechanical-biological waste-treatment facilities with biofilters, the same study obtained the following emission factors:

$EF-N_2O$ = 375 g N_2O/Mg waste
$EF-CH_4$ = 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:

$EF-N_2O$ = 100 g N_2O/Mg waste
$EF-CH_4$ = 55 g CH_4/Mg waste

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)

Recalculations were carried out for the year 2007, since the waste-quantity statistics of the *Federal Statistical Office* do not cover all versions of MBT systems and thus show too-low waste quantities.

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.

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 between the inventory calculations for the 2009 report year and those for the 2010 report year. Further information regarding the recalculations is provided in CRF tables Table 8(a) and Table 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-source analysis reveals a need to change methods for individual source categories. In addition, a range of factors in specialised/technical areas can necessitate recalculations.

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 source, 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 AR 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 2010 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):

- With regard to activity data most recently used for 2007, transition from the evaluation tables to the Energy Balance (1.A)
- Revision of the Energy Balance data for the period 2003 to 2006 (1.A)
- Updating of activity data for waste and biomass incineration (1.A.1, 1.A.2.f)
- Revision of methane emission factors for stationary combustion engines (1.A.1, 1.A.2.f Other)
- Comprehensive recalculation following transition to Tier 2a (1.A.3.a)
- Cross-checking of activity data against the relevant Energy Balance figures (kerosene: as of 1995; avgas: as of 1995) (1.A.3.a)
- Updating (as of 1995) of the TREMOD software (currently, Version 5.03 is being used) (1.A.3.b)
- Updating of the activity data for use of petroleum and LP gas, in each case for the period 2000-2007 (1.A.3.b)
- Use of new data for natural gas as a fuel, as of 2004 (1.A.3.b)
- Correction of activity data within the Energy Balances for 2005 & 2006 (1.A.3c &.d)
- First-time inclusion of use of biodiesel in railway transports and inland-waterway shipping, in each case as of 2004 (1.A.3.c &.d)
- Recalculations of the activity data for construction-sector and agricultural transports (as of 1995) (1.A.3.e i, 1.A.4.c ii)
- Use of new data for use of avgas in military air transports, as of 1990 (1.A.5.b)
- Correction of a units error in conversion of $EF(CO_2)$ and new $EF(CH_4)$ (1.B.2.a i)
- Use of new data for direct CO_2 and CH_4 emissions from petroleum extraction (1.B.2.a ii)
- Use of new data for direct CH_4 emissions from natural gas extraction (1.B.2.b ii)
- Use of new data for CO_2 emissions from acid gas processing (1.B.2.b ii)
- Change in methods for calculation of activity rates (1.B.2.a iv, b iii, iv & v)
- Use of new EF (CO_2 and CH_4) for flaring (1.B.2.c)

Industrial processes:

- Adjustmemt, to association data, of activity rates for limestone inputs (2004-2007) (2.A.2)
- Transition to plant-specific activity rates for ammonia and nitric-acid production and, thus, from a Tier-2 method to a Tier-3 method (2.B)
- Adjustment of the average stocks of refrigerated containers and, thus of HFC-134a emissions (2007) (2.F.1)
- Adjustment of the emission factor for production of room air conditioners (as of 1998) (2.F.1)
- Adjustment of the activity rate for disposal of air conditioners of utility vehicles (2007) (2.F.1)

- Adjustment of the AR and emissions for/from use and disposal of automobile air conditioners (2007) (2.F.1)
- Adjustment of the EF for HFC-134a and 152a from production of PUR one-component foams (as of 2003) (2.F.2)
- Correction of the time at which production of PUR one-component foams with HFC-152a ceased (2004 instead of 2006) (2.F.2)
- Correction of the percentage shares for (one-component-)foam spray cans filled with HFC-134a and -152a (2003-2005), and of the total production quantities involved (2006, 2007; only HFC-134a) (2.F.2)
- Correction of the number of installed fire extinguishers, and adjustment of the EF(HFC-23) to the relevant figure in the IPCC Guidelines 2006 (2.F.3)
- Slight correction in the numbers of medium-voltage systems (2.F.7.a)

Solvent and other product use:

- No recalculations with respect to the 2009 submission.

Agriculture (selection):

- Fundamental revision of the dairy-cow model (with regard to a range of aspects, including energy requirements, methane-conversion factor, VS excretions), with impacts on all relevant years (4.A, 4.B)
- Revision of the models for other cattle (including recalculation of the numbers of heifers and fattening bulls, of energy requirements and of end weights) (4.A, 4.B)
- Revision of the models for keeping of swine (including recalculation of the numbers of swine, of energy conversion and of energy requirements) (4.A, 4.B)
- Correction of transfer errors with regard to mean energy content of feed, and correction of conversion errors in calculation of N ingested with feed N (4.A, 4.B)
- Recalculations of N_2O emissions from manure management, to take account of adjustments in the area of liquid-manure-based and straw-based systems (including correction of N excretions, and correction of the fattening-bull model) (4.B)
- Return to calculation of emissions from agricultural soils in keeping with the Revised 1996 IPCC Guidelines (4.D)
- First-time inclusion of mules and asses (as of 1990)
- Correction of the area of cultivated organic soils (as of 2006) (4.D)
- Recalculation of N excretions during grazing and of emitted reactive N (4.D)
- Recalculation of N losses from leaching and surface run-off, to take account of first-time inclusion of N inputs during grazing and correction of N inputs from crop residues and farm manure (4.D)
- Recalculation of N inputs from sewage sludge, to take account of new AR data (4.D)

Land use, land-use changes and forestry (selection):

- Pertinent new data available, from Inventurstudie 2008 (5.A)
- Recalculation and supplementation of the areas in the various land-use classes and the relevant changes, and of the areas with organic soils (5.A)
- Recalculation of carbon-stock changes in biomass (5.A)
- First-time inclusion of carbon emissions from forest-floor litter in connection with deforestation, and of carbon emissions from soils (5.A)
- Extensive recalculation of data sets for 2006 and 2007 (5.B - F)

- Recalculation of data sets for "Forest land converted to cropland", to take account of of first-time use of EF for deforestation as available from forestry-sector reporting as of 1990 (5.B.2.1)
- Recalculation of emissions from liming as of 1990 (5.B.1, 5.G)

Waste and wastewater:

- Updating of the available data, on the basis of the Statistical Yearbook 2007-2008 (FAO: protein intake, 1992-2007) and of the Statistisches Jahrbuch 2009 (Statistical yearbook 2009, *FEDERAL STATISTICAL OFFICE*: population statistics, 2006-2007) (6.B.2)
- Correction of activity data for 2007 (6.D)
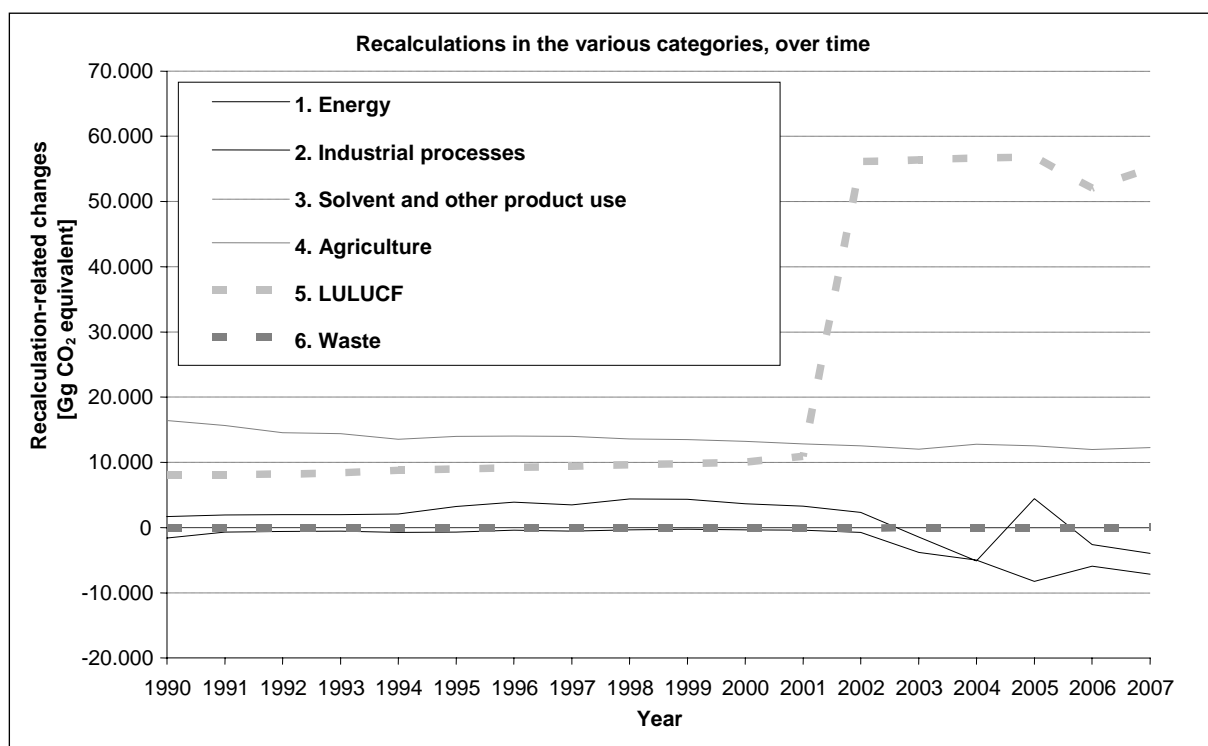
Figure 34:   Change in total emissions, for all categories, and for the entire time series, in comparison to the relevant figures in the 2009 report

10.1.1.3   Recalculations in the 2009 inventory, by gases

CO_2: Recalculations were carried out in the following source categories (in each case, cf. the specifications under 10.1.1.2):

- Energy
- Industrial processes
- Solvent and other product use
- LULUCF

CH_4: Recalculations were carried out in the following source categories (in each case, cf. the specifications under 10.1.1.2):

- Energy
- Agriculture
- LULUCF
- Waste and wastewater

N_2O: Recalculations were carried out in the following source categories (in each case, cf. the specifications under 10.1.1.2):

- Energy
- Agriculture
- Industrial processes
- Waste and wastewater

F gases: Recalculations were carried out in the following source categories (in each case, cf. the specifications under 10.1.1.2):

- Industrial processes

Table 185:   Inventory recalculations with respect to last year's report

	Base year (1990/ 1995)	2007
	Change in [%]	
Total (CO_2 equiv.)	1.37%	0.16%
CO_2	0.11%	-0.86%
CH_4	5.62%	13.12%
N_2O	14.18%	5.56%
HFC, PFC, SF_6	0.00%	0.25%

Source: own calculations; emissions do not include LULUCF
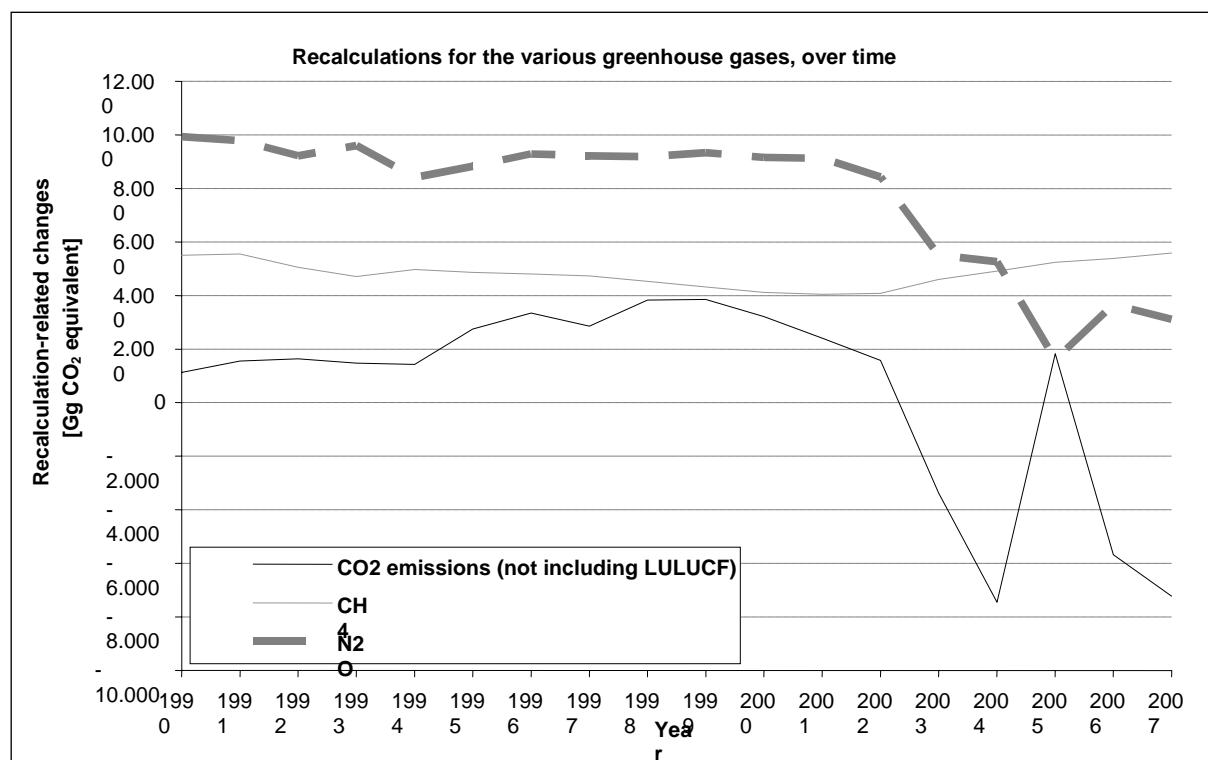
Figure 35:   Recalculation-related changes in pollutant-specific total emissions, for all source categories, and for the entire time series, in comparison to the relevant figures in the 2009 report

10.1.1.4   Recalculations to implement results of the review process

A few recalculations have been made in direct response to requirements identified in past reviews:

- Implementation of a Tier-2a method for calculation of emissions from air transports (1.A.3.a), for all years as of 1990
- Transition to plant-specific activity rates for ammonia and nitric-acid production and, thus, from a Tier-2 method to a Tier-3 method (2.B)
- Return to calculation of emissions from agricultural soils in keeping with Revised 1996 IPCC Guidelines (4.D)

10.1.2   KP-LULUCF Inventory

Since this year is the first inventory year under the Kyoto Protocol, no recalculations are possible yet. The relevant improvements under UNFCCC are described in Chapter 7.2.8.

10.2   Impact on emissions levels

10.2.1   Greenhouse-gas inventory

The inventory has been considerably improved with regard to completeness and accuracy.

The emissions increase is due primarily to the extensive methodological conversions that were carried out in the area of *Agriculture*.

Table 186:   Inventory recalculations, in time series, with respect to last year's report

	Total national emissions of greenhouse gases, not including carbon dioxide from LULUCF		
	2009 submission	**2010 submission**	**Change**
	[Gg CO$_2$ equivalent]	**[Gg CO$_2$ equivalent]**	**[%]**
1990	1,215,265.05	1,231,865.49	1.37
1991	1,168,855.95	1,185,787.49	1.45
1992	1,118,728.22	1,134,688.47	1.43
1993	1,108,200.85	1,124,025.12	1.43
1994	1,090,246.29	1,105,097.95	1.36
1995	1,084,953.65	1,101,439.78	1.52
1996	1,104,723.17	1,122,222.85	1.58
1997	1,067,626.79	1,084,485.28	1.58
1998	1,042,512.99	1,060,143.16	1.69
1999	1,009,933.80	1,027,502.71	1.74
2000	1,008,220.19	1,024,777.42	1.64
2001	1,025,859.27	1,041,495.41	1.52
2002	1,007,147.48	1,021,290.45	1.40
2003	1,007,847.46	1,014,627.65	0.67
2004	997,973.44	1,000,737.51	0.28
2005	969,644.74	978,382.81	0.90
2006	980,667.20	984,097.15	0.35
2007	956,775.26	958,335.17	0.16

Source: own calculations; does not include carbon dioxide from LULUCF

The *LULUCF* sector was also extensively revised, but its CO$_2$ emissions are not included.

In the area of communications provided for information only, recalculations, affecting all relevant years, were carried out for international air transports. The CO$_2$ emissions from

biomass changed as a result of first-time inclusion of biodiesel in railway transports (1.A.3.c) and in inland-waterway shipping (1.A.3.d).

Table 187:   Recalculations for informational-only inventory data provided in addition to data from last year's report

	1990	2008
	Change in [%]	
Emissions from international transports	-0.01%	-0.25%
Air transports	-0.01%	-0.36%
Maritime transports	0.00%	0.03%
Multilateral missions	NE	NE
CO$_2$ emissions from biomass	-5.70%	26.13%

Source: Own calculations

10.2.1.1   Impacts on 1990 emissions levels

Total emissions for 1990 changed only slightly, by a total of 1.36 %. The changes were primarily the result of corrections in methods.

Most of the changes occurred in the *Agriculture* sector. In that area, extensive methodological revision resulted in an increase in the emissions reported for 1990, amounting to about 16.415 Gg or more than 26.6 %.

Smaller adjustments in the areas of *Energy* (+1,723 Gg) and *Industry* (-1.593 Gg) cancel each other out almost completely.

CO$_2$ storage in the *LULUCF* sector, which is not included here, increased by about 8,031 Gg, or 28.43 %.

More detailed pertinent information, in addition to that provided in the following table, is available in CRF tables 8(a)s1 and 8(a)s2.

Table 188:   Recalculation of source-category-specific total emissions, for all gases in 1990

	Reported 2009 [Gg]	Reported 2010 [Gg]	Change, in CO_2 equivalents [Gg]	Change [%]
Total national emissions (not including CO^2 from LULUCF)	**1,215,265**	**1,231,865**	**16,600**	**1.37%**
1. Energy	987,938	989,661	1,723	0.17%
2. Industrial processes	119,820	118,227	-1,593	-1.33%
3. Solvent and other product use	5,396	5,396	0	0.00%
4. Agriculture	61,631	78,046	16,415	26.63%
5. Land-use changes and forestry	-28,250	-20,165	8,085	28.62%
Net CO_2 emissions / storage	-28,306	-20,277	8,029	28.36%
N_2O + CH_4 (emissions)	56	113	56	99.16%
6. Waste	**40,424**	**40,424**	**0**	**0.00%**
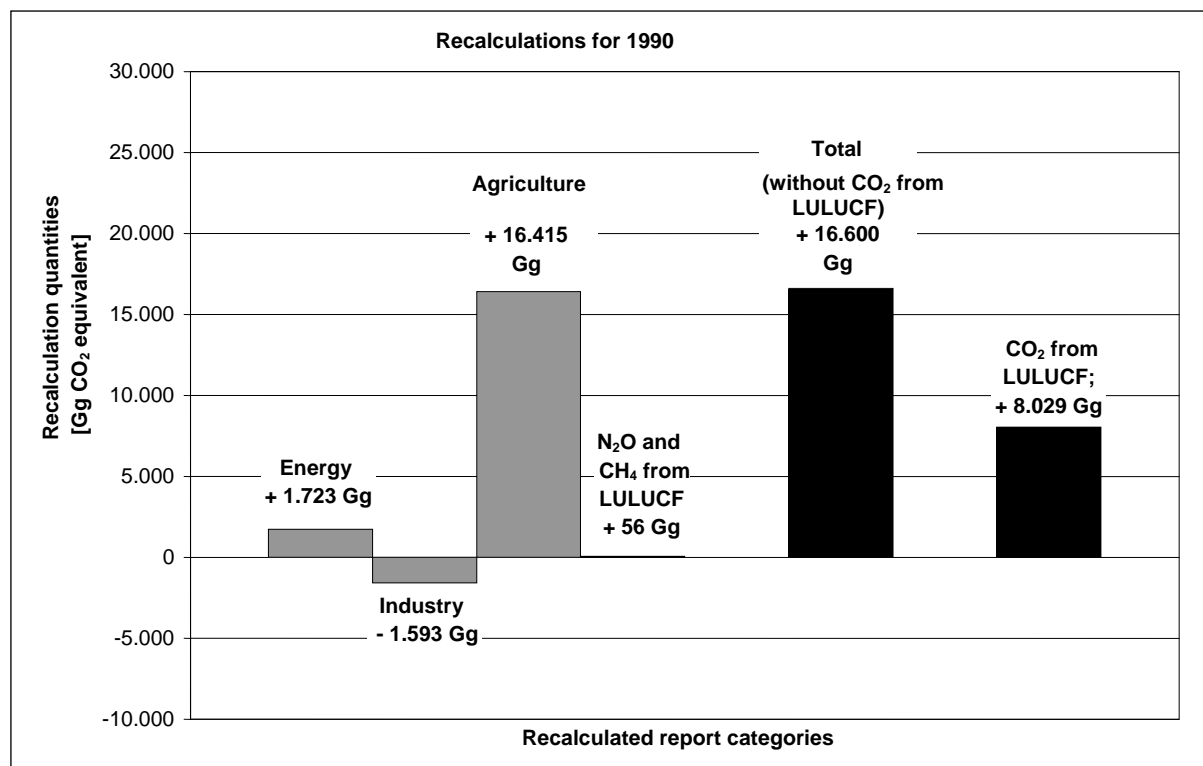
Figure 36:   Recalculations of all greenhouse gases for 1990

10.2.1.2   Impacts on 2007 emissions levels

In comparison to the 2009 submission, total emissions for 2007, not including CO_2 from LULUCF, increased by 0.16 %.

Most of the changes occurred in the *Agriculture* sector, in which emissions increased markedly as a result of the recalculations, and in the *Energy* and *Industrial processes* sectors, in which recalculations led to relatively large reductions.

Recalculation of emissions from *Energy Production*, inter alia on the basis of revised Energy Balances, led to an emissions reduction of somewhat more than 0.5 % (or about 4,000 Gg).

In the industry sector, emissions decreased by a total of about 7,147 Gg, or 6.15 %, as a result of the recalculations.

In spite of the *Energy* und *Industry* sectors' large share of total emissions, their reductions are more than offset by the considerably larger increases in the *Agriculture* sector: As a result of extensive revision of the Agriculture sector, the emissions reported for that sector increased by 12,284 Gg, or about 23.9 %.

What is more, in the *LULUCF* category, reported non-CO_2 emissions increased considerably, as a result of first-time inclusion of methane (+51 %).

In the area of CO_2 in the *LULUCF* sector (which emissions are not included), emissions outweighed storage after the methodological changes: The category changed from a CO_2 sink into a CO_2 source.

Additional information about recalculations is provided in CRF tables 8(a)s1, 8(a)s2 and 8(b) and in the table below.

Table 189:   Recalculation of source-category-specific total emissions, for all gases in 2007

	Reported 2009 [Gg]	Reported 2010 [Gg]	Change, in CO_2 equivalents [Gg]	Change [%]
Total national emissions (not including CO^2 from LULUCF)	**956,775**	**958,335**	**1,560**	**0.16%**
1. Energy	**773,675**	**769,714**	**-3,961**	**-0.51%**
2. Industrial processes	**116,123**	**108,976**	**-7,147**	**-6.15%**
3. Solvent and other product use	**3,316**	**3,316**	**0**	**0.00%**
4. Agriculture	**51,479**	**63,763**	**12,284**	**23.86%**
5. Land-use changes and forestry	**-16,128**	**38,961**	**55,088**	**341.58%**
Net CO_2 emissions / storage	-16,790	37,961	54,751	326.09%
N_2O + CH_4 (emissions)	662	1,000	338	51.01%
6. Waste	**11,519**	**11,566**	**47**	**0.41%**
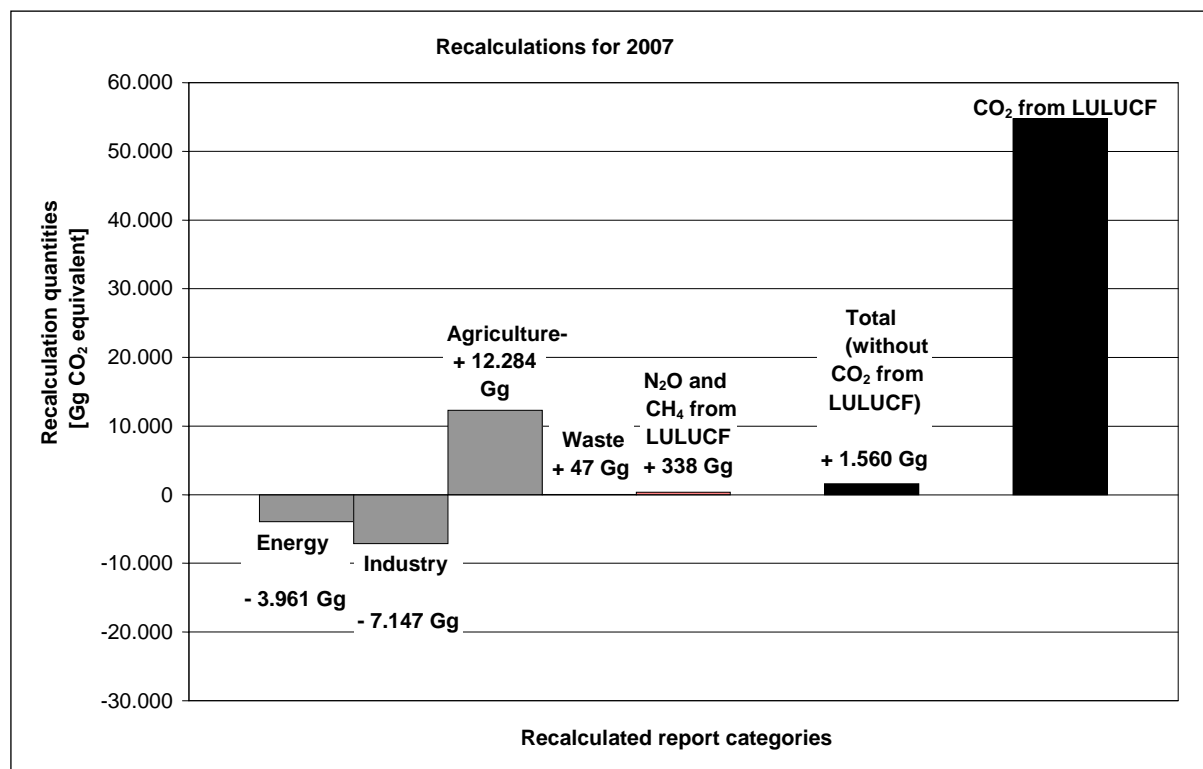
Figure 37:   Recalculations of all greenhouse gases for 2007

10.2.2   KP-LULUCF inventory

Since this year is the first inventory year under the KP, no recalculations are possible yet.

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. Both the source-category-specific trends and the trends at high aggregation levels changed, in some cases markedly (CRF 4 & 5).

As a result, the trend for total national emissions (not including CO_2 from LULUCF) shows a reduction of 22.4 % with respect to the base year.

CO_2 emissions remained virtually unchanged with respect to the previous year (-0.1 %). CH_4 emissions decreased slightly (-0.8 %), while N_2O emissions increased, somewhat more markedly (+1.9 %). HFC, PFC und SF_6 emissions all show clear increases (+3, +0.5 and +5 %).

10.3.2   KP-LULUCF Inventory

Since this year is the first inventory year under the KP, no recalculations are possible yet.

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 references and remarks made by the ERT in earlier UNFCCC-Reviews and from the Initial Review under the Kyoto Protocol. The table lists only aspects that were not already successfully addressed during the Review.

Table 190:   Summary of the improvements documented in the NIR 2010

CRF		Recommendation / Issue	Improvement	Corresponding Chapter in the NIR 2010
Complete-ness	ARR 2008	§12: ERT encourages Germany to provide estimates for all categories reported as "NE", for which methods are available in accordance with the IPCC	With the 2010 submission category coverage were further improved. The misuse of notation keys were corrected.	misc.
Complete-ness	Draft ARR 2009	§9 / §11: During the review ERT presented the Party with a list of categories and subcategories that were reported as "NE" and for which methodologies by the IPCC are available. ERT encourages the Party in it's efforts to increase the completeness of the inventory.	With the 2010 submission category coverage were further improved. The misuse of notation keys were corrected. Germany has increase the completeness of the inventory with the 2010 submission substantially.	misc.
QA	Draft ARR 2009	§§ 39, 44a: ERT recommends that Germany reports on the results of the comparison made with the EU ETS system on a regular basis.	The use of EU ETS information for additional QC has been implemented and is taken out on a regular basis starting with the 2009 submission.	Chapter 1.3.3.1.7
Recalcu-lations; 2.	Draft ARR 2009	§§34, 62: ERT recommends that Germany improve the reporting of recalculations in the next annual submission.	Germany solved the issue of different values reported in the tables 126, 127 and 128 of the NIR 2009 with the submission 2010	Chapter 10.2
1.BU.2	Draft ARR 2009	§56: ERT recommends that Germany improve consistency in the estimates for intern. Bunkers	Germany addressed the issue in the 2010 submission. Now, identical data from similar sources are provided in tables 1.A.(b) and 1.C.	CRF table 1.A(b) and 1.C.
2.A.3	Draft ARR 2009	§63: ERT recommends that the allocation of emissions from limestone and dolomite use be reported in accordance with the Revised 1996 IPCC GL.	Germany has improved the transparency in the NIR 2010	Chapter 4.2.3
2.B.1	ARR 2008 IRR 2007	ERT recommended the usage of plant specific data to emission estimation	Germany reports emissions according TIER 3 since submission 2010	Chapter 4.3.1
2.B.2	ARR 2006 IRR 2007	The ERT recommends that Germany pursue the use of plant-specific	Germany reports emissions according TIER 3 since submission 2010	Chapter 4.3.2
4.	ARR 2006 IRR 2007	ERT criticized the missing reporting of AD in the NIR	Solved in the submission 2010	Chapter 6.1.3.2, 6.2.2.2, 6.3.2.2.2, 6.3.4.2.2, 6.5.2.2
4.	ARR 2008	§ 21: ERT recommended a detailed description of IPCC 2006 GL to estimate emissions from agriculture and a comparison of both methods	Germany has completely reworked the reporting of the agriculture sector with the 2010 submission and improve the transparency substantially. The usage of the 2006 IPCC GL in accordance with the IPCC GPG were insured. Where this could not ensured Germany changed back to the 1996 IPCC GL.	Chapter 6.2.2.1, 6.3.2.2.1, 6.3.3.2.1, 6.3.4.2.1, 6.5.2.1, 19.4
4.	Draft ARR 2009	§18: ERT identified a number of additional areas were further improvements to the inventory are needed, including transparency of reporting of the agriculture and LULUCF sector, ensure that methodologies and default Efs from the 2006 IPCC GL are used in accordance with the IPCC GPG	Germany has completely reworked the reporting of the agriculture sector with the 2010 submission and improve the transparency substantially. The usage of the 2006 IPCC GL in accordance with the IPCC GPG were insured. Where this could not ensured Germany changed back to the 1996 IPCC GL.	Chapter 6

CRF		Recommendation / Issue	Improvement	Corresponding Chapter in the NIR 2010
4.	Draft ARR 2009	§37: ERT reiterates the request that Germany improve the methodological description by category and gas for the agriculture inventory and provide a discussion on the appropriateness of the methodological choice.	Germany clarified the issue of usage of different GL specifically in the agriculture sector in it's 2010 submission	
4.	Draft ARR 2009	§§ 73-83, 85, 86, 90,91,94,97,103:	All ERT recommendations in these paragraphs are addressed in the 2010 submission.	misc.
4.A / 4.B	ARR 2008	§ 47: ERT recommended the update of reporting of emission from asses and mules	Emissions for asses and mules are reported with the submission 2010	Chapter 6.2.2.3, 6.2.2.4, 6.3.2.2.3, 6.3.2.2.4, 6.3.4.2.3, 6.3.4.2.4
4.A.	ARR 2006 IRR 2007	§75: ERT reiterates the recommendation that Germany provide more information on gross energy intake, corresponding milk yields and other parameters underlying the country-specific EFs.	Germany provides information required in the submission 2010	Chapter 6.1.3.3
4.D.	ARR 2006 IRR 2007	ERT recommends that Germany provide more information on the volatilization losses, especially the resulting N amounts from housing and storage and the N left for spreading and N input to soils.	Germany incorporated information on the resulting N amounts from housing and storage in the submission	Chapter 6.3.3.2.1
5.	ARR 2006 IRR 2007	ERT criticized the insufficient description of methods and approaches to a consistent representation of land use categories	Germany has improved the description of methods and approaches to the representation of land use categories	Chapter 7.2.2, 7.2.3, 7.3.3, 19.5.1.3, 19.5.2.1,
5.	Draft ARR 2009	§89: ERT encourages Germany to report a consistent time-series of AD for each land use and land-use change category.	Germany reports a consistent land areas in the 2010 submission	Chapter 19.5.2.1
5.A.	ARR 2006 IRR 2007	ERT criticized the missing transparent explanation of the stock-change-approach and the data used.	Germany has include the recommendation in the 2010 submission	Chapter 7.2.4
5.A.	ARR 2006 IRR 2007	ERT recommended a transparent explanation of the equation to estimate stock changes	Germany has include the recommendation in the 2010 submission	Chapter 7.2.4
5.A.	ARR 2008	§ 65: ERT recommended the estimation of CH4 and N2O emissions for wild fire	Emissions of wild fires are reported since the submission 2010	Chapter 7.2.4.5.2
6.D.	ARR 2008	§75: ERT recommended a detailed description of methods used, AD and EF, and recalculations on emissions from composting and MBT in the NIR	Germany has include the recommendation in the 2010 submission	Chapter 8.5.1 and 8.5.2
6.D.	Draft ARR 2009	§104: ERT recommends that Germany include in the NIR the AD.	Germany has include the recommendation in the 2010 submission	Chapter 8.5.1 and 8.5.2

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 relative to the planned improvements are provided in the relevant source-category chapters.

10.4.2   KP & LULUCF

Because this is the first separate inventory for the Kyoto Protocol, no information about planned or already executed improvements to these inventories can be provided. The improvements relative to the area of LULUCF are described in the previous chapter.

11   SUPPLEMENTARY INFORMATION AS REQUIRED PURSUANT TO ARTICLE 7 (1) OF THE KYOTO PROTOCOL

11.1   General information

11.1.1   The definition of "forest", and other criteria

The Federal Forest Inventory is the main data source used in determination of activity data and emission factors. Its definition of "forest", which serves as a basis for the report, is presented in Chapter 7.3.3.

In order to achieve area consistency with agricultural areas, ATKIS data have been used as of 2008. Information relative to ATKIS, and to the relevant definitions, is provided in Chapters 7.2.2.4 and 7.3.3.

Pursuant to UNFCCC (1998), areas are to be assigned to the classes *afforestation* and *deforestation* if they have been afforested / deforested since 1990. Such areas remain in those assigned classes until the end of the commitment period. As a result, the total areas in those classes show continual growth. The *afforestation* class is further broken down into *harvested since the beginning of the commitment period* and *not harvested since the beginning of the commitment period*. Germany does not have any areas that were afforested after 1990 and have already been harvested.

For the new German Länder, maps of forest cover in 1990, and of relevant changes until 2002 and until 2005, were developed in the project GSE Forest Monitoring (GSE, 2009). The data, criteria and definitions used in that effort are described in Chapter 7.2.3.

In keeping with the first German report under the Kyoto Protocol, the following definition of "forest", which accords with the relevant FAO definition, has been used:

- Area planted / covered by trees amounts to over 10 % of the relevant area
- The smallest area to be taken into consideration is 0.1 ha
- Potential tree height of at least 5 metres

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. As comparative studies have shown, the differences between different activity-data calculations carried out in accordance with the aforementioned definitions are negligible.

11.1.2   Selected activities under Article 3 (4) of the Kyoto Protocol

In keeping with its first report under the Kyoto Protocol, Germany has selected the option of crediting forestry activities pursuant to Article 3 (4) of the Kyoto Protocol.

11.1.3   Description of ways in which the definitions of all activities pursuant to Article 3.3, and of all selected activities pursuant to Article 3.4, have been implemented and applied in a constant manner over time

The definitions used by Germany for "new afforestation", "reafforestation" and "deforestation" are in accordance with GPG (IPCC 2003). Planting of trees on open, managed land is referred to as "new afforestation" (or "reafforestation") if the relevant rejuvenation suffices for producing forest in accordance with the national definition of "forest". In general, the time of

new afforestation (or reafforestation) is the time at which the first activity in the relevant regeneration process was carried out. In the case of spontaneous regeneration of trees, the time of new afforestation (or reafforestation) is the time at which the relevant national conditions for fulfillment of the definition of "forest" have been established. Accordingly, agricultural land can change from (managed) cropland into unmanaged pasture and, via spontaneous establishment of trees, into (managed) forest. The last of these land-use transitions should be considered "reafforestation". At the same time, spontaneous establishment of trees on areas that were never managed/cultivated should not be considered new afforestation. This would apply, for example, in the case of establishment of trees in alpine regions as a result of temperature increases. No differentiation is made between new afforestation and reafforestation, since the data that such differentiation would necessitate are not available.

Since Germany is a densely populated and intensively managed country, every instance of new forest formation or of deforestation is considered to be human-caused. Forest formation on open cropland or pastures, via succession, is also considered to be human-caused new-forest formation, since it results directly from an active decision (discontinuation of agricultural cultivation).

Forest management is the process, either formal or informal, of planning and integrating practices that support the fulfillment of the forest's relevant environmental, economic, social and cultural functions. The class "managed forest" comprises the forest that is managed. Managed forests include all forests that support the fulfillment of relevant environmental, economic, social and cultural functions. That category includes all forest areas that are accessible to society, regardless of whether the underlying land uses are visible or not.

Since every land-use change toward forest is considered "new afforestation", every land-use change from forest to a different land-use category is considered "deforestation", and all forests are considered to be managed and 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 the priority conditions and/or hierarchy among the activities pursuant to Article 3.4, and description of how those conditions/hierarchy have been constantly applied in determining land classification

Since broad definitions are used for forest management and for afforestation / deforestation, the activities pursuant to Arts. 3.3 and 3.4 (to the extent selected) are in keeping with the following categories pursuant to reporting under the UN Framework Convention on Climate Change:

Afforestation / reafforestation corresponds to the following:

- 5.A.2.1. Cropland to forest
- 5.A.2.2. Grassland to forest
- 5.A.2.3. Wetlands / water bodies to forest
- 5.A.2.4. Settlement to forest
- 5.A.2.5. Other to forest

Deforestation corresponds to the following:

- 5.B.2.1. Forest to cropland
- 5.C.2.1. Forest to grassland
- 5.D.2.1. Forest to wetlands / water bodies
- 5.E.2.1. Forest to settlement
- 5.F.2.1. Forest to other

Source and sink impacts of forest management correpond to the following:

- 5.A.1 Forest land remaining forest land

Methods for deriving activity data and emission factors are described in detail in Chapter 7.2.

11.2   Country-oriented information

11.2.1   Area-assessment unit used for determining areas of land units pursuant to Article 3.3

The method used to derive activity data (areas) is described in Chapter 7.2.3. It corresponds to report method 1 pursuant to the GPG for LULUCF (IPCC 2003). The area reference unit is all of Germany. The areas assigned to the land-use type "forest", along with their additions and removals, are derived from the point data of the Federal Forest Inventory for the old German Länder for the period 1990 to 2002 and for Germany as a whole for the period 2002 to 2007. Areas in the new German Länder, for the period 1990 bis 2002, were defined with data from the GSE/FM project (GSE, 2009). For 2008, the areas were derived from ATKIS.

11.2.2   Method used to develop the land-transition matrix

The method used to define forest areas, and to derive areas for the "change" classes in the old German Länder, is described in detail in Chapter 7.2.3.1.

Chapter 7.2.3.2 describes the methods used to derive the areas for the new German Länder.

11.2.3   Maps and/or databases for determining geographic position, and the identification-code system for geographic positions

The following data sources were used in determination of activity data:

- Federal Forest Inventory 1 (Bundeswaldinventur; BWI 1)
- Federal Forest Inventory 2 (Bundeswaldinventur; BWI 2)
- Inventurstudie 2008 (IS08; Inventory Study)
- GSE Forest Monitoring[80] (GSE)
- Amtliches Topographisch-Kartographisches Informationssystem (ATKIS; Official topographic-cartographic information system)
- Bodenübersichtskarte der Bundesrepublik Deutschland 1:1.000.000 (BÜK 1000; overview soil map for the Federal Republic of Germany)
- 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 Chapter 7.2.2.

---

[80] GSE =GMES Services Elements

 GMES = Global Monitoring for Environment and Security

11.3   Activity-specific information

11.3.1   Methods for determining carbon-stock changes, greenhouse-gas emissions and estimated reductions

11.3.1.1   Description of methods and of the relevant applied and underlying assumptions

11.3.1.1.1   Changes in biomass

- Forest land remaining forest land (cf. Chapter 7.2.4.1.1)
- New forest land (cf. Chapter 7.2.4.1.2)
- Deforestation areas (cf. also Chapter 19.5.1.3):

With regard to deforested areas, an individual-tree calculation was carried out on the basis of the BWI 1 and 2 inventories. Only trees in the old German Länder were taken into account, since the BWI 1 inventory was carried out only there. 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 final-use classes were deducted – and thus taken into account.

Since it was not possible, for the new German Länder, to derive deforestation-area wood stocks directly from comparison of two inventories, the relevant values for the old German Länder were used.

The biomass stocks released upon deforestation are counted, completely, as "emissions" in the same year.

- Derivation of stock changes pursuant to the "stock-change method" (difference method) (cf. Chapter 7.2.4.1.3)
- Conversion into above-ground individual-tree biomass (cf. Chapter 7.2.4.1.4)
- Below-ground individual-tree biomass (cf. Chapter 7.2.4.1.5)
- Conversion of individual-tree biomass into carbon (cf. Chapter 7.2.4.1.7)
- Extrapolation algorithms for the status as of 1987, 2002 and 2008 (cf. Chapter 7.2.4.1.7)
- Extrapolation algorithms for the change between 1987 and 2002, and between 2002 and 2008 (derivation of stock changes using the "stock-change method") (cf. Chapter 7.2.4.1.8)
- Interpolation of time periods to obtain estimates of annual changes (cf. Chapter 7.2.4.1.9)

11.3.1.1.2   Dead wood

- Forest land remaining forest land (cf. Chapter 7.2.4.2.1)
- New forest land (cf. Chapter 7.2.4.2.2)
- Deforestation areas (cf. also Chapter 19.5.1.3.2.1):

The dead wood located on a deforestation area is taken into account as "C emissions" in the same year the deforestation takes place.

11.3.1.1.3   Forest-floor litter and mineral soils

- Forest land remaining forest land (cf. Chapter 7.2.4.3.1)
- New forest land (cf. Chapter 7.2.4.3.2)

Deforested areas:

> The carbon-stock changes in mineral soils of deforested areas were calculated for 2008 by the Johann Heinrich von Thünen Institute's Institute of Agricultural Climate Research (vTI-AK; cf. Chapter 7.3.4.1).

For calculation of the litter ground cover, the status data of BZE 1 and the provisional status data of BZE 2 were used. The average carbon stocks in litter ground cover, so the result, are 26.25 MgC/ha. They are recorded as C emissions that take place immediately upon deforestation.

11.3.1.1.4   *Organic soils*

- Forest land remaining forest land (cf. Chapter 7.2.4.4.1)
- New forest land (cf. Chapter 7.2.4.4.2)

Deforested areas:

> The C-stock changes in organic soils of deforested areas were calculated for 2008 by the Johann Heinrich von Thünen Institute's Institute of Agricultural Climate Research (vTI-AK; cf. Chapter 7.3.4.2).

11.3.1.1.5   *Other greenhouse-gas emissions from forests*

- Liming (cf. Chapter 7.2.4.5.1)
- Wildfire (cf. Chapter 7.2.4.5.2)
- Drainage (cf. Chapter 7.2.4.5.3)
- Land-use change from forest to cropland (cf. Chapter 7.2.4.5.4)

11.3.1.2   Justification for non-consideration of a given carbon pool or of greenhouse-gas emissions / reductions in connection with activities pursuant to Article 3.3 and selected activities pursuant to Article 3.4

For greenhouse-gas inventories, it was assumed, for mineral soils and forest-floor litter, that such stocks under existing forest do not change (corresponds to "Tier 1"). A detailed description for this approach is presented in Chapter 7.2.4.3.1. Therfore the used notation key in CRF-table NIR 1 "NO" should be read as "NR" (not reported).

Newly afforested areas contain no dead wood. Therefore the pool dead wood cannot be a source. A detailed description for the approach choosen is provided in chapter 7.2.4.2.2. Therfore the used notation key in CRF-table NIR 1 "NO" should be read as "NR" (not reported).

No fertilisation of forest land with mineral fertiliser, or drainage of mineral soils, takes place in Germany.

11.3.1.3   Information as to whether indirect or natural greenhouse gases and reductions were excluded

No indirect or natural greenhouse-gas emissions or reductions were taken into account – and thus excluded from the inventory.

11.3.1.4   Changes in data and methods since the last submission (recalculations)

In the report, new data sources and methods were taken into account, and recalculations were carried out for selected time series. Details about the new data sources used, and about the relevant new calculations, are presented in Chapter 7.2.7.

11.3.1.5   Estimation of uncertainties

The following error calculations were carried out:

- Uncertainties in estimation of areas with land-use changes (cf. Chapter 7.2.5.1)
- Uncertainties in conversion of standing-timber volume into tree wood volume (cf. Chapter 7.2.5.2)
- Uncertainties relative to volume densities of specific tree-species groups (cf. Chapter 7.2.5.3)
- Uncertainties in derivation of below-ground biomass (cf. Chapter 7.2.5.4)
- Sampling errors (cf. Chapter 7.2.5.5)
- Error budget (cf. Chapter 7.2.5.6)

11.3.1.6   Information about other methods

No information about other methods is available.

11.3.1.7   The initial year of an activity, if after 2008

No information about this is available at present.

11.4   Article 3.3

11.4.1   Information proving that activities pursuant to Article 3.3 began on or after 1 January 1990, and prior to 31 December 2012, and are directly human-caused

As described in Chapters 7.2.3.1 and 7.4.2, the process for determining land-use changes to and from forest covers land-use changes only as of 1990 for the new German Länder and only as of 1987 for the old German Länder (although, as a result of the method used, only the changes as of 1990 have entered into the present inventory). Since the available information covers only the period until the present, the relevant activities cannot have taken place between now and 2012.

With application of a broad definition of management and human impacts, it is assumed that the existence and implementation of a plan for landcape development must already be considered a direct impact. Germany is a densely populated and intensively managed country, and virtually all of its territory is covered by plans for landscape management (such as landscape plans) and for protection and management (for forests, for example, forest-management plans). Compliance with such plans is closely monitored by federal, Länder and municipal authorities. It may safely be assumed that every instance of land-use change, either from or to forest, is caused by human activity.

11.4.2 Information about the distinction between a) harvest or forest disturbance that is followed by new forest formation and b) deforestation

In the German forestry sector (all forest areas are managed), it is common practice to manage larger-area uses as follows (to the extent such uses take place; in Germany, clear-cutting is prohibited by law): on such areas, planned rejuvenation is quickly carried out via either allowance of natural rejuvenation (efficient use of natural regeneration of forests) or artificial rejuvenation (planting). It is also possible to combine the two procedures. A similar approach is taken in connection with disruptions (especially wind-caused breakage and uprooting). In the case of large disturbances, rejuvenation/restoration measures are often supported by the state. Inclusion of managed forest in the definition applied (complete forest area) makes it possible for the system to include areas that are temporarily not forested.

11.4.3 Information about the size and geographic position of forest lands that have lost their forest cover but are not considered deforested

In the course of forest management, very small unforested areas (bare areas; accounting for <1% of total forest area) can occur. In keeping with the definition of "forest", such areas are considered to be forest, and they are covered by the sampling procedures used in forest inventories. For this reason, they enter into calculations relative to stocks and their changes.

11.5 Article 3.4

11.5.1 Information proving that activities pursuant to Article 3.4 began after 1 January 1990 and are human-caused

Since an integrated procedure is used for surveying forest lands, land-use changes and the stock changes caused by relevant activities, the statements made in Chapter 11.4.1 apply mutatis mutandis for the activity "forest management".

11.5.2 Information relative to management of cultivated areas and pastures, and to grassland restoration, if selected, for the base year

Germany has opted only for crediting of forest management pursuant to Article 3.4 KP (cf. Chapter 11.1.2).

No information about other activities is available.

11.5.3 Information about forest management

Germany's laws require that forests be properly and sustainably managed. Such actions must take account of the forest's functions as a source of raw materials, as a basis for species, soil, climate and water-body protection and as a resource for public recreation and enjoyment. Forest management thus entails ongoing balancing of economic, ecological and social interests, with the aim of protecting the forest's different functions in the long term.

11.6   Further information

11.6.1   *Key-source analysis for activities pursuant to Article 3.3, and for selected activities pursuant to Article 3.4*

In connection with analysis for the UNFCCC inventory, key-source 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 17.1.3.

11.7   Information relative to Article 6 (JI & CDM projects / management of ERU)

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 take place in Germany.

12   INFORMATION REGARDING ACCOUNTING (BOOKKEEPING) WITH REGARD TO KYOTO UNITS

12.1   Background information

According to the legal requirement the Standard Electronic Format (SEF) can be found in the Annex 6 to this submission. The SEF has been generated with the SEF application version 1.2, provided by the secretariat at 9th of January 2009. The German registry has been tested for the generation of the SEF. The secretariat has awarded a SEF test certificate of conformity to the German registry, dated 2nd January 2009.

In addition a list of all transactions for the forwarding of CER from the CDM registry into the German emissions trading registry is included in the Annex 6.

12.2   Summary of information reported in the SEF tables

The year 2009 showed a much higher level of transactions as the starting year of the commitment period. Transactions with most European countries within the European Emissions Trading Scheme took place. In addition, Kyoto units have been transferred to non-European countries as well. In 2009 Germany converted ERUs for the first time. Two JI projects (track 1) have produced CO_2 offsets and the corresponding amount of AAUs have been converted into ERUs. Another figure is remarkable. Nearly 300,000 CERs have been cancelled for compensation. The German Federal Government has cancelled more than 96,000 CERs for compensation of official missions. The rest comes from companies, private persons and NGO.

12.3   Discrepancies and Notifications

The German registry does not show discrepant transactions in the reported year. All reconciliations have been performed successfully. A list of the reconciliation results is included in Annex 6.

12.3.1   Reversal of storage information

12.3.1.1   15/CMP.1 Annex I.E paragraph 13

Germany has not received a reversal of storage notification in the reported year.

Germany has not received a notification for the replacement of ICER in accordance with paragraph 49 of the annex to decision 5/CMP.1.

12.3.2   Non-certification notifications

12.3.2.1   15/CMP.1 Annex I.E paragraph 14

Germany has not received a non-certification notification.

Germany has not received a notification for the replacement of ICER in accordance with paragraph 50 of the annex to decision 5/CMP.1.

12.3.3   Non-replacement notifications

12.3.3.1   15/CMP.1 Annex I.E paragraph 15

Germany has not neglected any replacements according to paragraph 56 of the annex to 5/CMP.1.

12.4   Publicly accessible information

The publicly available information is based on the requirements of Annex VXI of the Commission Regulation (EC) No 994/2008 of 8 October 2008 for a standardised and secured system of registries pursuant to Directive 2003/87/EC of the European Parliament and of the Council and Decision No 280/2004/EC of the European Parliament and of the Council (Registry Regulation). A list of publicly available information is included in the Annex 6 of this document. This information is accessible trough the following link:

https://www.register.dehst.de/crweb/report/public/publicReportList.do

The publicly available information according to the decisions indetail:

12.4.1   13/CMP.1 Annex II Paragraph 45

The requested information is publicly available for each account in the German registry. The list of the information presented is provided in Annex V of this document. The data on operator holding accounts can be viewed online at:

https://www.register.dehst.de/crweb/report/public/accountOh.do

The data on all accounts can be viewed online at:

https://www.register.dehst.de/crweb/report/public/account.do

Comprehensive search functionality is available.

12.4.2   13/CMP.1 Annex II Paragraph 46

There was no issuance of ERU in the reported year. A list of the JI projects in Germany can be found at:

http://www.dehst.de/cln_090/nn_476696/DE/JI__CDM/JI/JI__Zustimmung/JI__Zustimmung__node.html?__nnn=true

12.4.3   13/CMP.1 Annex II Paragraph 47

The information requested in (a), (d), (f) and (l) is considered to be confidential due to national and European law and therefore not publicly available. The information requested in the other items is given in the following:

(b)   The total number of issued AAU can be found at the public registry page:
           https://www.register.dehst.de/crweb/report/public/cpr.do
(c)   No ERU have been issued in the reported year.
(e)   No RMU have been issued in the reported year.
(g)   No ERU, CER, AAU and RMU have been cancelled on the basis of activities under Article 3, paragraphs 3 and 4 in the reported year.
(h)   No ERU, CER, AAU and RMU have been cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1 in the reported year.
(i)   No other ERU and RMU have been cancelled in the reported year. The total number of voluntary cancelled CER is 100,425 and the total number of voluntary cancelled AAU is 215.
(j)   No ERU, CER, AAU and RMU have been retired in the reported year.
(k)   There has been no carry over of ERU, CER, AAU or RMU from the previous commitment period.

12.5   Calculation of the Commitment Period Reserve

The German registry never approached the Commitment Period Reserve (CPR) during the reported year. The calculation of the CPR is performed in the German registry software according to the computation instructions of the secretariat. The commitment period reserve for Germany is based on the assigned amount and not the most recently reviewed inventory. Therefore it has not changed since the initial report review (4,381,287,024 t CO_2 equiv.).

The status of the CPR is publicly available and can be found at:

https://www.register.dehst.de/crweb/report/public/cpr.do

The system keeps track of all incoming and outgoing transactions. The status is updated after every completed transaction.

The German registry software has been prepared for keeping the CPR. Any transaction that would breach the CPR would be rejected by the German registry. This functionality has been thoroughly tested in our own testing and together with secretariat (Annex H test).

13   INFORMATION REGARDING CHANGES IN THE NATIONAL SYSTEM

In the present reporting cycle, significant improvements in institutionalisation of the National System were achieved.

Adoption and entry into force of the 3rd SME Relief Act (MEG 3):

The 3rd SME Relief Act (MEG 3) entered into force in March 2009. This act on tendering supplements the Environmental Statistics Act, the Act on Energy Statistics and the Production Statistics Act in ways that enable the Federal Statistical Office to provide confidential data (single-element and double-element data-query results, cases involving predominance) to the Federal Environment Agency for purposes of emissions reporting. As a result, the basic data available for emissions reporting has been considerably improved in that a number of experts' assessments and data gaps have been supplanted / filled with data from official statistics.

With the entry into force of the MEG 3, responsibility for protection of statistical secrecy passed to the Single National Entity. As a result, that entity now has to refine and

supplement, as necessary, its procedures for protecting confidentiality and for managing and handling confidential data. For further information regarding handling of confidential data, cf. Chapter 1.6.3.

The text of the MEG 3 is available in the Internet[81].

Conclusion of an administrative agreement with the *Federal Statistical Office*:

For purposes of implementing the provisions of the 3rd SME Relief Act (MEG; see above), the Federal Statistical Office and the Federal Environment Agency concluded an administrative agreement on data exchange. The agreement, which was signed on 13 January 2010 by the presidents of the two agencies, defines the data requirements of the Federal Environment Agency with regard to emissions reporting, and it defines the quality control and quality assurance system to be in place at the *Federal Statistical Office*. For purposes of updating, the Single National Entity, in co-operation with the responsible section at the *Federal Statistical Office*, reviews the agreement on an annual basis and adapts its annexes as necessary. The administrative agreement is available at the Internet address listed in the imprint.

Co-operation agreements with industry:

In 2009, the Single National Entity, in co-operation with the Federal Ministry of Economics and Technology (BMWi), signed co-operation agreements with industry associations and companies. In the area of source category 2.B., an agreement was concluded with the *Industrieverband Agrar* agricultural industry association, and with the German producers of ammonia and nitric acid, relative to source categories 2.B.1 (ammonia) and 2.B.2 (nitric acid). In addition, a total of three company agreements on data provision were concluded with the German producers of adipic acid (2.B.3). Furthermore, an association agreement, on data provision, 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). With these efforts, the Single National Entity is addressing the reference provided in Paragraph 18 of the 2007 Initial Review.

Changes in the National System with regard to Articles 3.3 / 3.4:

The changes in the National System, in the area of agriculture and LULUCF, are described in Chapter 1.2.1.5. As part of the changes, the remarks provided in Articles §§ 10 and 62 in the 2008 annual review report (ARR) has been addressed.

14   INFORMATION REGARDING CHANGES IN THE NATIONAL REGISTRIES

Germany had no previously identified questions of implementation pertaining to transactions.

14.1   Change to the database or the capacity of National Registry

14.1.1   15/CMP.1 Annex II.E Paragraph 32.(c)

The database structure has not been changed. The following views have been added in order to allow the correct computation of the SEF:

---

[81] Drittes Gesetz zum Abbau bürokratischer Hemmnisse insbesondere in der mittelständischen Wirtschaft (Drittes Mittelstandsentlastungsgesetz; Third Act for elimination of bureaucratic obstacles, especially in the SME sector). Internet: http://dipbt.bundestag.de/extrakt/ba/WP16/154/15414.html (last checked on 30 October 2009)

- calculation of the figure "Independently verified ERU" in table 2 (b)
- time value in calculation of "Requirement to replace" on notifications

There was no change in the capacity of the national registry. In order to minimise the fragmentation of unit blocks Germany has implemented a defragmentation tool to join single unit blocks if they fit to each other. This development has been undertaken in close cooperation with the secretariat. For detailed information see attached document 1.

14.2 Change of conformance to technical standards

14.2.1 15/CMP.1 Annex II.E Paragraph 32.(d)

There was no need to change the registry software in order to better conform with the requirements to the technical standards for data exchange between registry systems for the purpose of ensuring the accurate, transparent and efficient exchange of data between national registries, the clean development mechanism registry and the transaction log.

14.3 Change of discrepancies procedures

14.3.1 15/CMP.1 Annex II.E Paragraph 32.(e)

For the time being there was no need to develop additional procedures or measures to minimize the risks described in 15/CMP.1 Annex II.E Paragraph 32. (e). Under (f) we describe an additional role of the technical administrator that will be implemented in 2009. This measure is not a consequence of an incident but an additional measure to minimize the risks.

14.4 Change of Security

14.4.1 15/CMP.1 Annex II.E Paragraph 32.(f)

In addition to the measures already introduced and reported in the Initial Independent Assessment Report we have restricted the access for administrators to a range of specific IPs. The range of IPs are those of the Umweltbundesamt (the authority to which the registry administration belongs) and of the consultancy Dr. Lippke and Dr. Wagner GmbH. This measure prevents the misuse of the administrator password from a computer outside the IP range specified. Even if a password would be stolen it would not be possible for the intruder to log into the system. He would also need to get access to the IP range specified. The occurrence of both events at the same time is extremely unlikely.

The measure described is based upon the modularisation of the software in a sense that the specific functionality of the administrator can be switched on and off by specifying the IP range that is allowed to access it.

It is planned to add an additional role of the technical administrator in the registry. This is a restricted access that allows the technical administrator to change account data, the data of representatives, to perform daily maintenance (status of transactions) and so on. The "real" administrator is allowed to perform all functions including issuance, conversions, transactions, cancellations, retirement and others. With this new role we can minimize the risk for failures of the daily administration to a minimum. It will be implemented in the course of 2009.

14.5   Actions and changes to address discrepancies

14.5.1   15/CMP.1 Annex I.E paragraph 17

The German registry had no discrepant transactions. Therefore there was no need to undertake actions to correct those problems or to perform changes to the national registry in order to prevent discrepancies from reoccurring.

15   INFORMATION REGARDING MINIMISATION OF NEGATIVE IMPACTS PURSUANT TO ARTICLE 3 (14)

The following tables list various policies and measures (sorted by sectors), along with their direct and indirect effects on developing countries.

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.

The only possible negative effect would occur via promotion of non-sustainably produced biofuels. 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.

Table 191:   Cross-cutting measures

Measure	Direct effects	Indirect effects
Emissions trading	none	
CDM	positive	
JI	none	
Energy/CO$_2$ taxes	none	

Table 192:   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 193:   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 194:   Forestry

Measure	Direct effects	Indirect effects
Reforestation	none	Positive: less deforestation
Sustainable forest management	none	none

Table 195:   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   FURTHER INFORMATION

This Chapter is currently not required.

17   ANNEX 1: GERMAN GREENHOUSE GAS INVENTORY - KEY SOURCES

In accordance with the "*IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*"[82] (*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 source". Key sources 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 sources. These methods include inventory analysis for one year (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 Trend Assessment with consideration of inaccuracies).

Such 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 sources.

For identified key sources, 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 sources

The results of the key-source analysis based on the two Tier 1 techniques (Level and Trend) are outlined below. In this context, we call attention to the description of the underlying

---

82 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 work to determine uncertainties in inventories was to be completed, and a report submitted 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

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, in keeping with their CO_2-equivalent emissions, into a total of 116 individual activities.

17.1.1   Tier 1 approach

As a result of **level analysis**, those source categories responsible for 95 % of total national emissions (as CO_2-equivalent emissions), in the Kyoto Protocol's base year and in 2007, are identified as key sources (●). Calculations were performed using formula 7.1 from the Good Practice Guidance.

In the source category summary used in this analysis, a total of 32 key sources were identified in 2007 using this approach (cf. Table 7, Chapter 1.5).

As a result of **trend analysis**, those source categories which have made a particular contribution to changes in total greenhouse gas emissions in 2007, in terms of the development of their contribution since the base year, are identified as key sources (●). 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 31 key sources (cf. Table 7, Chapter 1.5).

17.1.2   Tier 2 Approach

The Tier 2 approach for key-source analysis is based on the results of Tier-2 uncertainties determination. Tier-2 uncertainties determination for the German greenhouse-gas inventory was carried out for the first time in 2007; Monte Carlo simulation was used (cf. in this regard NIR 2007, Chapter 1.7, and Chapter 18, in the Annex). The results provided extensive confirmation of the results of the pertinent Tier 1 analyses. At the same time, N_2O emissions from soils were included, and those emissions are considered to be subject to very large uncertainties. Since uncertainties in emissions calculation can be reduced only gradually, as methods continue to improve, the required detailed uncertainties for the German greenhouse-gas inventory are determined only every three years. Tier 2 analysis based on such uncertainties determination is being carried out in connection with the 2010 report.

17.1.3   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 196:　　　KP CRF Table NIR.3: Summary overview for key sources for Land Use, Land-Use Change and Forestry Activities under the Kyoto Protocol

Key sources 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 sources according to the national level of disaggregation used[1]					
Afforestation and Reforestation	CO_2	Conversion to forest land	No	High expected growth.	The value is very close to the value in the smallest category considered key in the UNFCCC inventory. The value has increased about tenfold since 1990.
Deforestation	CO_2	Conversion to cropland, Conversion to grassland, Conversion to settlements, Conversion to other land	Yes	Regarding only Land converted to Grassland: high expected growth.	Regarding only Land converted to Grassland: The value is very close to the value in the smallest category considered key in the UNFCCC inventory. The value has increased about tenfold since 1990.
Forest Management	CO_2	Forest land remaining 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 CO₂ 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. 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 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.

The complete Energy Balances for the years since 1990 are available in the Internet at:

http://www.ag-energiebilanzen.de/daten/inhalt1.php

The members of the Working Group on Energy Balances (AGEB) include (as of: September 2008):

- 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,
- Gesamtverband des deutschen Steinkohlenbergbaus (GVSt) (General Association of the German Hard Coal Industry), Essen,
- Mineralölwirtschaftsverband (MWV) (Association of the German Petroleum Industry), Hamburg,
- Verband der Industriellen Energie- and Kraftwirtschaft e.V. (VIK) (Association of Industrial Energy and Power Producers), Essen,
- 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.

Since the 1995 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). Overall, with due regard for the available data, the Energy Balances provide a reliable picture of energy production and use in the German economy.

The most important sources are listed in Table 197. 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 197:   Data sources for the Energy Balances:

All energy resources	**Federal Ministry of Economics and Technology (BMWi)** Electricity Industry Department – Annual statistical reports Gas Industry Department – Annual statistical reports **Federal Office for Statistics** Annual figures for the manufacturing industry Fachserie (Specialised series) 4 Manufacturing sector - Series 3.1 Production in the manufacturing industry - Series 4.1.1 Employment and revenue of manufacturing-sector companies - Series 6.4 Power-production facilities of mining and manufacturing companies Fachserie (Specialised series) F4 Foreign trade - Series 2 Foreign trade by types of goods and countries Selected figures on the energy industry **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** 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 for Food, Agriculture and Consumer Protection** Gasoil consumption in agriculture
Gases	**Federal Statistical Office, Düsseldorf branch** Iron and Steel Statistics: Fuel, Gas and Electricity Statistics **Wirtschaftsverband Erdöl- and Erdgasgewinnung e.V. (Association of the Petroleum and Natural Gas Extraction Industry)** Annual reports **Statistics from the Kohlenwirtschaft e.V. (Coal Industry Association)** Gas Statistics **Deutscher Verband Flüssiggas e.V. (German Liquid Petroleum Gas Association)** The LPG Market – Annual Reports
Other energy resources	**Arbeitsgemeinschaft Fernwärme e.V. (Working Group on District Heating)** District heating reports
"Non-fuels"	**Mineralölwirtschaftsverband e.V. (MWV) (Association of the German Petroleum Industry)** **Verband der Chemischen Industrie e.V. (VCI) (Chemicals Industry Association)**

 (ZIESING et al, 2003)

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 Figure 38). 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.

Energy Balance until 1994	Line
Primary energy balance	
Domestic production	1
Imports	2
Removals from stocks	3
Domestic energy production	*4*
Exports	5
Maritime bunkering	6
Additions to stocks	7
Domestic primary energy consumption	*8*
Transformation balance	
Transformation Input	
Coking plants	9
Municipal gas works	10
Hard-coal briquetting plants	11
Lignite briquetting plants	12
Public thermal power stations	13
Mine power stations	14
Other industrial thermal power stations	15
Nuclear power stations	16
Hydroelectric power stations	17
Thermal power stations, district heating stations	18
Blast furnaces	19
Refineries	20
Other energy producers	21
Total transformation input	*22*
Transformation Emissions	
Coking plants	23
Municipal gas works	24
Hard-coal briquetting plants	25
Lignite briquetting plants	26
Public thermal power stations	27
Mine power stations	28
Other industrial thermal power stations	29
Nuclear power stations	30
Hydroelectric power stations	31
Thermal power 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
Municipal gas works	39
Lignite mines, briquetting plants	40
Power stations	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 difference	**46**

Domestic energy supply and transformation balance	**47**
Non-energy-related consumption	**48**
Statistical differences	**49**
Energy consumption (per sector)	
Final energy consumption	50
Other mining	51
Non-metallic minerals	52
Iron and steel	53
Iron and steel foundries (including malleable casting)	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 basic materials and producer's goods	60
Basic materials and producer's goods	51-60
Machine tools	61
Automotive, aircraft and spacecraft	62
Electrical engineering, precision mechanics, optics	63
Ironware, tinware and metalware	64
Other manufacturing of industrial goods	65
Manufacturing of industrial goods	61-65
Glass and fine ceramics	66
Production of plastic products	67
Textiles	68
Other manufacturing of consumables	69
Manufacturing of consumables	66-69
Sugar industry	70
Other food industry	71
Drink industry	72
Food and drink industry	70-72
Other mining and manufacturing, total	73
Railway transport	74
Road transport	75
Air transport	76
Coastal and inland shipping	77
Total transport	*78*
Total households and small consumers	*79*
Military agencies	80

Energy Balance of the Federal Republic of Germany as of 1995	Line
Primary energy balance	
Domestic production	1
Imports	2
Removals from stocks	3
Domestic energy production	4
Exports	5
Maritime bunkering	6
Additions to stocks	7
Domestic primary energy consumption	8
Transformation balance	
Transformation Input	
Coking plants	9
Hard-coal and lignite briquetting plants	10
Public thermal power stations (not including CHP stations)	11
Industrial thermal power stations	12
Nuclear power stations	13
Hydroelectric power stations, windpower and photovoltaic systems	14
Public thermal power stations	15
District heating stations	16
Blast furnaces	17
Refineries	18
Other energy producers	19
Total transformation input	*20*
Transformation Emissions	
Coking plants	21
Hard-coal and lignite briquetting plants	22
Public thermal power stations (not including CHP stations)	23
Industrial thermal power stations	24
Nuclear power stations	25
Hydroelectric power stations, windpower and photovoltaic systems	26
Public thermal power 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, briquetting plants	35
Power stations	36
Oil and gas production	37
Refineries	38
Other energy producers	39
Total energy consumption in the transformation sector	40
Flaring and line losses	**41**

Domestic energy supply and transformation sector	**42**
Non-energy-related consumption	**43**
Statistical differences	**44**
Energy consumption (per sector)	
Final energy consumption	45
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
Metal products	54
Non-ferrous metal products and casting	55
Metal processing	56
Machine tools	57
Automotive industry	58
Other industrial sectors	59
Total mining, extraction of non-metallic minerals, manufacturing	*60*
Railway transport	61
Road transport	62
Air transport	63
Coastal and inland shipping	64
Total transport	*65*
Households	66
Commerce, trade, services and other consumers	67
Military agencies	68

Source: AGEB, 2003

Figure 38:   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 38 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		**As of 1995**	
Hard coal	HC coal	Hard coal	HC coal
	HC coke		HC briquettes
	HC briquettes		HC coke
	HC raw tar		Other HC products
	HC pitch	Lignite	L coal
	HC other		L briquettes
	Crude benzene		Other L products
Lignite	L coal		Hard lignite
	L briquettes	Petroleum	Oil
	L coke		Gasoline
	L coal dust		Raw gasoline
	Hard lignite		Jet kerosine
Other solid fuels	Firewood		Diesel fuel
	Peat		Heating oil, light
	Sewage sludge		Heating oil, heavy
Petroleum	Oil		Petrol coke
	Gasoline		LP gas
	Raw gasoline		Refinery gas
	Avgas		Other petroleum products
	Jet kerosene	Gases	Coke-oven and city gas
	Diesel		Blast-furn. & converter gas
	Heating oil, light.		Natural gas, petroleum gas
	Heating oil, heavy		Pit gas
	Petrol coke	Renewable energies	Hydropower
	Other petroleum products		Wind and photovol. systems
Gases	LP gas		Waste and other biomass
	Refinery gas		Other renewable energies
	Coke-oven gas	Electricity and other energy resources	Electricity
	Blast-furnace gas		Nuclear power
	Natural gas		District heat
	Petroleum gas	Total energy resources	Primary energy resources
	Pit gas		Secondary energy resources
	Landfill gas		Total
Electricity and other energy resources	Electricity		
	Hydropower		
	Nuclear power		
	District heat		
	Other energy resources		
Total energy resources	Primary energy resources		
	Secondary energy resources		
	Total		

Source: ZIESING et al, 2003

Figure 39:   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 from the year 1950 on are available for the Federal Republic of Germany in the territorial delimitation prior to 3 October 1990. Moreover, Energy Balances have been drawn up for the years 1990 to 1994 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 39. 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, along with 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 (m³) 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.

18.3   Preparation of provisional energy balances, by the Federal Environment Agency

To date, Energy Balances through 2007 have been published. In order to meet the requirement for currentness in emissions reporting, the Federal Environment Agency has prepared provisional energy balances on the basis of detailed evaluation tables of the Working Group on Energy Balances (AGEB). Every year (in the summer), the Working Group on Energy Balances (AGEB) publishes **evaluation tables for the Energy Balance** that contain data for the previous year. The figures in the evaluation tables are provisional, except where they have been updated, for earlier years, on the basis of the final Energy Balances. Such figures can deviate considerably from those of the final Energy Balances. In addition, some changes are made to published Energy Balances. For purposes of reporting, such changes necessitate only minor recalculations, however.

The *evaluation tables on the Energy Balance* contain the following information:

- Structure of energy consumption, by sectors,

- Primary energy consumption, by energy resources,
- Domestic primary energy production, by energy resources,
- Total final energy consumption, by energy resources and sectors,
- Other mining and manufacturing,
- Traffic and transport,
- Households (residential),
- Commerce, trade and services (commercial/institutional) and military agencies,
- Use of energy resources for power generation.

This information is used to prepare provisional Energy Balances. Since these values cover only part of the Energy Balance, additional data are used in preparing balances. Such data include published coal statistics and information, provided by the Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry, on petroleum production and use. The trend in fuel distribution in the various relevant sectors, over the last few years, is determined and then compared with developments in emissions trading. This is not possible for all sectors. Data of the Federal Statistical Office cannot be used, since its energy statistics for the report year are not yet available at the time the Federal Environment Agency carries out its calculations. For some values, such as figures for non-energy-related consumption, no guiding indications are immediately available. Such indications must then be estimated on the basis of trends of the past years and of the current industrial development.

With the available data, a complete provisional Energy Balance is prepared, for all conventional fuels, that is consistent within itself. That Energy Balance does not include any figures on use of electricity and district heat, since those energy resources do not figure in relevant emissions calculations. For biomass and waste fuels, the available data do not support any balance preparation. In this area, figures of the Working Group on Renewable Energies Statistics (AGEE-Stat) relative to biomass use, are entered directly into the database. The same procedure is used for that group's findings relative to development of the sector for power stations fired with substitute fuels and for waste-incineration systems.

This year, the model for preparation of the provisional Energy Balance was expanded to include the first 8 lines needed for the reference procedure. As a result, inventories are prepared in accordance with standardised criteria. Data on imports, exports, domestic production and high-seas bunkering are available for nearly all fuels, from various sets of statistics. Additions to, and removals from, stocks can be calculated with the help of data on transformation inputs and final energy consumption.

18.4   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 relevant 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.

Reducing-agent inputs for pig-iron production are listed in the Energy Balance as energy-related consumption, in EB line 54. Use of the related blast-furnace gas for energy production is listed in the relevant Energy Balance lines, 11, 12, 15, 33 and 54. According to the IPCC Guidelines, reducing-agent inputs must be reported in a process-oriented manner, under source category 2.C.1. Consequently, those inputs must be calculated out of the Energy Balance. *A detailed description with regard to source categories 1.A.2.a and 2.C.1 is provided in Chapter 4.4.1.2.*

18.5   Uncertainties and time-series consistency 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 2003 through 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.

18.5.1 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. This is described in 18.5.1.

18.6 Uncertainties in the activity rates for stationary combustion systems

See NIR 2007, Chapter 13.6.

18.7 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).

18.7.1 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.

Figure 40:   Base and inventory emission factors for CO_2
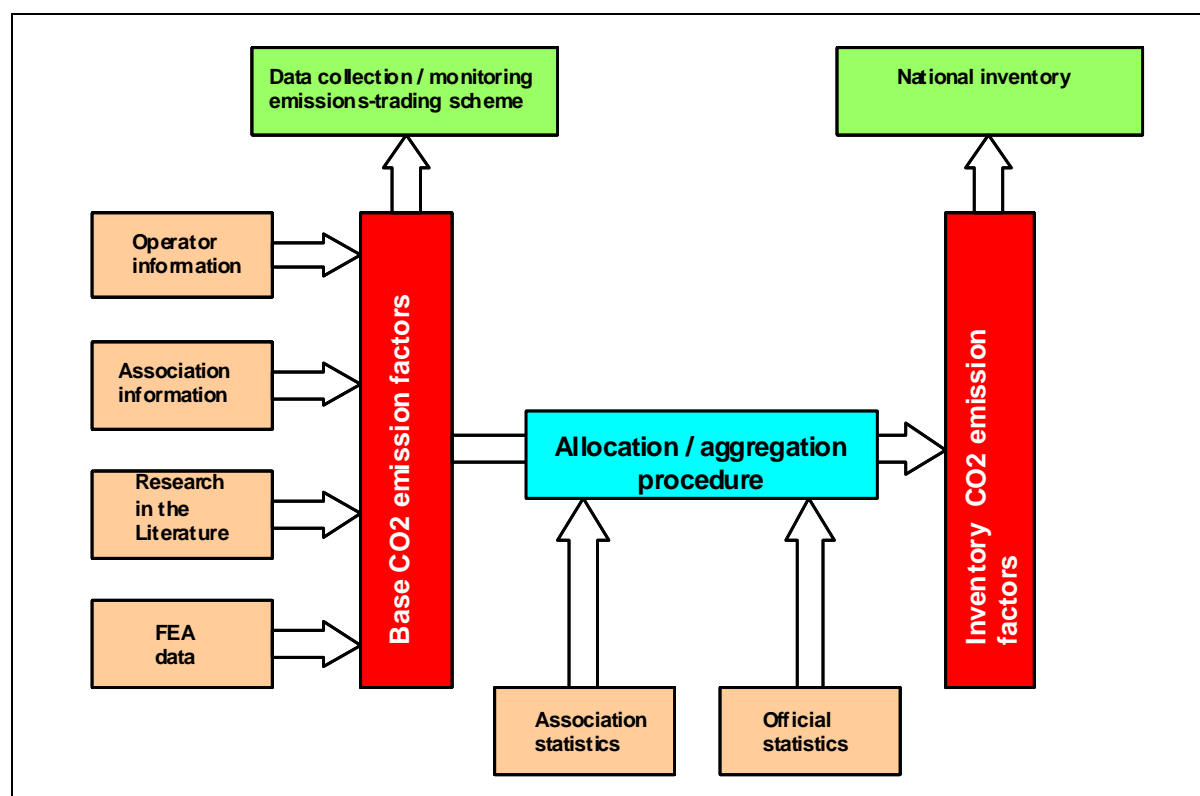
Source: Öko-Institut

With this in mind, a consistent concept for CO_2 emission factors was developed (Figure 40).

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 rates 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.

18.7.2   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

18.7.3   Determination of 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 198).

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 198 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).

Finally, it must be noted that, in order to maintain consistency, the emission factor for hard-coal coke is used for blast-furnace gas and converter gas in calculation of CO_2 emissions from pig-iron and steel production. To prevent double-counting, the emission factors for blast-furnace gas and converter gas are set to zero for purposes of inventory preparation, since the relevant emissions have already been reported under 2.C.1 and 1.A.2.a.

Table 198:   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	2005	2006	2007	2008
Coal																			
Hard coal																			
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	94.0	94.2	94.1	94.3
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	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	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	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																			
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	112.3	112.2	112.3	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	111.4	110.6	111.4	110.5
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	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	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	NO	NO	NO	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	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	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	99.7	99.7	99.6	99.6
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	98.0	98.0	97.9	98.0
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	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	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	2005	2006	2007	2008
Petroleum																			
Crude oil	NO	NO	NO	NO	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	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	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	73.3	73.3	73.3	73.3
Aircraft fuel	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	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	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	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	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	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	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	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	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	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	80.0	80.0	80.0	80.0
Gases																			
Coking-facility and city gas *Germany*						40.0	40.0	40.0	40.0	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														
Blast-furnace and converter gas [3]	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Flammable gas *New German Länder*	49.0	49.0	49.0	49.0	49.0														
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	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	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	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	2005	2006	2007	2008
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	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	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	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	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	74.6	74.6	74.6	74.6
Recycled tyres	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3	97.3
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	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	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	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	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	56.9	56.9	56.9	56.9
Sewage sludge	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	95.1	95.1	95.1	95.1	95.1	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	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	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	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	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	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	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	2005	2006	2007	2008
Biomass fuels [4]																			
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	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	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	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	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	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	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	74.9	74.9	74.9	74.9
Firewood [5]	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	71.4	71.4	71.4	71.4
Landfill gas, sewage-treatment gas, biogas [5]	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	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	72.0	72.0	72.0	72.0
Biodiesel [5]	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	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	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) Annual change in the EF as a result of differences in shares for combustion systems and companies' own plants; for 1990-1994, listed separately in each case for old German Länder / new German Länder

3) CO_2 emissions from blast-furnace-gas production and use, and from reducing agents, are taken into account via balancing of CO_2 emissions for the area of iron and steel production.

4) 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.

5) Default values

Remark: **In general, please note that the inventory emission factors have not been derived for purposes of single-plant calculations (for example, for purposes of compliance with the emissions trading scheme). Any use of inventory emission factors must take account of the relevant descriptions in the relevant source-category chapters.**

Table 199:   Emission factors for CO_2 as of 1990, as derived for emissions reporting: industrial processes

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	2005	2006	2007	2008
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	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	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	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	440,00	440,00	440,00	440,00
2.A.4 Production of soda ash	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
2.A.7 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	29,10	29,10	29,10	29,10
2.A.7 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	28,60	28,60	28,60	28,60
2.A.7 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	193,00	193,00	193,00	193,00
2.A.7 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	208,00	208,00	208,00	208,00
2.A.7 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	120,00	120,00	120,00	120,00
2.A.7 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	113,00	113,00	113,00	113,00
2.A.7 Production of glass fibre (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	198,00	198,00	198,00	198,00
2.A.7 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	299,00	299,00	299,00	299,00
2.A.7 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	NO	NO	NO	NO
2.B Production of ammonia	1.586,89	1.557,90	1.582,14	1.581,70	1.520,87	1.550,09	1.513,23	1.509,35	1.503,09	1.535,57	1.481,95	1.468,98	1.458,39	1.411,58	1.442,22	1.389,32	1.332,81	1.326,16	1320,76
2.B Production of calcium carbide	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
2.B Production of calcium carbide (new German Länder)	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	62,42	62,42	62,42	62,42
2.B Coke burn-off in catalyst regeneration	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96	1,96
2.C.1 Production of electric steel	8,50	8,00	7,50	7,00	7,00	6,60	6,30	5,90	5,60	5,30	5,00	4,77	4,77	4,77	4,77	4,77	4,77	4,77	4,77
2.C.1 Production of oxygen steel*	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00	1307,00
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	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	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	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	1367,00	1367,00	1367,00	1367,00

*   Factor for the ideal blast-furnace process (Scholz factor) pursuant to the Allocation Ordinance in connection with the National Allocation Plan

Remark: **In general, please note that the inventory emission factors have not been derived for purposes of single-plant calculations (for example, for purposes of compliance with the emissions trading scheme). Any use of inventory emission factors must take account of the relevant descriptions in the relevant source-category chapters.**

18.8   Development of a preliminary reference approach on the basis of the evaluation tables for the Energy Balance

This information is provided in Annex 2, Chapter 13.8 of the 2007 inventory report (NIR 2007).

18.9   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 201 (see below) presents a comparison of the consumption listed in line 43 and 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 the carbon used of fossil fuels with 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 1A, 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-use 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, 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 distribution of emissions and products' carbon content among the various fuels involved is based on expert knowledge and assumptions. The example of ethylene (C_2H_4) is used to illustrate the manner in which the carbon is converted into CO_2:

$M (CO_2)$ = 44 g/mol
$M (C_2H_4)$ = 28
CO_2 equivalents   = AD *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	Lower net calorific value
	t CO_2/TJ	TJ/Gg
Bitumen	80.6	40.2
Paraffin wax	73.3	40.2
Lubricating oil	73.3	40.2

For 2007, the sum of the carbon from the pertinent emissions and of the carbon stored in products amounts to 110 % of the non-energy-related consumption given in line 43 of the Energy Balance. Table 200 shows the various processes' percentage shares of non-energy-related consumption. The total share for the chemical industry is about 75 %, and the total share for refinery products is about 24 %.

Table 200:   Various processes' shares of non-energy use

Source category	%
2.B: Chemical industry	**74.6**
2.B.1: Ammonia production	5.4
2.B.1: Ammonia production: CO_2 for other uses	4.3
2.B.5: Carbide production	0.0
2.B.5: Other	64.9
Methanol CH_3OH	6.5
Ethylene C_2H_4	20.2
Propylene C_3H_6	13.8
1,3-butadiene C_4H_6	4.7
Benzene C_6H_6	9.4
Toluene C_7H_8	3.2
Xylene C_8H_{10}	2.4
Carbon black	4.7
2.C: Metal industry	**1.0**
2C1: Iron and steel production	IE
2C2: Production of ferroalloys	0.0
2C3: Primary aluminium production	1.0
2.D: Other production:	
3: Solvent and other product use	
3A-D: Solvents	IE
Exceptions that are reported elsewhere	
1.A Fuel combustion activities	**24.4**
1.A.1.b: Petroleum refining	
Lubricants	9.0
Waxes, paraffins, vaseline, etc.	1.1

Table 201: Verification of completeness of reported CO_2 from non-energy use of fossil fuels

			Coal						Petroleum									Natural gas	
Year	2007	Unit	Hard coal	Hard-coal coke	Other hard-coal products	Lignite	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
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 CO2	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				3,87				0,45	1,00			0,95	0,02	1,00		2,21	1,11	1,06	1,06

	AD	EM						Gg CO2											
	Gg	Gg CO2	Hard coal	Hard-coal coke	Other hard-coal products	Lignite	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
F: Total fossil IPPU CO2 reported		8.763		760,0				760,0	34.206,3			11.413,0	17,5	3.497,5		24.402,0	73.536,3	5.183,4	5.183,4
2 Industrial processes																			
2.A: Mineral industry																			
2.B: Chemical industry		8.003							34.206			11.413	18	3.497		5,001	54.135	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
CO2 for other uses	3.390											3.390,0					3.390,0		
2.B.5: Carbide production	C	18											17,5				17,5		
2.B.5: Other																			
Methanol CH_3OH	2.025	2.351										5.135,7					5.135,7		
Ethylene C_2H_4	5.097								12.832,5					1.312,1		1.876,9	16.020,6		
Propylene C_3H_6	3.492								8.790,8					898,8		1.285,2	10.974,8		
1,3-butadiene C_4H_6	1.149								3.000,1					306,7		438,6	3.745,4		
Benzene C_6H_6	2.214								6.003,0					613,8		877,6	7.494,4		
Toluene C_7H_8	760								2.039,2					208,5		298,1	2.545,9		
Xylene C_8H_{10}	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		760		760,0				760,0											
2.C.1: Iron and steel production (1)	IE	IE																	
2.C.2: Production of ferroalloys	25	3		3				2,8											
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										

Year	AD [Gg]	EM [Gg CO$_2$]	Coal						Petroleum									Natural gas	
			Hard coal	Hard-coal coke	Other hard-coal products	Lignite	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																	19.401,3	19.401,3		
1.A.1.b: Petroleum refining																				
Lubricants	2.431																7.162,2	7.162,2		
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)

19.1.1.1 Activity rates for the year 1990

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".

With use, inter alia, of the original data sources listed below, realistic fuel consumption figures were derived. These were then compared, in light of the structure of the BEU model (Balance of Emissions Sources), to the CSE data, in order to identify relevant data differences and gaps:

- Energiewirtschaftlicher Jahresbericht 1990 für die NBL, Band 1a (annual energy-sector report for the new German Länder, for the year 1990, Volume 1a),
- Accounting of the former GDR's energy balance for 1988,
- Overall energy balance (Gesamtenergiebilanz) for 1989 for the economic area of the former GDR,
- Overall energy balance for 1990, for the economic area covered by the five new Länder in the Federal Republic of Germany,
- 1992 Statistical Yearbook of the Federal Republic of Germany,
- Precise determination of energy requirements trends for the areas of business and industry, the public and other consumers, for the period until 2005 (in these studies, specific energy consumption and relevant production quantities for 1990, in the area of energy-intensive products, were estimated),
- A revision, carried out by the Federal Environment Agency, relative to process combustion,
- Own calculations.

Some of the primary data lacking for the year 1990 were filled in via interpolation, from data for previous and subsequent years, and via supporting assessments by experts.

The 1990 figures for inputs of fuels, including hard coal and lignite, liquid fuels, gases, and substitute fuels – such as waste or other petroleum products – and for use of renewable energies, were brought into a form suitable for comparison. The following two sub-chapters present the relevant methodological foundations and results.

19.1.1.2   Method for revising the activity rates for the year 1990

The term "stationary combustion systems" includes all power stations that produce electric power, or electric power and heat, that is then used for industrial processes or for heating purposes. Boiler systems in district heating stations, and consumption of auxiliary energy in the transformation sector, must also be taken into account. Furthermore, final-energy consumption in industrial boilers for process combustion, in the "other mining" and manufacturing sectors, must also be included.

Power stations are subdivided by types into the categories of public thermal power stations and gas turbine systems, mine (pit) power stations and industrial power stations (refinery power stations are listed separately).

In addition, the combustion systems of these power-station types are subdivided into large combustion systems (Großfeuerungsanlagen; GFA), in keeping with the relevant definition in the 13th Federal Immission Control Ordinance (BimSchV), and systems falling under the Technical Instructions on Air Quality Control (TA Luft).

Finally, within the category of industrial power stations, fuels used in power stations of German Railways are listed separately.

In a first step, the entire set of relevant power stations, as it existed in 1990, was entered into a database, together with information relative to electrical outputs, steam heat production and fuel consumption.[83] This set comprised a total of 229 power stations. It did not include the Greifswald and Rheinsberg power stations, nor did it include hydroelectric and storage power stations.

The lignite sector was subdivided by regions into the Lausitz and Mitteldeutschland coal fields, since the two fields differ in their CO_2 emission factors, and the differences have to be taken into account for calculation of CO_2 emissions.

The new power-station database, with parameters as described above, was then used for recalculations, oriented to specific power-station types, covering all fuels used for electricity production, industrial process heat and district heat – as listed in the relevant Energy Balance lines.

In addition – i.e. apart from work with figures in the new power-station database – fuel consumption for district-heat production in public district-heating stations, in keeping with the listing in Energy Balance line 18, was determined.

As a third position within the transformation balance, an entry was made in Energy Balance line 45 for fuel inputs for auxiliary energy consumption in the categories of heat in the

---

[83]   In keeping with definitions pertinent to the energy-sector statistics of the former GDR, at the end of each calendar year all power-station operators reported data, as required under central provisions, to the ORGREB – the power station institute (Institut für Kraftwerke) in Vetschau – which then used the data to prepare its annual general report [EWJB 90]. This report appeared for the last time in 1990, in a shortened form; the pertinent detailed summary of power stations was then submitted only internally, however, to the then IfE.

petroleum industry, drying heat in production of lignite briquettes and lignite dust, and auxiliary energy consumption in coking plants and local gas works.

In the final energy consumption sector, fuel consumption in the various types of power stations, for supplied industrial process heat, was entered in Energy Balance line 73. In addition, i.e. apart from work with the figures in the new power-station database, this line is also used for fuel consumption in industrial boilers and in process combustion. For a total of eleven identified key processes, it was possible to allocate fuel consumption for process combustion specifically to relevant industrial sectors; the remaining processes were combined to form an aggregate.

19.1.1.3   Results (activity rates for 1990)

The basis for the analysis presented here is the overall energy balance (Gesamtenergiebilanz) of 1990. In terms of levels, consumption of all fuels remained the same; there were no major deviations. This also means that the revision has not significantly changed pertinent CO_2 emissions.

Differences from the original energy balance result solely in allocation of fuel inputs to individual balance lines. The total of all fuels used in power stations for electricity production shows a reduction in consumption of 8,640 TJ. With respect to the originally listed energy consumption for power production, amounting to 1,046,012 TJ, a relative transfer of fuel inputs results, amounting to a transfer of 0.83 % from the transformation sector into the final-energy consumption sector. The consumption increase in the latter sector, seen in the "other mining" and manufacturing areas, amounts to 8,640 TJ.

Originally, the CSE contained a total of 268 time series for source categories 1.A.1 and 1.A.2 (not including private households / small consumers and the military sector). Now, through use of new data sources and pertinent evaluation, a more differentiated allocation and presentation results, with some new structural elements and with a total of 360 time series. The new divisions include a regional breakdown of the lignite sector into the Mitteldeutschland and Lausitz coal fields. These quantitative energy data relative to stationary combustion systems, in time series, are being individually provided in fulfillment of reporting obligations in the framework of the National Inventory of greenhouse gases (NIR 2006).

The relevant fuel-consumption figures have been obtained via intensive data research and via calculations (multi-stage, in some cases) and then allocated, in pertinent Energy Balance lines, to power stations and/or station or industrial boilers. The following tables provide a relevant overview.

Table 202:   Fuel inputs for electricity production in public thermal, mine and industrial power stations (new German Länder, 1990)

	Units	Electricity production in large combustion systems of public thermal power stations	Electricity production in gas turbines of public thermal power power stations	Electricity production in large combustion systems of power stations of the lignite-mining sector	Electricity production in large combustion systems of other industrial thermal power stations	Of these, railways' power stations	Electricity production in other industrial thermal power stations (TA-Luft)	Of these, railways' power stations	Electricity generation in large combustion systems of refinery power stations	Total
Installed output	**MW**	**14,544**	**1,253**	**2,872**	**1,401**	**44**	**118**	**2**	**682**	**20,870**
Bottleneck capacity	**MW**	**11,367**	**989**	**1,727**	**574**	**20**	**26**	**1**	**236**	**14,918**
Boiler efficiency	**%**	**82.64%**	**94.72%**	**80.52%**	**81.44%**	**79.72%**	**73.17%**	**80.25%**	**82.96%**	**82.30%**
Electricity production	**GWh**	**74,084**	**92**	**13,035**	**4,219**	**169**	**191**	**1**	**1,926**	**93,546**
Heat for electricity production	**TJ**	**685,440**	**1,175**	**115,910**	**32,919**	**2,490**	**1,606**	**3**	**16,747**	**853,797**
Fuel for electricity production	**TJ**	**829,386**	**1,240**	**143,944**	**40,419**	**3,124**	**2,195**	**3**	**20,187**	**1,037,372**
Crude lignite	TJ	813,525	0	124,106	18,378	3,088	714	3	7,881	**964,605**
> *Lausitz coal field*	TJ	*662,638*	*0*	*97,829*	*4,551*	*504*	*165*	*0*	*0*	***765,183***
> *Mitteldeutschland coal field*	TJ	*150,887*	*0*	*26,277*	*13,827*	*2,584*	*550*	*3*	*7,881*	***199,422***
- Lignite briquettes	TJ	488	0	690	1,791	0	402	0	24	**3,394**
> *Lausitz coal field*	TJ	*98*	*0*	*171*	*398*	*0*	*200*	*0*	0	***867***
> *Mitteldeutschland coal field*	TJ	*390*	*0*	*519*	*1,392*	*0*	*203*	*0*	*24*	***2,527***
- Dry coal	TJ	0	0	5,941	0	0	0	0	238	**6,178**
> *Lausitz coal field*	TJ	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***0***
> *Mitteldeutschland coal field*	TJ	*0*	*0*	*5,941*	*0*	*0*	*0*	*0*	*238*	***6,178***
- Lignite semi-coke	TJ	1	0	5,462	2,113	0	223	0	876	**8,674**
> *Lignite low-temperature coke*	TJ	*1*	*0*	*5,462*	*2,113*	*0*	*223*	*0*	*876*	***8,674***
> *Lignite high-temperature coke*	TJ	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***0***
- Hard coal	TJ	37	0	1,047	2,787	0	286	0	0	**4,157**
- Hard-coal coke	TJ	0	0	0	0	0	0	0	0	**0**
- Hard-coal briquette	TJ	0	0	0	0	0	0	0	0	**0**
- Firewood	TJ	0	0	0	0	0	0	0	0	**0**
- Light heating oil	TJ	0	94	0	0	0	0	0	0	**94**
- Heavy heating oil	TJ	6,984	0	162	2,205	13	12	0	883	**10,245**
- Diesel fuel	TJ	0	146	0	0	0	0	0	0	**146**
- Natural gas	TJ	7,705	1,000	77	9,271	0	31	0	4,322	**22,406**
> *imported natural gas*	TJ	*5,663*	*1,000*	*25*	*4,835*	*0*	*0*	*0*	*4,322*	***15,845***
> *domestic natural gas*	TJ	*2,042*	*0*	*53*	*4,436*	*0*	*31*	*0*	*0*	***6,561***
- LP gas	TJ	0	0	0	0	0	0	0	0	**0**
- Gas from sewage treatment	TJ	0	0	0	0	0	0	0	0	**0**
- City gas / other Natural gas	TJ	29	0	2,877	1,287	0	93	0	1,318	**5,604**
- Blast furnace gas	TJ	0	0	0	1,940	0	0	0	0	**1,940**
- Special fuels	TJ	618	0	3,582	648	23	434	0	4,646	**9,926**
		↓	↓	↓	↓		↓		↓	
		EBL 13	**EBL 13**	**EBL 14**	**EBL 15**		**EBL 15**		**EBL 15**	

Table 203:   Fuel inputs for industrial heat production in public thermal, mine and industrial power stations (new German Länder, 1990)

	Units	Heat production in large combustion systems of public thermal power stations	Heat production in large combustion systems of power stations of the lignite-mining sector	Heat production in large combustion systems of other industrial power stations	Of these, railways' power stations	Heat production in combustion systems of other industrial power stations (TA-Luft)	Of these, railways' power stations	Heat production in large combustion systems of refinery power stations	Total
Boiler efficiency	**%**	**82.44%**	**78.82%**	**79.27%**	**79.21%**	**74.27%**	**80.25%**	**83.06%**	**79.48%**
Industrial heat production	**TJ**	**3,611**	**128,533**	**100,426**	**171**	**10,291**	**158**	**44,878**	**287,740**
Fuel for industrial heat	**TJ**	**4,380**	**163,065**	**126,687**	**216**	**13,856**	**196**	**54,031**	**362,020**
Crude lignite	TJ	4,122	150,799	60,263	207	6,892	196	18,303	**240,379**
> *Lausitz coal field*	TJ	*1,759*	*96,135*	*10,294*	*207*	*1,743*	*0*	*0*	***109,931***
> *Mitteldeutschland coal field*	TJ	*2,364*	*54,664*	*49,969*	*0*	*5,149*	*196*	*18,303*	***130,448***
- Lignite briquettes	TJ	0	333	8,084	0	3,640	0	0	**12,057**
> *Lausitz coal field*	TJ	*0*	*79*	*3,328*	*0*	*2,021*	*0*	*0*	***5,428***
> *Mitteldeutschland coal field*	TJ	*0*	*255*	*4,756*	*0*	*1,619*	*0*	*0*	***6,630***
- Dry coal	TJ	0	2,912	0	0	0	0	0	**2,912**
> *Lausitz coal field*	TJ	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***0***
> *Mitteldeutschland coal field*	TJ	*0*	*2,912*	*0*	*0*	*0*	*0*	*0*	***2,912***
- Lignite semi-coke	TJ	0	2,677	6,199	0	944	0	58	**9,878**
> *Lignite low-temperature coke*	TJ	*0*	*2,677*	*6,199*	*0*	*944*	*0*	*58*	***9,878***
> *Lignite high-temperature coke*	TJ	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***0***
- Hard coal	TJ	0	378	10,353	0	951	0	0	**11,682**
- Hard-coal coke	TJ	0	0	0	0	0	0	0	**0**
- Hard-coal briquette	TJ	0	0	0	0	0	0	0	**0**
- Firewood	TJ	0	0	0	0	0	0	0	**0**
- Light heating oil	TJ	0	0	0	0	0	0	0	**0**
- Heavy heating oil	TJ	113	119	9,070	0	303	0	2,520	**12,124**
- Diesel fuel	TJ	0	0	0	0	0	0	0	**0**
- Natural gas	TJ	145	0	26,000	0	606	0	8,933	**35,684**
> *imported natural gas*	TJ	*2*	*0*	*12,887*	*0*	*0*	*0*	*8,933*	***21,822***
> *domestic natural gas*	TJ	*143*	*0*	*13,113*	*0*	*606*	*0*	*0*	***13,862***
- LP gas	TJ	0	0	0	0	0	0	0	**0**
- Gas from sewage treatment	TJ	0	0	0	0	0	0	0	**0**
- City gas / other Natural gas	TJ	0	3,119	1,988	0	0	0	12,599	**17,706**
- Blast furnace gas	TJ	0	0	1,479	0	0	0	0	**1,479**
- Special fuels	TJ	0	2,728	3,252	9	521	0	11,619	**18,120**
		↓	↓	↓		↓		↓	
		EBL 73	**EBL 45 / 73**	**EBL 73**		**EBL 73**		**EBL 45**	

Table 204:   Fuel inputs for district-heat production in public thermal, mine and industrial power stations (new German Länder, 1990)

	Units	Heat production in large combustion systems of public thermal power stations	Heat production in gas turbines of public thermal power stations	Heat production in large combustion systems of power stations of the lignite-mining sector	Heat production in large combustion systems of other industrial power stations	Of these, railways' power stations	Heat production in combustion systems of other industrial power stations (TA-Luft)	Of these, railways' power stations	Heat production in large combustion systems of refinery power stations	Total
Boiler efficiency	**%**	**83.26%**	**68.11%**	**79.30%**	**80.59%**	**79.37%**	**76.97%**		**85.02%**	**82.57%**
District-heat production	**TJ**	**109,565**	**167**	**10,874**	**14,253**	**723**	**2,659**	**0**	**3,952**	**141,469**
Fuel for district heat	**TJ**	**131,588**	**245**	**13,713**	**17,686**	**911**	**3,454**	**0**	**4,648**	**171,334**
Crude lignite	TJ	87,000	0	10,557	8,770	880	1,128	0	1,023	**108,478**
> *Lausitz coal field*	TJ	*46,503*	*0*	*6,603*	*4,321*	*645*	*598*	*0*	*0*	***58,024***
> *Mitteldeutschland coal field*	TJ	*40,497*	*0*	*3,954*	*4,449*	*235*	*530*	*0*	*1,023*	***50,453***
- Lignite briquettes	TJ	7,939	0	503	2,462	0	1,247	0	0	**12,151**
> *Lausitz coal field*	TJ	*1,012*	*0*	*333*	*780*	*0*	*722*	*0*	*0*	***2,847***
> *Mitteldeutschland coal field*	TJ	*6,927*	*0*	*170*	*1,682*	*0*	*525*	*0*	*0*	***9,304***
- Dry coal	TJ	0	0	169	0	0	0	0	0	**169**
> *Lausitz coal field*	TJ	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***0***
> *Mitteldeutschland coal field*	TJ	*0*	*0*	*169*	*0*	*0*	*0*	*0*	*0*	***169***
- Lignite semi-coke	TJ	64	0	0	165	0	11	0	0	**240**
> *Lignite low-temperature coke*	TJ	*64*	*0*	*0*	*165*	*0*	*11*	*0*	*0*	***240***
> *Lignite high-temperature coke*	TJ	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	***0***
- Hard coal	TJ	1,282	0	2,090	1,503	0	907	0	0	**5,782**
- Hard-coal coke	TJ	0	0	0	0	0	0	0	0	**0**
- Hard-coal briquette	TJ	0	0	0	0	0	0	0	0	**0**
- Firewood	TJ	0	0	0	0	0	0	0	0	**0**
- Light heating oil	TJ	0	245	0	0	0	0	0	0	**245**
- Heavy heating oil	TJ	13,820	0	50	504	1	0	0	3	**14,378**
- Diesel fuel	TJ	0	0	0	0	0	0	0	0	**0**
- Natural gas	TJ	20,956	0	2	3,891	0	150	0	501	**25,500**
> *imported natural gas*	TJ	*13,268*	*0*	*1*	*1,641*	*0*	*0*	*0*	*501*	***15,410***
> *domestic natural gas*	TJ	*7,688*	*0*	*1*	*2,250*	*0*	*150*	*0*	*0*	***10,089***
- LP gas	TJ	0	0	0	0	0	0	0	0	**0**
- Gas from sewage treatment	TJ	0	0	0	0	0	0	0	0	**0**
- City gas / other Natural gas	TJ	134	0	205	223	0	0	0	2,931	**3,494**
- Blast furnace gas	TJ	0	0	0	0	0	0	0	0	**0**
- Special fuels	TJ	391	0	136	167	29	11	0	190	**896**

<div align="center">

↓ **EBL 18**   ↓ **EBL 18**   ↓ **EBL 18**   ↓ **EBL 18**   ↓ **EBL 18**   ↓ **EBL 18**

</div>

Table 205:   Total fuel inputs in public thermal, mine and industrial power stations (new German Länder, 1990)

	Units	Total heat production in large combustion systems of public thermal power stations	Total heat production in gas turbines of public thermal power stations	Total heat production in large combustion systems of power stations of the lignite-mining sector	Total heat production in large combustion systems of other industrial power stations	Of these, railways' power stations	Total heat production in combustion systems of other industrial power stations (TA-Luft)	Of these, railways' power stations	Total heat production in large combustion systems of refinery power stations	Total
Boiler efficiency	**%**	**82.73%**	**90.33%**	**79.61%**	**79.87%**	**79.62%**	**74.63%**	**80.25%**	**83.15%**	**81.68%**
Total heat production	**TJ**	**798,616**	**1,342**	**255,317**	**147,599**	**3,384**	**14,556**	**160**	**65,576**	**1,283,006**
Fuel for total heat	**TJ**	**965,354**	**1,486**	**320,722**	**184,792**	**4,251**	**19,505**	**200**	**78,866**	**1,570,725**
Crude lignite	TJ	904,647	0	285,462	87,411	4,175	8,735	200	27,207	1,313,462
> Lausitz coal field	TJ	*710,899*	*0*	*200,568*	*19,166*	*1,356*	*2,506*	*0*	*0*	*933,138*
> Mitteldeutschland coal field	TJ	*193,748*	*0*	*84,895*	*68,245*	*2,819*	*6,229*	*200*	*27,207*	*380,323*
- Lignite briquettes	TJ	8,427	0	1,526	12,336	0	5,290	0	24	27,603
> Lausitz coal field	TJ	*1,111*	*0*	*582*	*4,506*	*0*	*2,944*	*0*	*0*	*9,142*
> Mitteldeutschland coal field	TJ	*7,317*	*0*	*944*	*7,830*	*0*	*2,346*	*0*	*24*	*18,461*
- Dry coal	TJ	0	0	9,021	0	0	0	0	238	9,259
> Lausitz coal field	TJ	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
> Mitteldeutschland coal field	TJ	*0*	*0*	*9,021*	*0*	*0*	*0*	*0*	*238*	*9,259*
- Lignite semi-coke	TJ	65	0	8,140	8,477	0	1,177	0	934	18,792
> Lignite low-temperature coke	TJ	*65*	*0*	*8,140*	*8,477*	*0*	*1,177*	*0*	*934*	*18,792*
> Lignite high-temperature coke	TJ	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
- Hard coal	TJ	1,320	0	3,515	14,643	0	2,144	0	0	21,621
- Hard-coal coke	TJ	0	0	0	0	0	0	0	0	0
- Hard-coal briquette	TJ	0	0	0	0	0	0	0	0	0
- Firewood	TJ	0	0	0	0	0	0	0	0	0
- Light heating oil	TJ	0	339	0	0	0	0	0	0	339
- Heavy heating oil	TJ	20,917	0	331	11,779	14	315	0	3,406	36,748
- Diesel fuel	TJ	0	146	0	0	0	0	0	0	146
- Natural gas	TJ	28,807	1,000	79	39,162	0	787	0	13,755	83,590
> imported natural gas	TJ	*18,934*	*1,000*	*25*	*19,363*	*0*	*0*	*0*	*13,755*	*53,078*
> domestic natural gas	TJ	*9,873*	*0*	*54*	*19,799*	*0*	*787*	*0*	*0*	*30,513*
- LP gas	TJ	0	0	0	0	0	0	0	0	0
- Gas from sewage treatment	TJ	0	0	0	0	0	0	0	0	0
- City gas / other Natural gas	TJ	164	0	6,202	3,498	0	93	0	16,847	26,803
- Blast furnace gas	TJ	0	0	0	3,420	0	0	0	0	3,420
- Special fuels	TJ	1,009	0	6,446	4,067	62	966	0	16,455	28,942

Table 206:   Fuel inputs in thermal power stations and district-heat stations (Energy Balance line 18) (new German Länder, 1990)

	Units	Fuels for district-heat production, 1990 EB line 18	District-heat production in large combustion systems of public thermal power stations	District-heat production from gas turbines in public thermal power stations	District-heat production in large combustion systems of power stations in the lignite-mining sector	District-heat production in large combustion systems of industrial power stations of the manufacturing sector and other mining sectors	District-heat production in TA-Luft systems of industrial power stations of the manufacturing sector and other mining sectors	District-heat production in large combustion systems of refinery power stations	District-heat production in public district-heating stations	Of these, district-heat production in large combustion systems	Of these, district-heat production in TA-Luft systems
Annual efficiency	%	81.60%	83.26%	68.11%	79.30%	80.59%	76.97%	85.02%	80.04%		
District-heat production	TJ	227,490	109,565	167	10,874	14,253	2,659	3,952	86,021		
Fuel for district heat	TJ	278,801	131,588	245	13,713	17,686	3,454	4,648	107,467	33,394	74,074
Crude lignite	TJ	189,784	87,000	0	10,557	8,770	1,128	1,023	81,306	25,265	56,042
> Lausitz coal field	TJ		46,503	0	6,603	4,321	598	0	32,522	10,106	22,417
> Mitteldeutschland coal field	TJ		40,497	0	3,954	4,449	530	1,023	48,784	15,159	33,625
- Lignite briquettes	TJ	19,569	7,939	0	503	2,462	1,247	0	7,418	2,305	5,113
> Lausitz coal field	TJ		1,012	0	333	780	722	0	1,738	540	1,198
> Mitteldeutschland coal field	TJ		6,927	0	170	1,682	525	0	5,680	1,765	3,915
- Coal dust / dry coal	TJ	532	0	0	169	0	0	0	363	113	250
> Lausitz coal field	TJ		0	0	0	0	0	0	0	0	0
> Mitteldeutschland coal field	TJ		0	0	169	0	0	0	363	113	250
- Lignite coke	TJ	243	64	0	0	165	11	0	3	1	2
> Lignite low-temperature coke	TJ		64	0	0	165	11	0			
> Lignite high-temperature coke	TJ		0	0	0	0	0	0			
- Hard coal	TJ	11,835	1,282	0	2,090	1,503	907	0	6,053	1,881	4,172
- Hard-coal coke	TJ		0	0	0	0	0	0	0	0	0
- Hard-coal briquettes	TJ		0	0	0	0	0	0	0	0	0
- Firewood	TJ		0	0	0	0	0	0	0	0	0
- Heating oil, light	TJ	1,217	0	245	0	0	0	0	972	302	670
- Heating oil, heavy	TJ	16,028	13,820	0	50	504	0	3	1,650	513	1,137
- Diesel fuel	TJ		0	0	0	0	0	0	0	0	0
- Natural gas	TJ	32,724	20,956	0	2	3,891	150	501	7,224	2,245	4,979
> imported natural gas	TJ		13,268	0	1	1,641	0	501			
> domestic natural gas	TJ		7,688	0	1	2,250	150	0			
- LP gas	TJ		0	0	0	0	0	0	0	0	0
- Gas from sewage treatment	TJ		0	0	0	0	0	0	0	0	0
- Other gases	TJ	5,973	134	0	205	223	0	2,931	2,479	770	1,709
> Fuel gas			0	0	0	0	0	0	0	0	0
> Coke-oven / city gas	TJ	5,973	134	0	205	223	0	2,931	2,479	770	1,709
> Refinery gas			0	0	0	0	0	0	0	0	0
- Blast furnace gas	TJ		0	0	0	0	0	0	0	0	0

	Units	Fuels for district-heat production, 1990 EB line 18	District-heat production in large combustion systems of public thermal power stations	District-heat production from gas turbines in public thermal power stations	District-heat production in large combustion systems of power stations in the lignite-mining sector	District-heat production in large combustion systems of industrial power stations of the manufacturing sector and other mining sectors	District-heat production in TA-Luft systems of industrial power stations of the manufacturing sector and other mining sectors	District-heat production in large combustion systems of refinery power stations	District-heat production in public district-heating stations	Of these, district-heat production in large combustion systems	Of these, district-heat production in TA-Luft systems
- Special fuels	TJ	896	391	0	136	167	11	190	0	0	0
> Other petroleum products	TJ		0	0	0	0	0	0	0	0	0
Lignite tar			0	0	0	0	0	0	0	0	0
> Industrial waste		896	391	0	136	167	11	190	0	0	0

Table 207:   Fuel inputs in the transformation sector (auxiliary energy / Energy Balance line 45) (new German Länder, 1990)

	Units	Corrected EB line 45	Heat production in large combustion systems of power stations of the lignite-mining sector	Production of hard-coal coke	Heat production in large combustion systems of refinery power stations	Total (transformation for power stations)	Other process combustion
Industrial heat production	**TJ**		118,198		44,878	163,076	
Fuel for final energy	**TJ**	224,150	149,953	3,053	54,031	207,037	17,113
Crude lignite	TJ	156,976	138,673	0	18,303	156,976	0
> Lausitz coal field	TJ		*88,405*		*0*	*88,405*	
> Mitteldeutschland coal field	TJ		*50,268*		*18,303*	*68,571*	
- Lignite briquettes	TJ	306	306	0	0	306	0
> Lausitz coal field	TJ		*72*		*0*	*72*	
> Mitteldeutschland coal field	TJ		*234*		*0*	*234*	
- Coal dust / dry coal	TJ	2,677	2,677	0	0	2,677	0
> Lausitz coal field	TJ		*0*		*0*	*0*	
> Mitteldeutschland coal field	TJ		*2,677*		*0*	*2,677*	
- Lignite coke	TJ	2,520	2,462	0	58	2,520	0
> Lignite low-temperature coke	TJ		*2,462*		*58*	*2,520*	
> Lignite high-temperature coke	TJ		*0*		*0*	*0*	
- Hard coal	TJ	348	348	0	0	348	0
- Hard-coal coke	TJ	60	0	0	0	0	60
- Hard-coal briquettes	TJ	0	0	0	0	0	0
- Firewood	TJ	0	0	0	0	0	0
- Heating oil, light	TJ	0	0	0	0	0	0
- Heating oil, heavy	TJ	5,438	109	0	2,520	2,629	2,809
- Diesel fuel	TJ	0	0	0	0	0	0
- Natural gas	TJ	10,459	0	1,526	8,933	10,459	0
> imported natural gas	TJ		*0*		*8,933*	*8,933*	
> domestic natural gas	TJ		*0*		*0*	*0*	
- LP gas	TJ	644	0	0	0	0	644
- Gas from sewage treatment	TJ	0	0	0	0	0	0
- Other gases	TJ	28,311	2,868	1,527	12,599	16,994	11,317
> Fuel gas		9,598	0	1,527	0	1,527	8,071
> Coke-oven / city gas	TJ	2,868	2,868	0	0	2,868	0
> Refinery gas		15,845	0	0	12,599	12,599	3,246
- Blast furnace gas	TJ	0	0	0	0	0	0
- Special fuels	TJ	16,410	2,509	0	11,619	14,128	2,282
> Other petroleum products		13,901	0	0	11,619	11,619	2,282
Lignite tar	TJ	0	0	0	0	0	0
> Industrial waste		2,509	2,509	0	0	2,509	0

Table 208:   Final-energy consumption in the "other mining" and manufacturing sectors: process combustion (Energy Balance line 73) (new German Länder, 1990)

Final energy consumption, manufacturing sector, 1990	Units	Corrected EB line 73	Calcium carbide production (process combustion)	Production of iron, steel and malleable cast iron (process combustion)	Glass production (process combustion)	Manufacturing of coarse ceramics (process combustion)	Lime production (process combustion)	Production of non-ferrous heavy metals (process combustion)	Manufacturing of pig iron (process combustion)	Production of Siemens-Martin steel (process combustion)	Sinter production (process combustion)	Manufacturing of rolled steel (process combustion)	Cement production (process combustion)	Sugar manufacturing (process combustion)	Subtotal, process combustion (not including carbide)
				2-9	10-16	17-25	26-37	38-43+80	44-48	49-52	53-55	56-58+81	59-71	72-79	
Industrial heat production	**TJ**														
Fuel for final energy	**TJ**	**547,693**		**2,981**	**6,240**	**7,569**	**7,560**	**6,155**	**25,732**	**12,932**	**5,340**	**6,660**	**26,248**	**4,633**	**112,050**
Crude lignite	TJ	169,921		0	401	2,225	0	0	0	0	0	0	0	0	2,626
> *Lausitz coal field*	TJ			0	241	890	0	0	0	0	0	0	0	0	1,130
> *Mitteldeutschland coal field*	TJ			0	160	1,335	0	0	0	0	0	0	0	0	1,495
- Lignite briquettes	TJ	74,324		0	23	3,300	0	1,102	0	0	0	0	0	0	4,425
> *Lausitz coal field*	TJ														
> *Mitteldeutschland coal field*	TJ														
- Coal dust / dry coal	TJ	27,266		0	0	0	0	365	0	0	0	0	14,836	0	15,201
> *Lausitz coal field*	TJ														
> *Mitteldeutschland coal field*	TJ														
- Lignite coke	TJ	22,149		0	0	0	2,100	0	0	0	3,348	0	0	0	5,448
> *Lignite low-temperature coke*	TJ														
> *Lignite high-temperature coke*	TJ														
- Hard coal	TJ	37,442		0	0	22	0	0	0	0	197	0	7,418	3,682	11,318
- Hard-coal coke	TJ	32,260		2,510	0	18	5,250	3,645	16,851	0	1,795	0	0	951	31,021
- Hard-coal briquettes	TJ	0		0	0	0	0	0	0	0	0	0	0	0	0
- Firewood	TJ	0		0	0	0	0	0	0	0	0	0	0	0	0
- Heating oil, light	TJ	2,402		0	141	71	0	0	0	0	0	0	0	0	212
- Heating oil, heavy	TJ	23,070		0	0	0	0	324	3,032	3,816	0	740	0	0	7,912
- Diesel fuel	TJ	10		0	0	0	0	0	0	0	0	0	0	0	0
- Natural gas	TJ	107,410		471	4,332	1,658	210	720	835	8,904	0	4,810	3,994	0	25,934
> *imported natural gas*	TJ														0
> *domestic natural gas*	TJ														0
- LP gas	TJ	2,395		0	0	0	0	0	0	0	0	0	0	0	0
- Gas from sewage treatment	TJ	0		0	0	0	0	0	0	0	0	0	0	0	0
- Other gases	TJ	28,956		0	1,342	276	0	0	0	212	0	1,110	0	0	2,940
> Fuel gas		2,803		0	0	0	0	0	0	0	0	0	0	0	0
> Coke-oven / city gas	TJ	24,762		0	1,342	276	0	0	0	212	0	1,110	0	0	2,940
> Refinery gas		1,392		0	0	0	0	0	0	0	0	0	0	0	0
- Blast furnace gas	TJ	11,417		0	0	0	0	0	5,013	0	0	0	0	0	5,013

Final energy consumption, manufacturing sector, 1990	Units	Corrected EB line 73	Calcium carbide production (process combustion)	Production of iron, steel and malleable cast iron (process combustion)	Glass production (process combustion)	Manufacturing of coarse ceramics (process combustion)	Lime production (process combustion)	Production of non-ferrous heavy metals (process combustion)	Manufacturing of pig iron (process combustion)	Production of Siemens-Martin steel (process combustion)	Sinter production (process combustion)	Manufacturing of rolled steel (process combustion)	Cement production (process combustion)	Sugar manufacturing (process combustion)	Subtotal, process combustion (not including carbide)
- Special fuels	TJ	8,674		0	0	0	0	0	0	0	0	0	0	0	0
> Other petroleum products	TJ	301		0	0	0	0	0	0	0	0	0	0	0	0
Lignite tar		511		0	0	0	0	0	0	0	0	0	0	0	0
> Industrial waste		7,862		0	0	0	0	0	0	0	0	0	0	0	0

Table 209:　　Final-energy consumption in the "other mining" and manufacturing sectors: Industrial heat from power stations and heating boilers (Energy Balance line 73) (new German Länder, 1990)

	Units	Corrected EB line 73	Subtotal, process combustion (not including carbide)	Heat production in large combustion systems of public thermal power stations	Heat production in large combustion systems of mine-sector power stations (not including heat for briquetting plants)	Heat production in large combustion systems of industrial power stations of the manufacturing and other mining sectors	Heat production in TA-Luft systems of industrial power stations of the manufacturing and other mining sectors	Heat production in industrial boilers of the manufacturing sector	Of these, heat production in large combustion systems (industrial boilers) of the manufacturing sector	Of these, heat production in TA-Luft systems (industrial boilers) of the manufacturing sector	Other process combustion
Industrial heat production	**TJ**			3,611	10,335	100,426	10,291				
Fuel for final energy	**TJ**	**547,693**	**112,050**	**4,380**	**13,112**	**126,687**	**13,856**	**160,370**	**62,305**	**98,065**	**117,238**
Crude lignite	TJ	169,921	2,626	4,122	12,126	60,263	6,892	76,000	29,527	46,473	7,892
> *Lausitz coal field*	TJ		*1,130*	*1,759*	*7,730*	*10,294*	*1,743*	*30,400*	*11,811*	*18,589*	*3,398*
> *Mitteldeutschland coal field*	TJ		*1,495*	*2,364*	*4,395*	*49,969*	*5,149*	*45,600*	*17,716*	*27,884*	*4,494*
- Lignite briquettes	TJ	74,324	4,425	0	27	8,084	3,640	40,000	15,540	24,460	18,148
> *Lausitz coal field*	TJ			0	6	3,328	2,021	*16,000*	*6,216*	*9,784*	
> *Mitteldeutschland coal field*	TJ			0	20	4,756	1,619	*24,000*	*9,324*	*14,676*	
- Coal dust / dry coal	TJ	27,266	15,201	0	234	0	0	3,500	1,360	2,140	8,331
> *Lausitz coal field*	TJ			*0*	*0*	*0*	*0*	*1,400*	*544*	*856*	
> *Mitteldeutschland coal field*	TJ			*0*	*234*	*0*	*0*	*2,100*	*816*	*1,284*	
- Lignite coke	TJ	22,149	5,448	0	215	6,199	944	3,500	1,360	2,140	5,843
> *Lignite low-temperature coke*	TJ			*0*	*215*	*6,199*	*944*				
> *Lignite high-temperature coke*	TJ			*0*	*0*	*0*	*0*				
- Hard coal	TJ	37,442	11,318	0	30	10,353	951	13,500	5,245	8,255	1,289
- Hard-coal coke	TJ	32,260	31,021	0	0	0	0		0	0	1,239
- Hard-coal briquettes	TJ	0	0	0	0	0	0		0	0	0
- Firewood	TJ	0	0	0	0	0	0		0	0	0
- Heating oil, light	TJ	2,402	212	0	0	0	0		0	0	2,190
- Heating oil, heavy	TJ	23,070	7,912	113	10	9,070	303	2,000	777	1,223	3,662
- Diesel fuel	TJ	10	0	0	0	0	0		0	0	10
- Natural gas	TJ	107,410	25,934	145	0	26,000	606	11,000	4,274	6,726	43,724
> *imported natural gas*	TJ		*0*	*2*	*0*	*12,887*	*0*				
> *domestic natural gas*	TJ		*0*	*143*	*0*	*13,113*	*606*				
- LP gas	TJ	2,395	0	0	0	0	0		0	0	2,395
- Gas from sewage treatment	TJ	0	0	0	0	0	0		0	0	0
- Other gases	TJ	28,956	2,940	0	251	1,988	0	7,000	2,720	4,280	16,778
> *Fuel gas*		2,803	0	0	0	1,988	0		0	0	815
> *Coke-oven / city gas*	TJ	24,762	2,940	0	251	0	0	7,000	2,720	4,280	14,571
> *Refinery gas*		1,392	0	0	0	0	0		0	0	1,392
- Blast furnace gas	TJ	11,417	5,013	0	0	1,479	0		0	0	4,924
- Special fuels	TJ	8,674	0	0	219	3,252	521	3,870	1,503	2,366	812
> *Other petroleum products*		301	0	0	0	0	0		0	0	301
Lignite tar	TJ	511	0	0	0	0	0		0	0	511
> *Industrial waste*		7,862	0	0	219	3,252	521	3,870	1,503	2,366	0

19.1.1.4   Revision of activity rates for the years 1991 through 1994

As a result of revision of the data for the new German Länder for 1990, it became necessary to revise the activity rates for subsequent years, through 1994, as well.

At the same time, it was not possible to carry out a bottom-up procedure of equivalent quality for these subsequent years, using detailed primary data in the approach followed for 1990. For example, 1990 is the last year for which detailed power-station-oriented data are available.

19.1.1.4.1   Method (Activity rates, 1991-1994)

Time-series-consistency requirements are met in that consistent data sources are used (e.g. Statistical Yearbooks (Statistische Jahrbücher), Energy Balances, an existing evaluation carried out by the Federal Environment Agency), congruent calculation methods are applied for subsequent years and standardised allocation and offsetting procedures are followed.

A multi-step procedure was used for determining fuel inputs in the years 1991 through 1994 and in allocating them to the relevant combustion inputs:

1. On the basis of "Annual reports on development of the lignite industry in the new German Länder" ("Jahresberichte zur Entwicklung der Braunkohle in den neuen Bundesländern") from 1991 through 1994 (Federal Ministry for Economics and Labour (BMWA) n.y.), and for purposes of checking figures already in the CSE, data on lignite production were obtained. In addition, the data were broken down by a) mining districts (coal fields) and b) lignite use for processed products and for boiler and combustion systems, in turn further broken down by consumer sectors.
2. In addition, fuel-heating requirements for briquette and lignite-dust production (heat for drying) were determined and broken down by the Lausitz and Mitteldeutschland districts (coal fields).
3. Final energy consumption in relevant energy-intensive processes identified for the base year was determined, with the help of Statistical Yearbooks and data from an unpublished *Fachserie* ("technical series"), for the years 1991 through 1994.
4. Additional fuel-consumption figures were determined via calculations.

For example, fuel consumption for industrial processes, as documented on the basis of the aforementioned sources, is deducted from the sum values for the relevant fuels as listed in Energy Balance line 73 in the Energy Balances for the years 1991 through 1994.

The difference remaining, in the various years, between the fuel consumption identified for these processes and the "total" values listed for the various fuels in the relevant Energy Balance is distributed proportionately among the remaining time series. For this remainder, as well as for all other fuel inputs in power stations, heating boilers and other industrial boilers, the following calculation approach is applied:

• The reference values used for dividing up fuel inputs in stationary combustion systems in the years 1991 through 1994 are the new time-series data through 1990, in their allocation to EB lines 13-15, 18, 45 and 73.
• The values for the various fuels as listed in the Energy Balances for the years 1991 – 1994 are allocated in keeping with the proportional allocations for the various fuels in the 1990 Energy Balance.

- Proportional allocation was not carried out in cases in which the 1991-1994 Energy Balances list a fuel-consumption figure, in their specific lines, that is listed as zero in the revised 1990 Energy Balance (multiplication by zero). In such cases, the fuel-consumption figures shown in the relevant Energy Balance cells for the years 1991 through 1994 were used. This approach ensures that all of the fuels listed in the Energy Balances of subsequent years are taken into account.

19.1.1.5   Results (activity rates, 1991-1994)

19.1.1.5.1   *Lignite*

A by-district breakdown of lignite consumption had to be obtained, as was accomplished for the year 1990. Table 210 provides an overview of lignite production by districts, of lignite inputs in product processing and of lignite inputs in boiler and combustion systems, broken down by consumer sectors. For checking purposes, the data were converted to obtain total consumption, and then compared with the total lignite consumption listed to date in the CSE.

Table 210 shows inputs, for coal briquetting, in lignite plants in the Lausitz and Mitteldeutschland districts, while Table 211 shows consumption for drying heat. These figures, when combined with the average net calorific values for the various districts, produce the values in EB line 12 in the relevant Energy Balances. Inputs in the lignite-industry power stations of both districts are in keeping with the values for mine-pit power stations as listed in EB line 14 of the Energy Balance for the period 1991 through 1994.

Table 210:   Lignite production by mining districts

		1990	**1991**	**1992**	**1993**	**1994**
Lignite production	kt	248,900	167,700	129,400	115,600	101,800
Lausitz	kt	168,000	116,800	93,100	87,400	79,400
Mitteldeutschland	kt	80,900	50,900	36,300	28,200	22,400
Removal from stocks, including import/export balance	**kt**	**4,338**	**3,704**	**2,908**	**2,162**	**797**
Lignite production & removal from stocks (by production quantities, broken down by mining districts)						
Lausitz	kt	170,928	119,380	95,192	89,035	80,022
Mitteldeutschland	kt	82,310	52,024	37,116	28,727	22,575
Lignite consumption	**kt**	**253,238**	**171,404**	**132,308**	**117,762**	**102,597**
Lignite consumption, by districts						
Consumption in the Lausitz district, in ...	**kt**	**170,928**	**119,380**	**95,192**	**89,035**	**80,022**
Briquetting plants (briquetting coal)	kt	45,644	25,960	14,677	11,974	9,497
Power stations of the lignite industry of the Lausitz district	kt	23,533	17,240	10,431	9,119	7,556
Power stations of VEAG	kt	80,020	62,500	60,800	60,548	57,488
Other power stations	kt	9,008	5,686	3,552	3,035	2,757
Industrial boilers	kt	7,415	5,641	4,005	3,269	2,106
Sales to public and commerce, trade services	kt	5,308	2,352	1,728	1,089	618
Consumption in the Mitteldeutschland district, in ...	**kt**	**82,310**	**52,024**	**37,116**	**28,727**	**22,575**
Briquetting plants (briquetting coal)	kt	29,506	12,058	7,034	5,075	2,864
Power stations of the lignite industry of the Mitteldeutschland district	kt	8,570	7,342	6,301	5,438	4,898
Power stations of VEAG	kt	15,880	12,700	10,128	8,639	8,025
Other power stations	kt	16,354	11,908	8,151	5,826	4,314
Industrial boilers	kt	9,444	6,989	4,830	3,397	2,300
Sales to public and commerce, trade services	kt	2,556	1,027	672	352	174

Source: Annual reports for the years 1991 through 1994 on development of the lignite industry in the new
            German Länder, Federal Ministry of Economics (BMWA, n.y.).

The following Table 211 provides an overview of fuel inputs for drying coal briquettes and
coal dust, in the Lausitz and Mitteldeutschland mining districts.

Table 211:   Fuel inputs for drying coal briquettes and coal dust, by mining districts

		1990	1991	1992	1993	1994
Briquette production*	kt	37,648	18,198	9,746	7,716	5,026
Lausitz	kt	22,200	12,200	6,500	5,300	3,900
Mitteldeutschland	kt	15,448	5,998	3,246	2,416	1,126
Coal dust / dry coal*	kt	1,817	1,641	1,590	1,166	1,378
Lausitz	kt	981	985	954	781	923
Mitteldeutschland	kt	836	656	636	385	455
Total production	kt	39,465	19,839	11,336	8,882	6,404
Specific heat requirements for drying	GJ/t	2.995	2.95	2.95	2.95	2.95
Heat requirements for drying	TJ	118,198	58,525	33,441	26,202	18,892
Boiler efficiency	%	78.82	79	79	79	79
Fuel requirements	TJ	149,953	74,082	42,331	33,167	23,914

* Source: Energy Balances for the years 1990 through 1994, and annual reports for the years 1991 through
           1994 on development of the lignite industry in the new German Länder, Federal Ministry of Economics
           (BMWA, n.y.).

Since all briquetting plants remained in operation in 1990, reductions in production led to reductions in dryer loading and, thus, to an increase in specific heat consumption. Reduced capacity use in briquetting plants also led to an increase in the briquetting factor.

Beginning in 1991, increasing numbers of briquetting plants were decommissioned. Nonetheless, the plants that remained in operation were unable to operate to capacity, with the result that specific heat consumption for coal drying remained at a level of about 2.95 GJ / t lignite briquettes for the years 1991 - 1994.

Heat for drying was produced primarily in combined heat/power generating systems in the lignite industry's power stations. As briquetting plants' absolute heat requirements decreased, in a trend linked to decreasing electricity requirements, power stations' capacity use also shrank – considerably.

For drying-heat consumption in briquetting plants during the period 1991 – 1994, and taking account of dates of decommissioning (BMWA, n.y.: 91-939), specific heat requirements of about 2.95 GJ / t lignite briquettes, and a mean boiler efficiency of about 79 % in the lignite industry's power stations, are assumed for purposes of determining fuel consumption for producing drying heat.

19.1.1.5.2   Energy-intensive industrial processes

The following tables (Table 212 through Table 219) provide overviews of development of fuel consumption in various energy-intensive industrial processes. The primary source for production figures for the years 1991 and 1992 is the 1993 Statistical Yearbook (Statistisches Jahrbuch 1993). Production figures for the years 1993 and 1994 were taken from an unpublished special analysis carried out by the Federal Statistical Office for 1993/1994.

For determination of fuel consumption in selected industrial processes, structural changes in fuel inputs, in keeping with changes in the Energy Balance, and partial improvement in specific indexes in the course of the years 1991 through 1994 are taken into account. For

example, use of coking gas / city gas was discontinued as of the year 1993/94. It is assumed that such gas was supplanted by natural gas.

Table 212:   Rolled steel

		1990	1991	1992	1993	1994
Production*	**Kt**	**3,700**	**2,700**	**2,300**	**2,000**	**2,300**
Specific energy consumption** (not including electricity and heat)	***TJ/kt***	***1.8***	***1.8***	***1.8***	***1.8***	***1.8***
Natural gas	TJ/kt	1.3	1.5	1.6	1.6	1.7
Coke-oven / city gas	TJ/kt	0.3	0.2	0.1	0.1	0
Heavy fuel oil	TJ/kt	0.2	0.1	0.1	0.1	0.1
Absolute energy consumption						
Natural gas	TJ	4,810	4,050	3,680	3,200	3,910
Coke-oven / city gas	TJ	1,110	540	230	200	0
Heavy fuel oil	TJ	740	270	230	200	230
Total	**TJ**	**6,660**	**4,860**	**4,140**	**3,600**	**4,140**

* Source: http://www.stahl-online.de/wirtschafts_und_Politik/stahl_in_zahlen/2005/Stahlerzeugung_in_OstDE.jpg
**   Remark pertaining to the specific energy consumption figure in all industrial processes included here: Because the prescribed system requires that electricity consumption in EB lines 13-15 be taken into account, and that heat provided by power stations for industrial processes also be listed separately, the specific energy consumption listed here includes only fuel consumption, but not consumption of electrical power and heat.

Table 213:   Pig iron

		1990	1991	1992	1993	1994
Production*	**kt**	**2,166**	**1,165**	**810**	**759**	**842**
Specific energy consumption (not including electricity and heat)	***TJ/kt***	***11.88***	***11.37***	***11.48***	***11.11***	***11.28***
Natural gas	TJ/kt	0.39	0.39	0.4	0.4	0.4
Blast-furnace gas	TJ/kt	2.31	2.3	2.3	2.3	2.3
Heavy fuel oil	TJ/kt	1.4	1.4	2	2.2	2.3
Hard-coal coke**	TJ/kt	7.78	7.28	6.78	6.21	6.28
Absolute energy consumption						
Natural gas	TJ	845	454	324	304	337
Blast-furnace gas	TJ	5,003	2,680	1,863	1,746	1,937
Heavy fuel oil	TJ	3,032	1,631	1,620	1,670	1,937
Hard-coal coke	TJ	16,851	8,481	5,492	4,713	5,288
Total	**TJ**	**25,732**	**13,246**	**9,299**	**8,432**	**9,498**

* Source: Statistical Yearbooks (Statistische Jahrbücher) 1991 through 1993, and data from the Federal Environment Agency (unpublished special analysis of the Federal Statistical Office for 1993/1994)
**   Following offsetting with equivalent for blast-furnace gas

Table 214:   Siemens-Martin steel

		1990	**1991**	**1992**	**1993**	**1994**
Production*	kt	**2,120**	**780**	**550**	**550**	**0**
Specific energy consumption (not including electricity and heat)	*TJ/kt*	*6.1*	*6.1*	*6.1*	*6.1*	*0*
Natural gas	TJ/kt	4.2	4.2	4.2	4.2	0
Coke-oven / city gas	TJ/kt	0.1	0.1	0.1	0.1	0
Heavy fuel oil	TJ/kt	1.8	1.8	1.8	1.8	0
Absolute energy consumption						
Natural gas	TJ	8,904	3,276	2,310	2,310	0
Coke-oven / city gas	TJ	212	78	55	55	0
Heavy fuel oil	TJ	3,816	1,404	990	990	0
Total	**TJ**	**12,932**	**4,758**	**3,355**	**3,355**	**0**

* Source: http://www.stahl-online.de/wirtschafts_und_Politik/stahl_in_zahlen/2005/Stahlerzeugung_in_OstDE.jpg

Table 215:   Cement clinkers

		1990	**1991**	**1992**	**1993**	**1994**
Production*	kt	**5,706**	**1,948**	**3,726**	**3,876**	**4,897**
Specific energy consumption (not including electricity and heat)	*TJ/kt*	*4.6*	*3.9*	*3.8*	*3.8*	*3.8*
Other petroleum products	TJ/kt		0.0	0.0	0.0	0.1
Heavy fuel oil	TJ/kt		0.5	0.5	0.5	0.5
Raw lignite, Mitteldeutschland district	TJ/kt		0.6	0.3	0.0	0.0
Natural gas	TJ/kt	0.7	0.0	0.0	0.1	0.1
Hard coal	TJ/kt	1.3	1.8	1.2	1.2	1.1
Dust / dry coal	TJ/kt	2.6	0.9	1.7	2.0	1.9
Absolute energy consumption						
Other petroleum products	TJ		0	0	0	656
Heavy fuel oil	TJ		1,049	1,969	1,906	2,592
Raw lignite, Mitteldeutschland district	TJ		1,188	1,287	0	0
Natural gas	TJ	3,994	91	91	214	277
Hard coal	TJ	7,418	3,447	4,580	4,813	5,607
Dust / dry coal	TJ	14,836	1,822	6,232	7,796	9,477
Total	**TJ**	**26,248**	**7,597**	**14,159**	**14,729**	**18,609**

* Source: Data from the Federal Environment Agency (unpublished special analysis of the Federal Statistical Office for 1993/1994)

Table 216:   Burnt lime

		1990	**1991**	**1992**	**1993**	**1994**
Production*	kt	**2,100**	**599**	**650**	**780**	**1,132**
Specific energy consumption (not including electricity and heat)	*TJ/kt*	*3.6*	*3.6*	*3.5*	*3.5*	*3.5*
Natural gas	TJ/kt	0.1	0.4	0.4	0.7	1
Hard-coal coke	TJ/kt	2.5	3.1	3	2.7	2.3
Lignite coke	TJ/kt	1	0	0	0	0
Heavy fuel oil	TJ/kt	0	0.1	0.1	0.1	0.2
Absolute energy consumption						
Natural gas	TJ	210	240	260	546	1,132
Hard-coal coke	TJ	5,250	1,857	1,950	2,106	2,604
Lignite coke	TJ	2,100	0	0	0	0
Heavy fuel oil	TJ	0	60	65	78	226
Total	**TJ**	**7,560**	**2,156**	**2,275**	**2,730**	**3,962**

* Source: Own calculations and data from the Federal Environment Agency (unpublished special analysis of the Federal Statistical Office for 1993/1994)

Table 217:   Sugar, glass and coarse ceramics

Since no reliable sources and statistics were available to IE Leipzig, the values reported to date by the Federal Environment Agency for 1990 through 1994 remain unchanged.

Table 218:   Iron and steel casting (including malleable casting)

		1990	**1991**	**1992**	**1993**	**1994**
Production*	kt	**523**	**330**	**260**	**150**	**125**
Specific energy consumption (not including electricity and heat)	*TJ/kt*	*5.7*	*5.7*	*5.7*	*5.7*	*5.7*
Natural gas	TJ/kt	0.9	0.9	0.9	0.9	0.9
Hard-coal coke	TJ/kt	4.8	4.8	4.8	4.8	4.8
Absolute energy consumption						
Natural gas	TJ	471	297	234	135	113
Hard-coal coke	TJ	2,510	1,584	1,248	720	600
Total	**TJ**	**2,981**	**1,881**	**1,482**	**855**	**713**

* Source: Own calculations

Table 219:   Non-ferrous heavy metals

		1990	**1991**	**1992**	**1993**	**1994**
Production*	kt	**108**	**35**	**30**	**20**	**10**
Specific energy consumption (not including electricity and heat)	*TJ/kt*	*57*	*46*	*43*	*53*	*52*
Natural gas	TJ/kt	6.67	15	15	15	15
Heavy fuel oil	TJ/kt	3	3	3	3	3
Hard-coal coke	TJ/kt	33.75	22	23	34	34
Dust / dry coal		3.38	0	0	0	0
Lignite briquettes	TJ/kt	10.2	6	2	1	0
Absolute energy consumption						
Natural gas	TJ	720	520	450	300	150
Heavy fuel oil	TJ	324	105	90	60	30
Hard-coal coke		3,645	760	690	680	340
Dust / dry coal	TJ	365	0	0	0	0
Lignite briquettes	TJ	1,102	210	60	20	0
Total	**TJ**	**6,156**	**1,600**	**1,290**	**1,060**	**520**

* Source: Own calculations

Application of the calculation procedure to all structural elements causes the elements to be taken into account in the years following 1990, in keeping with their relative proportions in the now-improved 1990 database. At the same time, proportional allocation/offsetting was not applied in those cases in which it was possible to obtain primary data from reliable sources.

Uncertainties were determined qualitatively.

19.1.2   Energy Industries (1.A.1)

19.1.2.1   Methodological issues in determination of emission factors (Kapitel 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 18.7).

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 equipment-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 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) is 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 were aggregated to form source-category-specific factors. Finally, factors for Germany as a whole were 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 2000 and 2010

    For description of continuing technological development, technology-specific emission factors are again determined. 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 will be 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 41 below.

Technology 1	Technology 2	Technology 3	Technology n

Step 1   **Analysis of emissions behaviour**

EF T1	EF T2	EF T3	EF Tn

Step 2   **Analysis of emitter structure**

Old German Länder

Sector 1	Sector m
a% EF T1 **b% EF T2** **...** **v% EF Tn**	**c% EF T1** **d% EF T3** **...** **w% EF Tn**

New German Länder

Sector 1	Sector m
e% EF T2 **f% EF T3** **...** **x% EF Tn**	**g% EF T3** **h% EF T5** **...** **y% EF Tn**

Step 3   **Aggregation of emission factors**

EF Sector 1	EF Sector 2	EF Sector n

Federal Republic of Germany

Figure 41:   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 part of the data comes from emissions declarations of the Länder Baden-Württemberg, Brandenburg, North Rhine – Westfalia and Thuringia for 1996. The annual pollutant loads listed therein are based, depending on the pollutant concerned, on measurements from continuous monitoring, on individual measurements or on calculation on the basis of 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 pollutants 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 %[84]. 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 facilities, evaluation and derivation of emission factors is carried out, using the sample data from Baden-Württemberg and with classification by "measurements" and "assumptions".

Table 220 provides an overview of the installation types in question and lists the relevant numbers under the 4th BimSchV and the relevant type of declaration required.

Table 220:   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 (plants)	≥ 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	1 - < 50 MW solid and liquid fuels (except for heating oil EL)	V
1 02B 2	Combustion systems	5 - < 50 MW heating oil EL	K
1 02C 2	Combustion systems	10 - < 50 MW for natural gas	K
	Combustion systems	10 - < 50 MW except for natural gas	V
1 03 1	Combustion systems	> 1 MW, other fuels	V
Index	Gas turbine systems		Type of declaration required
1 05 1	Gas turbines	≥ 50 MW for natural gas	K
	Gas turbines	≥ 50 MW, except for natural gas	V
1 05 2	Gas turbines	< 50 MW for natural gas	K
	Gas turbines	< 50 MW, except for natural gas	V

In the analyses, emissions data is differentiated by combustion technologies. Table 221 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.

---

[84] 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. This value is termed a *quantile*: or, where percentage shares are used, as a *percentile*:). The best-known percentile that separates the lower half of all values from the upper half is the 50% percentile, the so-called *median*. The 25 and 75% 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 221:   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 222 summarises the emission factors shown in Tables 3, 4 and 5 of Annex E of the research project RENTZ et al (2002):

Table 222:   Methane emission factors for combustion systems < 50 MW thermal output and for gas turbines, pursuant to RENTZ et al, 2002

Facility type	**Fuel**	**Länder**	**CH_4 EF [kg/TJ]**
Combustion systems < 50 MW thermal output	Hard coal	ABL	3.4
		NBL	3.3
	Hard-coal coke	ABL/NBL	19
	Lignite	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 convert 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. In terms of installed output, some 87 % of all power stations in Germany 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):

$$CaCO_3 + SO_2 + 1/2O_2 + 2H_2O ==> CaSO_4.2H_2O + CO_2$$
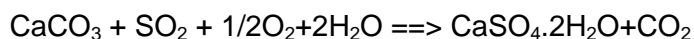
This equation can be used to derive the limestone/plaster molar mass ratio. Such derivation shows that 581.39 kilograms of limestone are used per produced tonne of plaster. Plaster-production figures thus can be used to obtain the theoretically maximal limestone inputs for flue-gas desulphurisation in 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. The results take account of figures for plaster production in all years between 1990 and 2006. To calculate plaster production for the years 2007 and 2008, we have used the 2006 plaster-production figure as a preliminary input figure.

Table 223: CO_2 emissions from flue-gas desulphurisation in public power stations

in Gg	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 from flue-gas desulphurisation in public power stations	618	652	629	662	616	683	867	878	1,005	966
in Gg	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
CO_2 from flue-gas desulphurisation in public power stations	1,135	1,069	1,094	1,156	1,162	1,142	1,076	1,073	1,069	

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 classified as 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)**

19.1.3.2   **Derivation of activity rates for road transport (1.A.3.b)**

19.1.3.2.1   *Cross-checking 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 224 below.

Table 224:   Energy inputs in road transports, 1990-2008

Year	Area of application	Energy Balance Line	Petrol	Diesel fuel	Biofuels	LP gas	Natural gas	Petroleum
Energy inputs pursuant to Energy Balances 1990-2006 (last revision: 10/2009), in TJ
1990	ABL	75	1,159,942	657,443	0	138	0	0
1990	NBL	75	170,537	78,477	0	0	0	0
1991	ABL	75	1,156,589	700,405	0	137	0	0
1991	NBL	75	175,696	84,769	0	0	0	0
1992	ABL	75	1,157,939	740,248	0	229	0	0
1992	NBL	75	186,190	113,254	0	0	0	0
1993	ABL	75	1,158,636	777,146	0	184	0	473
1993	NBL	75	191,981	130,641	0	0	0	0
1994	ABL	75	1,082,653	787,800	0	184	0	559
1994	NBL	75	193,984	144,260	0	0	0	0
1995	D	62	1,299,982	964,013	1,504	138	0	610
1996	D	62	1,299,879	964,580	2,046	115	0	638
1997	D	62	1,297,487	979,586	3,652	106	0	357
1998	D	62	1,300,463	1,022,794	4,081	106	0	637
1999	D	62	1,300,602	1,097,036	5,370	100	0	637
2000	D	62	1,237,055	1,108,105	12,276	94	0	414
2001	D	62	1,199,318	1,097,416	16,740	98	0	471
2002	D	62	1,166,381	1,105,842	20,460	607	0	472
2003	D	62	1,108,989	1,078,352	30,132	694	0	0
2004	D	62	1,072,720	1,110,931	38,370	1,887	0	0
2005	D	62	992,377	1,077,173	78,609	2,357	2,843	0
2006	D	62	930,834	1,081,161	143,554	4,605	5,211	0
Provisional figures pursuant to "Mineralölzahlen 2008" (fossil; "2008 Mineral-Oil Statistics") and Amtliche Mineralöldaten 12/2008 (bio; "Official Mineral-Oil Data 12/2008")
2007	D	62	891,642	1,078,596	155,588	8,942	4,089	0
2008	D	62	852,812	1,108,199	126,170	16,211	5,000	0

Sources: Evaluation tables of the Energy Balances, "Mineralöl-Zahlen 2008" ("Mineral-Oil Statistics 2008") of the Association of the German Petroleum Industry (MWV) (MWV, 2009) and Amtliche Mineralöldaten ("Official Mineral-Oil Data"). [ABL = old German Länder; NBL = new German Länder]

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 average 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 of the Working Group on Energy Balances (AGEB) are used (cf. Table 225).

Table 225:   Net calorific values for petrol and diesel fuel

Year	Petrol	Diesel fuel
1990-1992	43.543 MJ/kg	42.704 MJ/kg
ab 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 226 below summarises the correction factors used.

Table 226:   Correction factors for adjustment to the Energy Balance

Year	Country	Petrol (including bioethanol)	Diesel fuel (including biodiesel)	
		Automobiles, light duty vehicles, motorcycles	Automobiles, light duty vehicles	Heavy duty vehicles, busse
1990	ABL	1.016	1.016	1.147
1990	NBL	1.024	1.024	1.588
1991	ABL	1.017	1.017	1.102
1991	NBL	1.036	1.036	1.097
1992	ABL	1.025	1.025	1.176
1992	NBL	0.989	0.989	1.253
1993	ABL	1.029	1.029	1.282
1993	NBL	0.974	0.974	1.186
1994	ABL	0.971	0.971	1.177
1994	NBL	0.971	0.971	1.177
1995	D	0.984	0.984	1.200
1996	D	0.988	0.988	1.179
1997	D	0.990	0.990	1.179
1998	D	0.988	0.988	1.242
1999	D	0.996	0.996	1.303
2000	D	0.971	0.971	1.333
2001	D	0.961	0.961	1.233
2002	D	0.959	0.959	1.190
2003	D	0.950	0.950	1.126
2004	D	0.960	0.960	1.067
2005	D	0.951	0.951	1.052
2006	D	0.932	0.932	1.084
2007	D	0.925	0.925	1.027
2008	D	0.934	0.934	1.003

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 and liquid 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 this 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 225) 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 resulting from emissions, in tonnes per structural element, divided 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

For all structural elements, the emission factors for biodiesel and petroleum are set at the same values as those for conventional diesel fuel. The emission factors for bioethanol are set at 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.

The emission factors for automobiles that run on LP gas are set as follows, in keeping with the Federal Environment Agency's specifications:

Table 227:   Emission factors for automobiles that run on LP gas

Gas	Vehicle	Structural element	EB line	Units	1995-2007
CH_4	Automobile	SV PKWO KOIO	EBZ 62	kg/TJ	3
CO	Automobile	SV PKWO KOIO	EBZ 62	kg/TJ	350
CO_2	Automobile	SV PKWO KOIO	EBZ 62	kg/TJ	65,000.00
N_2O	Automobile	SV PKWO KOIO	EBZ 62	kg/TJ	1.7
NH_3	Automobile	SV PKWO KOIO	EBZ 62	kg/TJ	0.5
NMVOC	Automobile	SV PKWO KOIO	EBZ 62	kg/TJ	157
NO_X	Automobile	SV PKWO KOIO	EBZ 62	kg/TJ	975
SO_2	Automobile	SV PKWO KOIO	EBZ 62	kg/TJ	1.7

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, 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, the present study can carry out a relevant breakdown only under the following assumptions:
  - o 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.
  - o 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 condition is not fulfilled, however: 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).

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 fresh 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 *chemical-thermal-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 18.

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 Comparison of IPCC Guidelines 2006 with IPCC Guidelines 1996b

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 justification applies to the use of the methods for methane emissions in the areas of enteric fermentation (4.A) and manure management (4.B), and to use of the methods for nitrous oxide emissions from manure management (4.B) and agricultural soils (4.D). In the area of agricultural soils (4.D) – except for the areas of emissions from organic soils and indirect emissions from leaching and surface run-off – the methods from IPCC 1996b are applied, however. For each sub-category, detailed reasons are provided why the selected method is used, along with descriptions of the relevant impacts on total emissions in comparison to use of the prescribed IPCC 1996b method.

The chapter information in the tables' second columns refer not to the present NIR 2010 but to the relevant chapters in HAENEL et. al., 2010).

_____

In accordance with the German Federal Environment Agency, the recommendations made by the ERT in their statement dd 5 September 2009 will be incorporated into the 2010 submission of agricultural emissions.

The following chapter responds in detail to the recommendations made by the ERT.

Choice of methodology and description of methods used in agriculture

In general, Germany follows the recommendation of GPG, pg. 7.18, to use the scientific knowledge available at the time of the construction of the inventory (*New methods become available*). The method itself is documented in the Methods and Data used in the documentation.

The ERT request that Germany provide a detailed methodological description by IPCC category and gas for its agricultural inventory where Germany does not use the parameters provided in the IPCC 1996 guidance documents.

This is made in the following table. It differentiates between

- CH_4 emissions from enteric fermentation (Table 228),
- CH_4 emissions from manure management (Table 229),
- N_2O emissions from manure management (Table 230) and
- N_2O emissions from soils (Table 231 and Table 232

For each of the gases and sources, the categories and subcategories are treated separately as shown in Column 1 of the table.

Column 2 provides the link to the Methods and Data chapter provided in the documentation.

The reason why Germany chooses to use the IPCC 2006 methodology is provided together with a statement in which way this affects the overall emissions of the respective trace gas.

In the right column, the parameter that was used in the 2010 submission is given for the reporting years 1990 and 2008 (as there may be a time course in them), and relates them to the respective IPCC 1996 proposal.

Table 228:　　　Methane emissions from enteric fermentation

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter
dairy cows	4.3.3	A very detailed approach is used to assess feed intake, energy and nutrient intake, CH_4 from enteric fermentation as well as VS and N excretion rates based on as much national information as possible. **The national IEF exceeds the IPCC 1996 default value.**	methane IEF 1990:　98.3　kg place^{-1} a^{-1} 2008:　113.8　kg place^{-1} a^{-1} IPCC 1996:　100　kg place^{-1} a^{-1}
other cattle	calfes: 4.4.4 heifers: 4.5.4 bulls: 4.6.4 suckler cows: 4.7.4 mature males: 4.8.4	A Tier 2 approach is used, differentiating between calves, heifers, bulls (beef), suckler cows and mature males. Energy requirements are calculated using national data. Feed properties vary with time and region. Constants are taken from IPCC 2006 as they are updated (see reasoning in IPCC 2006, pg. 10.30). The methane conversion rate for all other cattle apart from calves is 6.5 % and thus exceeds the one proposed in IPCC 1996. As calves are not ruminating, a value of 2 % is used (national expertise). **The mean methane conversion factor proposed in IPCC 2006 exceeds that from IPCC 1996.**	mean methane conversion factor 1990:　6.16　% 2008:　6.14　% IPCC 1996:　6.0　%
pigs	sows: 5.3.4 weaners: 5.4.4 fatteners: 5.5.4 boars: 5.6.4	A very detailed approach is used, differentiating between sows, weaners, fatteners and boars. It assesses feed intake, energy and nutrient intake, CH_4 from enteric fermentation as well as VS and N excretion rates based on as much national information as possible. IPCC 2006 fails to give a methane conversion rate. This is felt to be inadequate. The IPCC 1996 approach is used instead. **Hence, the method applied will lead to increased methane emissions as compared to IPCC 2006.**	methane conversion factor 1990:　0.6　% 2008:　0.6　% IPCC 1996:　0.6　%
sheep	6.2.2	The Tier 1 approach uses default emission factors. **Default emission factors in IPCC 1996 equal those in IPCC 2006.**	default emission factor 1990:　8　kg place^{-1} a^{-1} 2008:　8　kg place^{-1} a^{-1} IPCC 1996:　8　kg place^{-1} a^{-1}
goats	6.6.2	The Tier 1 approach uses default emission factors. **Default emission factors in IPCC 1996 equal those in IPCC 2006.**	default emission factor 1990:　5　kg place^{-1} a^{-1} 2008:　5　kg place^{-1} a^{-1} IPCC 1996:　5　kg place^{-1} a^{-1}
horses	horses: 7.2.1.2, 7.3.1.2	The definition of horses given in IPCC 1996 and 2006 applies to heavy horses (size, weight, energy requirements). The German inventory differentiates light horses and ponies with respect to their different properties. In order to derive emission factors the ratio between GE intakes and emission factors is assumed to be constant (see documentation).	
horses	heavy horses: 7.2.2	**The default emission factors for heavy horses in IPCC 1996 equal those in IPCC 2006.**	default emission factor 1990:　18　kg place^{-1} a^{-1} 2008:　18　kg place^{-1} a^{-1} IPCC 1996:　18　kg place^{-1} a^{-1}
horses	ponies: 7.3.2	**IPCC 1996 and 2006 fail to provide an adequate default emission factor for light horses and ponies.**	default emission factor 1990:　12　kg place^{-1} a^{-1} 2008:　12　kg place^{-1} a^{-1} IPCC 1996:　NO
mules and asses	7.5.2	The Tier 1 approach uses default emission factors. **Default emission factors in IPCC 1996 equal those in IPCC 2006.**	default emission factor 1990:　10　kg place^{-1} a^{-1} 2008:　10　kg place^{-1} a^{-1} IPCC 1996:　10　kg place^{-1} a^{-1}
buffalo	8.2.2	The Tier 1 approach uses default emission factors. **Default emission factors in IPCC 1996 equal those in IPCC 2006.**	default emission factor 1990:　55　kg place^{-1} a^{-1} 2008:　55　kg place^{-1} a^{-1} IPCC 1996:　55　kg place^{-1} a^{-1}

Table 229:   Methane emissions from manure management

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter
dairy cows	4.3.6	A very detailed approach is used to assess feed intake, energy and nutrient intake, CH_4 from enteric fermentation as well as VS and N excretion rates based on as much national information as possible. The German inventory differentiates between regional feeds, temperatures as well as housing and storage systems. In a mass flow approach it is important to differentiate between the various housing and storage systems, as these have an effect on both CH_4 and N_2O emission factors. IPCC 2006 allows for a better description of emissions from storage for both gases. If IPCC 2006 is used, the mass flow can be calculated consistent with the NH_3 emissions. In addition, IPCC 2006 provides temperature dependent methane conversion factors, whereas IPCC 1996 differentiates between temperature regimes only. **The maximum methane producing capacity provided by IPCC 2006 equals that of IPCC 1996.** **The methane conversion factor for solid storage given by IPCC 2006 exceeds that of IPCC 1996.** **The MCF for pasture equals that of IPCC 1996.**	maximum methane producing capacity 1990: 0.24 m^3 kg^{-1} CH_4 2008: 0.24 m^3 kg^{-1} CH_4 IPCC 1996: 0.24 m^3 kg^{-1} CH_4 mean methane conversion factor for slurry 1990: 0.139 kg kg^{-1} CH_4 2008: 0.134 kg kg^{-1} CH_4 IPCC 1996: 0.10 kg kg^{-1} CH_4 methane conversion factor for solid storage 1990: 0.02 kg kg^{-1} CH_4 2008: 0.02 kg kg^{-1} CH_4 IPCC 1996: 0.01 kg kg^{-1} CH_4 methane conversion factor for pasture 1990: 0.01 kg kg^{-1} CH_4 2008: 0.01 kg kg^{-1} CH_4 IPCC 1996: 0.01 kg kg^{-1} CH_4
other cattle	calfes: 4.4.5 heifers: 4.5.5 bulls: 4.6.5 suckler cows: 4.7.5 mature males: 4.8.5	A Tier 2 approach is used, differentiating between calves, heifers, bulls (beef), suckler cows and mature males. The German inventory differentiates between regional feeds, temperatures as well as housing and storage systems. Energy and nutrient requirements are calculated using national data. Feed properties vary with time and region. The methodology used allows to derive VS and N excretion rates. In a mass flow approach it is important to differentiate between the various housing and storage systems, as these have an effect on both CH_4 and N_2O emission factors. IPCC 2006 allows for a better description of emissions from storage for both gases. If IPCC 2006 is used, the mass flow can be calculated consistent with the NH_3 emissions. In addition, IPCC 2006 provides temperature dependent methane conversion factors, whereas IPCC 1996 differentiates between temperature regimes only. Constants are taken from IPCC 2006 as they are updated (see reasoning in IPCC 2006, pg. 10.30). **The maximum methane producing capacity provided by IPCC 2006 equals that of IPCC 1996.** **The methane conversion factor for solid storage given by IPCC 2006 exceeds that of IPCC 1996.** **The MCF for pasture equals that of IPCC 1996**	maximum methane producing capacity 1990: 0.18 m^3 kg^{-1} CH_4 2008: 0.18 m^3 kg^{-1} CH_4 IPCC 1996: 0.17 m^3 kg^{-1} CH_4 mean methane conversion factor for slurry 1990: 0.138 kg kg^{-1} CH_4 2008: 0.133 kg kg^{-1} CH_4 IPCC 1996: 0.10 kg kg^{-1} CH_4 methane conversion factor for solid storage 1990: 0.02 kg kg^{-1} CH_4 2008: 0.02 kg kg^{-1} CH_4 IPCC 1996: 0.01 kg kg^{-1} CH_4 methane conversion factor for pasture 1990: 0.01 kg kg^{-1} CH_4 2008: 0.01 kg kg^{-1} CH_4 IPCC 1996: 0.01 kg kg^{-1} CH_4

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter
pigs	sows: 5.3.5 weaners: 5.4.5 fatteners: 5.5.5 boars: 5.6.5	A very detailed approach is used, differentiating between sows, weaners, fatteners and boars. It assesses feed intake, energy and nutrient intake, VS and N excretion rates based on as much national information as possible. In a mass flow approach it is important to differentiate between the various housing and storage system, as these have an effect on both CH_4 and N_2O emission factors. IPCC 2006 allows for a better description of emissions from storage for both gases. If IPCC 2006 is used, the mass flow can be calculated consistent with the NH_3 emissions. IPCC 2006 provides temperature dependent methane conversion factors, whereas IPCC 1996 differentiates between temperature regimes. **The maximum methane producing capacity provided by IPCC 2006 equals that of IPCC 1996.** **The methane conversion factors for slurry and solid storage given in IPCC 2006 exceed that of IPCC 1996.**	maximum methane producing capacity 1990: 0.45 $m^3\,kg^{-1}\,CH_4$ 2008: 0.45 $m^3\,kg^{-1}\,CH_4$ IPCC 1996: 0.45 $m^3\,kg^{-1}\,CH_4$ mean methane conversion factor for slurry 1990: 0.170 $kg\,kg^{-1}\,CH_4$ 2008: 0.164 $kg\,kg^{-1}\,CH_4$ IPCC 1996: 0.10 $kg\,kg^{-1}\,CH_4$ methane conversion factor for solid storage 1990: 0.02 $kg\,kg^{-1}\,CH_4$ 2008: 0.02 $kg\,kg^{-1}\,CH_4$ IPCC 1996: 0.01 $kg\,kg^{-1}\,CH_4$
sheep	6.2.3	Default VS excretion rates in IPCC 2006 were combined with national manure management frequency distributions. **The IPCC 2006 default VS excretion rate equals that of IPCC 1996.** **The maximum methane producing capacity provided by IPCC 2006 equals that of IPCC 1996.** **The methane conversion factor for solid storage given in IPCC 2006 exceeds that of IPCC 1996, the MCF for pasture equals that of IPCC 1996.**	maximum methane producing capacity 1990: 0.19 $m^3\,kg^{-1}\,CH_4$ 2008: 0.19 $m^3\,kg^{-1}\,CH_4$ IPCC 1996: 0.19 $m^3\,kg^{-1}\,CH_4$ methane conversion factor for solid storage 1990: 0.02 $kg\,kg^{-1}\,CH_4$ 2008: 0.02 $kg\,kg^{-1}\,CH_4$ IPCC 1996: 0.01 $kg\,kg^{-1}\,CH_4$ methane conversion factor for pasture 1990: 0.01 $kg\,kg^{-1}\,CH_4$ 2008: 0.01 $kg\,kg^{-1}\,CH_4$ IPCC 1996: 0.01 $kg\,kg^{-1}\,CH_4$
goats	6.6.3	IPCC 2006, Table 10.15, gives a default emission factor of 0.13 kg place-1 a-1 CH_4, which reflects all-year-round grazing as can be recalculated from the data set provided in Table 10A-9. Doing so, one realizes that the IPCC 1996 default emission factor is incorrect (0.12 kg place-1 a-1). Germany makes use of the default VS excretion rate and default B_o listed in Table 10A-9 and combines them with German manure management system frequency distributions. **The default emission factors provided in IPCC 2006 exceeds that given in IPCC 1996.** **The German emission factor exceeds that of IPCC 2006.**	implied emission factor 1990: 0.22 $kg\,place^{-1}\,a^{-1}$ 2008: 0.22 $kg\,place^{-1}\,a^{-1}$ IPCC 1996: 0.12 $kg\,place^{-1}\,a^{-1}$

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter
horses	heavy horses: 7.2.3 ponies: 7.3.3	For the subdivision of horses in subcategories see above (enteric fermentation). A Tier 2 approach is used linking emissions to VS excretion rates. Solid manure is treated in the same way as for other herbivores. **The maximum methane producing capacity provided by IPCC 2006 falls slightly below that of IPCC 1996.** **The methane conversion factor for solid storage given in IPCC 2006 exceeds that of IPCC 1996, the MCF for pasture equals that of IPCC 1996.** **The resulting CH_4 emission exceeds that obtained from the application of IPCC 1996 parameters.**	maximum methane producing capacity 1990: 0.3 $m^3 kg^{-1} CH_4$ 2008: 0.3 $m^3 kg^{-1} CH_4$ IPCC 1996: 0.33 $m^3 kg^{-1} CH_4$ methane conversion factor for solid storage 1990: 0.02 $kg kg^{-1} CH_4$ 2008: 0.02 $kg kg^{-1} CH_4$ IPCC 1996: 0.01 $kg kg^{-1} CH_4$ methane conversion factor for pasture 1990: 0.01 $kg kg^{-1} CH_4$ 2008: 0.01 $kg kg^{-1} CH_4$ IPCC 1996: 0.01 $kg kg^{-1} CH_4$
mules and asses	7.5.3	IPCC 2006, Table 10.15, gives a default emission factor of 0.76 kg place-1 a-1 CH_4, which reflects all-year-round grazing as can be recalculated from the data set provided in Table 10A-9. Germany makes use of the default VS excretion rate and default B_o listed in Table 10A-9 and combines them with German manure management system frequency distributions for horses. **The default emission factors provided in IPCC 2006 exceeds that given in IPCC 1996.** **The German emission factor exceeds that of IPCC 2006.**	implied emission factor 1990: 1.36 $kg place^{-1} a^{-1}$ 2008: 1.36 $kg place^{-1} a^{-1}$ IPCC 1996: 0.76 $kg place^{-1} a^{-1}$
buffalo	8.2.3	A Tier 2 approach is used. 100 % of slurry stored produce natural crust. **The maximum methane producing capacity provided by IPCC 2006 exceeds that of IPCC 1996.** **The methane conversion factor for slurry equals that given in IPCC 1996.** **The methane conversion factor for solid storage given in IPCC 2006 exceeds that of IPCC 1996.** **The MCF for pasture equals that of IPCC 1996.**	maximum methane producing capacity 1990: 0.17 $m^3 kg^{-1} CH_4$ 2008: 0.17 $m^3 kg^{-1} CH_4$ IPCC 1996: 0.10 $m^3 kg^{-1} CH_4$ methane conversion factor for slurry 1990: 0.10 $kg kg^{-1} CH_4$ 2008: 0.10 $kg kg^{-1} CH_4$ IPCC 1996: 0.10 $kg kg^{-1} CH_4$ methane conversion factor for solid storage 1990: 0.02 $kg kg^{-1} CH_4$ 2008: 0.02 $kg kg^{-1} CH_4$ IPCC 1996: 0.01 $kg kg^{-1} CH_4$ methane conversion factor for pasture 1990: 0.01 $kg kg^{-1} CH_4$ 2008: 0.01 $kg kg^{-1} CH_4$ IPCC 1996: 0.01 $kg kg^{-1} CH_4$

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter
laying hens	9.3.6	A very detailed methodology is used to derive VS and N excretion rates as a function of time. In a mass flow approach it is important to differentiate between the various housing and storage system, as these have an effect on both CH_4 and N_2O emission factors. IPCC 2006 allows for a better description of emissions from storage for both gases. If IPCC 2006 is used, the mass flow can be calculated consistent with the NH_3 emissions. IPCC 1996 does not differentiate between various species among poultry. IPCC 2006 provides temperature dependent methane conversion factors, whereas IPCC 1996 differentiates between temperature regimes only. **The maximum methane producing capacity provided by IPCC 2006 exceeds that of IPCC 1996.** **The methane conversion factors solid storage given in IPCC 2006 exceeds that of IPCC 1996.**	maximum methane producing capacity 1990: 0.39 m^3 kg^{-1} CH_4 2008: 0.39 m^3 kg^{-1} CH_4 IPCC 1996: 0.32 m^3 kg^{-1} CH_4 methane conversion factor for solid storage 1990: 0.015 kg kg^{-1} CH_4 2008: 0.015 kg kg^{-1} CH_4 IPCC 1996: 0.01 kg kg^{-1} CH_4
broilers	9.4.6	A very detailed methodology is used to derive VS and N excretion rates as a function of time. In a mass flow approach it is important to differentiate between the various housing and storage system, as these have an effect on both CH_4 and N_2O emission factors. IPCC 2006 allows for a better description of emissions from storage for both gases. If IPCC 2006 is used, the mass flow can be calculated consistent with the NH_3 emissions. IPCC 1996 does not differentiate between various species among poultry. IPCC 2006 provides temperature dependent methane conversion factors, whereas IPCC 1996 differentiates between temperature regimes only. **The maximum methane producing capacity provided by IPCC 2006 exceeds that of IPCC 1996.** **The methane conversion factors solid storage given in IPCC 2006 exceeds that of IPCC 1996.**	maximum methane producing capacity 1990: 0.36 m^3 kg^{-1} CH_4 2008: 0.36 m^3 kg^{-1} CH_4 IPCC 1996: 0.32 m^3 kg^{-1} CH_4 methane conversion factor for solid storage 1990: 0.015 kg kg^{-1} CH_4 2008: 0.015 kg kg^{-1} CH_4 IPCC 1996: 0.01 kg kg^{-1} CH_4
pullets	9.5.6	A very detailed methodology is used to derive VS and N excretion rates as a function of time. In a mass flow approach it is important to differentiate between the various housing and storage system, as these have an effect on both CH_4 and N_2O emission factors. IPCC 2006 allows for a better description of emissions from storage for both gases. If IPCC 2006 is used, the mass flow can be calculated consistent with the NH_3 emissions. IPCC 1996 does not differentiate between various species among poultry. IPCC 2006 provides temperature dependent methane conversion factors, whereas IPCC 1996 differentiates between temperature regimes only. IPCC 2006 does not mention pullets explicitly. The data for laying hens are used accordingly. IPCC 1996 does not differentiate between categories of poultry. Hence, the calculation makes use of the parameters provided for laying hens in IPCC 2006. **The maximum methane producing capacity provided by IPCC 2006 exceeds that of IPCC 1996.** **The methane conversion factors solid storage given in IPCC 2006 exceeds that of IPCC 1996.**	maximum methane producing capacity 1990: 0.39 m3 kg^{-1} CH_4 2008: 0.39 m3 kg^{-1} CH_4 IPCC 1996: 0.32 m3 kg^{-1} CH_4 methane conversion factor for solid storage 1990: 0.015 kg kg^{-1} CH_4 2008: 0.015 kg kg^{-1} CH_4 IPCC 1996: 0.01 kg kg^{-1} CH_4
geese	10.3.4	IPCC 2006 does not mention geese explicitly. IPCC 1996 does not differentiate between categories of poultry. **The default emission factor provided for poultry in IPCC 1996 is used.**	default emission factor 1990: 0.078 kg $place^{-1}$ a^{-1} 2008: 0.078 kg $place^{-1}$ a^{-1} IPCC 1996: 0.078 kg $place^{-1}$ a^{-1}
ducks	10.4.6	National VS excretion rates are used in connection with IPCC 2006 values for maximum methane producing capacities and methane conversion factors for solid storage. IPCC 2006, Table 10A-9, lists an MCF of 0.01 kg kg-1 CH_4. The use of this MCF is considered inconsistent in comparison with other poultry keeping in mind that it is almost impossible to keep a duck house "dry". Thus, the German inventory uses an MCF of 0.015 kg kg-1 CH_4 as given for other poultry species. IPCC 1996 does not differentiate between categories of poultry. **The maximum methane producing capacity provided by IPCC 2006 exceeds that of IPCC 1996.** **The methane conversion factors solid storage given in IPCC 2006 exceeds that of IPCC 1996.**	maximum methane producing capacity 1990: 0.36 m^3 kg^{-1} CH_4 2008: 0.36 m^3 kg^{-1} CH_4 IPCC 1996: 0.32 m^3 kg^{-1} CH_4 methane conversion factor for solid storage 1990: 0.015 kg kg^{-1} CH_4 2008: 0.015 kg kg^{-1} CH_4 IPCC 1996: 0.01 kg kg^{-1} CH_4

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter
turkeys		National VS excretion rates are used in connection with IPCC 2006 values for maximum methane producing capacities and methane conversion factors for solid storage. IPCC 1996 does not differentiate between categories of poultry. **The maximum methane producing capacity provided by IPCC 2006 exceeds that of IPCC 1996.** **The methane conversion factors solid storage given in IPCC 2006 exceeds that of IPCC 1996.**	maximum methane producing capacity 1990: 0.36 $m^3\ kg^{-1}\ CH_4$ 2008: 0.36 $m^3\ kg^{-1}\ CH_4$ IPCC 1996: 0.32 $m^3\ kg^{-1}\ CH_4$ methane conversion factor for solid storage 1990: 0.015 $kg\ kg^{-1}\ CH_4$ 2008: 0.015 $kg\ kg^{-1}\ CH_4$ IPCC 1996: 0.01 $kg\ kg^{-1}\ CH_4$

Table 230:   Nitrous oxide emissions from manure management

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter
dairy cows **other cattle** **pigs** **sheep** **goats** **horses** **mules and asses** **buffalo**		In most cases, a detailed methodology is used to derive VS and N excretion rates. In the mass flow approach used in any case it is important to differentiate between the various housing and storage systems, as these have an effect on CH_4, NMVOC, NH_3, N_2, NO and N_2O emissions. The application of both NH_3 and N_2O emission factors designed for non-mass flow calculations and based on the knowledge available in 1996 to a mass flow system reveals that emissions exceed the size of the TAN pools. When the mass flow methodology was established, partial emission factors for all species reflecting the state of knowledge were compiled. For N_2O, IPCC 2006 partial emission factors were taken into account, as they can be assigned to the storage systems used in Germany (see also Amon et al., 2001). For cattle, these emission factors allow for a differentiation between slurry stored with and without a natural crust cover in particular. The mean N_2O emission factor is strongly depending on the emission factor chosen for solid storage. Here, the IPCC 1996 factor unduly extrapolates from the dry lot storage systems (0.02 kg kg^{-1} N_2O) to straw based systems used in Germany, see comment in IPCC 2006, Table 10.21 ("Judgement of IPCC Expert Group in combination with Amon et al. (2001), which shows emissions ranging from 0.0027 to 0.01 kg N_2O-N $(kg N)^{-1}$.") To illustrate the effect of the differentiation in slurry storage with and without a natural crust and a high or low emission factor for solid storage, exemplary calculations were performed for dairy cows (see column on the right hand side). Note that IPCC 2006 EFs consider N_2O-N, whereas IPCC 1996 EFs describe N_2O. These exemplary calculations performed for dairy cows and pigs are to illustrate the dependency of an implied N2O emission factor using the 2006 and 1996 methodologies. For cattle, calculations were made using a share of 50 % of natural crusts, reflecting the average situation in Germany. For pigs, almost 100 % of all pig slurry stores in Germany do not produce a natural crust. Application of the corrected IPCC 1996 methodology (using EFsolid = 0.005 kg kg^{-1} N_2O-N) yields lower N_2O emissions than the German methodology.	dairy cows: mean N2O emission factor using IPCC 2006 1990: 0.0049 kg kg^{-1} N2O 2008: 0.0045 kg kg^{-1} N2O dairy cows: mean N2O emission factor using IPCC 1996 with EFsolid = 0.005 kg kg^{-1} 1990: 0.0020 kg kg^{-1} N_2O 2008: 0.0016 kg kg^{-1} N_2O pigs: mean N_2O emission factor using IPCC 2006 1990: 0.0028 kg kg^{-1} N_2O 2008: 0.0024 kg kg^{-1} N_2O pigs: mean N2O emission factor using IPCC 1996 with EFsolid = 0.005 kg kg^{-1} 1990: 0.0016 kg kg^{-1} N_2O 2008: 0.0015 kg kg^{-1} N_2O
poultry		In most cases, a detailed methodology is used to derive VS and N excretion rates. In any case, in a mass flow approach it is important to differentiate between the various housing and storage system, as these have an effect on CH_4, NMVOC, NH_3, N2, NO and N_2O emissions. When the methodology was established, partial emission factors for all species reflecting the state of knowledge were compiled. In contrast to IPCC 2006, IPCC 1996 does not provide partial emission factors reflecting poultry housing systems in general. For N_2O, IPCC 2006 partial emission factors were taken into account, as they can be assigned to the storage systems used in Germany. The resulting N_2O emission factors as obtained by use of IPCC 2006 fall below that of IPCC 1996.	poultry manure with litter 1990: 0.0015 kg kg^{-1} N_2O 2008: 0.0015 kg kg^{-1} N_2O IPCC 1996: 0.02 kg kg^{-1} N_2O

Table 231:   Nitrous oxide: direct soil emissions

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter
mineral fertilizer	11.1.2.3	The IPCC 1996 emission factor (EF1 = 0.0125 kg kg^{-1} N$_2$O-N) represents the poor knowledge available at the time. The emission factor derived for IPCC 2006 (EF1 = 0.01 kg kg^{-1} N$_2$O-N) includes the knowledge gained since then (see date of publications listed in IPCC 2006, Table 11.1, and footnote 8). The submissions of the previous years used the EF1 recommended in IPCC 2006. In order to avoid confusion, the 2010 and subsequent submissions use the IPCC 1996 emission factor until further notice.	EF1 in submission 2010 1990: 0.0125 kg kg^{-1} N$_2$O-N 2008: 0.0125 kg kg^{-1} N$_2$O-N IPCC 1996: 0.0125 kg kg^{-1} N$_2$O-N
animal manure	11.2.2.2	The IPCC 1996 emission factor (EF1 = 0.0125 kg kg^{-1} N$_2$O-N) represents the poor knowledge available at the time. The emission factor derived for IPCC 2006 (EF1 = 0.01 kg kg^{-1} N$_2$O-N) includes the knowledge gained since then (see date of publications listed in IPCC 2006, Table 11.1, and footnote 8). The submissions of the previous years used the EF1 recommended in IPCC 2006. In order to avoid confusion, the 2010 and subsequent submissions use the IPCC 1996 emission factor until further notice.	EF1 in submission 2010 1990: 0.0125 kg kg^{-1} N$_2$O-N 2008: 0.0125 kg kg^{-1} N$_2$O-N IPCC 1996: 0.0125 kg kg^{-1} N$_2$O-N
imported animal manure	11.2.1.2	Neither IPCC 1996 nor IPCC 2000 mention the treatment of animal manures not produced in the reporting country. However, complete reporting has to include this source. Imported animal manure is treated like manure produced in Germany. The submissions of the previous years used the EF1 recommended in IPCC 2006. In order to avoid confusion, the 2010 and subsequent submissions use the IPCC 1996 emission factor until further notice. This leads to increased emissions from animal manure.	Emissions in submission 2010 1994: 0.14 Gg a^{-1} N$_2$O 2008: 0.14 Gg a^{-1} N$_2$O IPCC 1996: 0.00 Gg a^{-1} N$_2$O
crop residues	12.3.2.2	The IPCC 1996 emission factor (EF1 = 0.0125 kg kg^{-1} N$_2$O-N) represents the poor knowledge available at the time. The emission factor derived for IPCC 2006 (EF1 = 0.01 kg kg^{-1} N$_2$O-N) includes the knowledge gained since then (see date of publications listed in IPCC 2006, Table 11.1, and footnote 8). The submissions of the previous years used the EF1 recommended in IPCC 2006. In order to avoid confusion, the 2010 and subsequent submissions use the IPCC 1996 emission factor until further notice.	EF1 in submission 2010 1990: 0.0125 kg kg^{-1} N$_2$O-N 2008: 0.0125 kg kg^{-1} N$_2$O-N IPCC 1996: 0.0125 kg kg^{-1} N$_2$O-N
N fixing crops	12.1.2.2	The IPCC 1996 emission factor (EF1 = 0.0125 kg kg^{-1} N$_2$O-N) represents the poor knowledge available at the time. However; IPCC 2006, footnote 2, explains that "biological nitrogen fixation has been removed as a direct source of N$_2$O because of the lack of evidence of significant emissions arising from the fixation process itself", which results in an EF 1, legumes = 0 kg kg^{-1} N$_2$O-N. The submissions of the previous years used the EF1 recommended in IPCC 2006. In order to avoid confusion, the 2010 and subsequent submissions use the IPCC 1996 emission factor until further notice.	EF1, legumes in submission 2010 1990: 0.0125 kg kg^{-1} N$_2$O-N 2008: 0.0125 kg kg^{-1} N$_2$O-N IPCC 1996: 0.0125 kg kg^{-1} N$_2$O-N
sewage sludge	11.3.2.2	IPCC 1996 recommends not to calculate emissions according to IPCC 1996, pg. 4.89 ("…except for sewage sludge application…. These sources … are not estimated because emissions are negligible or data are insufficient."). In IPCC 2000, the knowledge gained recommended to treat sewage sludge in the same way as mineral fertilizer and animal manure. The submissions of the previous years used the EF1 recommended in IPCC 2006 (0.01 kg kg^{-1} N$_2$O-N). In order to avoid confusion, the 2010 and subsequent submissions use the IPCC 1996 emission factor (0.0125 kg kg^{-1} N$_2$O-N) until further notice.	EF1 in submission 2010 1990: 0.0125 kg kg^{-1} N$_2$O-N 2008: 0.0125 kg kg^{-1} N$_2$O-N IPCC 1996: 0.0125 kg kg^{-1} N$_2$O-N
organic soils	11.4.2.2	IPCC 2000, Table 4.17, states that N$_2$O emissions from organic soils shall be related to the respective area using an emission factor EF2 = 8 kg ha^{-1} a^{-1} N$_2$O-N instead of EF2 = 5 kg ha^{-1} a^{-1} N$_2$O-N as proposed in IPCC 1996. The submissions of the previous years used the EF1 recommended also in IPCC 2006 (8 kg ha^{-1} a^{-1} N$_2$O-N), which is applied in the 2010 submission. The emission factor given in IPCC 2000 and 2006 exceeds that of IPCC 1996.	EF2 in submission 2010 1990: 8 kg ha^{-1} a^{-1} N$_2$O-N 2008: 8 kg ha^{-1} a^{-1} N$_2$O-N IPCC 1996: 5 kg ha^{-1} a^{-1} N$_2$O-N
grazing	12.2.2.2	IPCC 1996, Table B-1, provides one emission factor for all animal categories and grazing (EF3 = 0.02 kg kg^{-1} N$_2$O-N). IPCC 2006 allows for a differentiation between cattle, poultry an pigs (EF3, PRP, CPP = 0.02 kg kg^{-1} N$_2$O-N) and for sheep and other animals (EF3, PRP, SO = 0.01 kg kg^{-1} N$_2$O-N). In order to avoid confusion, the 2010 and subsequent submissions use the IPCC 1996 emission factor EF3 until further notice.	EF3 in submission 2010 1990: 0.02 kg kg^{-1} N$_2$O-N 2008: 0.02 kg kg^{-1} N$_2$O-N IPCC 1996: 0.02 kg kg^{-1} N$_2$O-N

Table 232:   Nitrous oxide: indirect soil emissions

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter		
deposition	12.4.2.2	Deposited N should be treated the same way as mineral fertilizer. The IPCC 1996 emission factor (EF4 = 0.01 kg kg-1 N_2O-N) is inconsistent in this respect (EF1 = 0.0125 kg kg^{-1} N_2O-N). However, the emission factor derived for IPCC 2006 (EF4 = 0.01 kg kg^{-1} N_2O-N) assumes equal emission factors. The submissions of the previous years and 2010 use the EF4 recommended in IPCC 1996 and 2006.	EF4 in submission 2010 1990: 2008: IPCC 1996:	0.01 0.01 0.01	kg kg^{-1} N_2O-N kg kg^{-1} N_2O-N kg kg^{-1} N_2O-N
leaching and run-off	12.5.2.2	The IPCC 1996 emission factor (EF5 = 0.025 kg kg^{-1} N_2O-N) represents the poor knowledge available at the time. The emission factor derived for IPCC 2006, Table 11.3 (EF5 = 0.0075 kg kg^{-1} N_2O-N) includes the knowledge gained since then. (see dates of publications listed in IPCC 2006, Table 11.3, and footnote 23). The new data set agrees with the German situation[85]. The submissions of the previous years and 2010 use the EF5 recommended in IPCC 2006. This results in reduced N_2O emissions as compared to results obtained from IPCC 1996.	EF5 in submission 2010 1990: 2008: IPCC 1996:	0.0075 0.0075 0.025	kg kg^{-1} N_2O-N kg kg^{-1} N_2O-N kg kg^{-1} N_2O-N

---

[85] Weymann D, Well R, Flessa H, von der Heide C, Deurer M, Meyer K, Konrad C, Walther W (2008) Ground water N2O emission factors of nitrate-contaminated aquifers as derived from denitrification progress and N2O accumulation. Biogeosciences, 5, 1215 – 1226.

Table 233:   Carbon dioxide emissions

Source	Chapter	Reason for not using the IPCC 1996 methodology	Effective parameter
liming	13.2.2.2	Neither IPCC 1996 nor IPCC 2000 mention CO_2 emissions from liming. IPCC 2006 requires these emissions to be calculated. The emission factor can be obtained by stoichiometry as related to CaO. The submissions of the previous years and for 2010 use this emission factor. The emissions reported according to IPCC 2006 exceed that of IPCC 1996.	EFCaO in submission 2010 1990: 44/56 kg kg^{-1} CO_2 2008: 44/56 kg kg^{-1} CO_2 IPCC 1996: 0 kg kg^{-1} CO_2
application of urea	11.1.3.1	Neither IPCC 1996 nor IPCC 2000 mention CO_2 emissions from the application of urea. IPCC 2006 requires these emissions to be calculated. The emission factor can be obtained by stoichiometry as related to N in $(H_2N)_2CO$. The submissions of the previous years and for 2010 use this emission factor. The emissions reported according to IPCC 2006 exceed that of IPCC 1996.	EFN in submission 2010 1990: 44/28 kg kg^{-1} CO_2 2008: 44/28 kg kg^{-1} CO_2 IPCC 1996: 0 kg kg^{-1} CO_2

19.5   Other detailed methodological descriptions for the source/sink category "Land-use change and forestry" (5)

19.5.1   Forest land (5.A)

19.5.1.1   Methodological issues

19.5.1.1.1   Below-ground individual-tree biomass

In contrast to derivation of above-ground biomass, the root dry substance was not calculated via a volume and the basic density; instead, it was established directly from the above-ground mass. Dry-root substance was estimated using the root/shoot ratio, with values pursuant to IPCC GPG-LULUCF (2003). To obtain plantation values, the above-ground biomass, differentiated by tree-species groups, was extrapolated to the hectare level for each sampling point, and then the below-ground biomass was derived.

Because root studies are so difficult to carry out, few root-biomass functions are available. For this reason, the relationships derived in "meta-analyses" were used. 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.

Equation 30:

$$\sqrt{rb} = \beta * \sqrt{ab} + \delta_{tree\ species} + \varepsilon$$

where:

ab	= above-ground biomass
β	= coefficient
ε	= residual scattering of the model
rb	= root biomass

It must be remembered that this derived function is oriented to plantation figures that always refer to one hectare.

Table 234:   Parameters for the function for below-ground biomass, as given by DIETER & ELSASSER

Tree Species	β	δ	Degrees of freedom	Sig. level	r²
Abies		1.8114		**	
Picea		1.169		**	
srb	0.4259	0.691	266	**	0.8
Pseudotsuga		0.4738		*	
Pinus		0.2864		*	
Fagus and Quercus		0			

For below-canopy and "selection forest" (Plenterwald), the authors assumed an average R/S (biomass) value of 0.18.
srb = short rotation broadleaves (in BWI= ALN)
* Significant α< 5 %, ** Significant α<1%.
Source: Dieter & Elsasser 2002

Since these calculations are subject to a great deal of uncertainty, a scenario with the values pursuant to IPCC (2003) was also calculated. The advantage of the IPCC table is that it includes the standard error in the estimates; this is not included in the study of DIETER &

ELSASSER (2002). The values entered into the CRF tables were derived pursuant to IPCC (2003).

Table 235:   Values for below-ground biomass, pursuant to IPCC (2003), with error values

Vegetation type	Above-ground biomass [t/ha]	Mean	SD	lower range	upper range
Conifer plantation	<50	0.46	0.21	0.21	1.06
Conifer plantation	50-150	0.32	0.08	0.24	0.5
Conifer plantation	>150	0.23	0.09	0.12	0.49
Oak forest	>70	0.35	0.25	0.2	1.16
Other broadleaf	<75	0.43	0.24	0.12	0.93
Other broadleaf	75-150	0.26	0.1	0.13	0.52
Other broadleaf	>150	0.24	0.05	0.17	0.3

The following Figure 42 shows the R/S values for fir and spruce and the mean R/S ratio pursuant to DIETER & ELSASSER (2002). These figures have been compared with the corresponding values pursuant to IPCC GPG-LULUCF (2003: "Conifer Plantation").
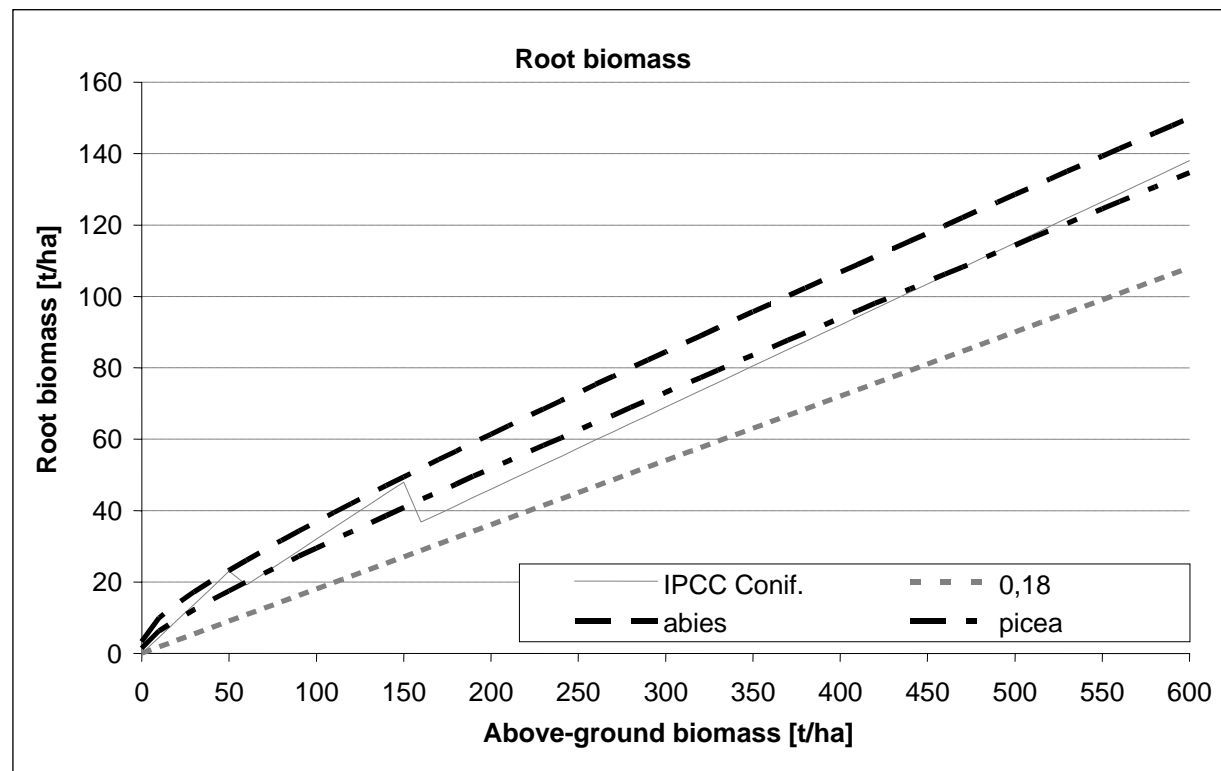
Figure 42:   Comparison of root biomass pursuant to IPCC and to DIETER & ELSASSER

19.5.1.2   Uncertainties and time-series consistency

19.5.1.2.1   *Measurement errors in the Inventurstudie 2008*

For data quality assurance, and for estimation of the measurement error, as part of the Inventurstudie 2008 control surveys were carried out on about 5 % of the total number of plots surveyed. That work focussed especially on analysing the error in the attributes "breast-height diameter" (BHD), "diameter at a height of 7 m" (D7) and "tree height" (H), since those attributes directly influence estimates of standing-timber volume of individual trees. The error resulting from use of the BWI tariff function itself cannot be studied in the present context, since no relevant findings are available.

The analyses draw on two Access databases – one containing measurements carried out by regular survey teams (Erstaufnahme (initial measurement) = EA), and one with measurements carried out by control teams (Kontrolltrupps – KT). By linking the two tables, which contain data from angle-count sampling with counting factor 4 (ACS/CF4 = WZP/ZF4, it was possible to compare the two sets of measurements directly. The statistical analyses were carried out with PASW Statistics 17.0.2 (formerly, "SPSS Statistics").

First, all measurement pairs of a given attribute were subjected to simple frequency analysis, and the relevant position and scattering figures were determined for purposes of rapid characterisation of the measurements. Extremes were studied separately, to permit identification of any entry errors or transposed digits. Such special cases were then excluded from further calculations. In addition, possible interrelationships and dependencies were checked – for example, interrelationships and dependencies relative to pertinent measurements from the first Federal Forest Inventory (BWI 1), where such measurements were available.

The "t-Test" and "Wilcoxon-Test" mean-value-comparison methods (both of which are used with linked samples) were then use to check the data from both surveys (EA and KT) for significant differences. A representative parametric test and a representative non-parametric test were selected; while parametric tests are extremely popular, since they supposedly have greater selectivity, they often do not fulfill all the criteria for a relevant application.

Where applicable, correlation checks were carried out at the end of the process, with the aim of identifying any possible dependencies a) among the measurement differences and b) between measurement differences and other characteristics.

A total of 5,952 measurement pairs were available for the study of the BHD survey errors. Analysis of the complete data set produced the values shown in Table 236.

Table 236:   Statistics on differences between BHD measurements, including outliers

N valid	5952
Mean	0.14 mm
Standard error in the mean	0.24 mm
Median	0.00 mm
Standard deviation	18.82 mm
Variance	354.48 mm²
Range	1,154.00 mm
Minimum	-586.00 mm
Maximum	568.00 mm

In a total of 5,624 cases (corresponds to 94.5 % of data sets), no difference was found between the EA and the KT; i.e. the measurements agreed down to the nearest millimetre! On average, a minimal positive deviation of 0.14 mm resulted, with a standard deviation of 18.8 mm; in other words, to a negligible degee, the EA obtained larger values than the KT did.

As Table 236 shows, shows, the two extremes account for a contribution of over half a metre. That figure can hardly be ascribed to measurement error in the narrow sense. The data set with -586 mm deviation is associated with a downward shift, amounting to 60 cm and carried out by the control team, in the BHD measurement height. At the same time, to justify that diameter difference, the tree in question would have to have an unusual form indeed. The largest positive difference involves a 30 cm reduction in the BHD measurement height,

carried out by the KT. At the same time, there are numerous other cases in which both survey teams used different BHD measurement heights and yet the resulting BHD measurements show no deviations.

In this light, the auditors removed three data sets in which the difference between EA and KT was more than 500 mm. With that action, the mean deviation drops to 0.05 mm, with a standard deviation of 13.7 mm (cf. Table 237).

Table 237:   Statistics on differences between BHD measurements, not including outliers

N valid	5949
Mean	0.05 mm
Standard error in the mean	0.18 mm
Median	0.00 mm
Standard deviation	13.75 mm
Variance	189.03 mm²
Range	664.00 mm
Minimum	-338.00 mm
Maximum	326.00 mm

Neither the t-Test and the non-parametric test pursuant to Wilcoxon give indications of significant differences between the mean BHD values in the two sample sets. This supports the assumption that the survey teams in the IS08 carried out excellent work.

In addition, the correlation between the values "difference in the BHD" (d_{BHD}) and "difference in the BHD measurement height" (d_{h_BHD}) was studied. Pearson's and Spearman's correlation coefficients both show a virtually non-existent (significant) dependency, with a value of 0.1. And it makes no difference whether all 5,952 data sets, or only the 5,949 data sets remaining after removal of outliers, are used. This result supports the above-mentioned theory to the effect that the attribute "BHD measurement height" is not sufficiently effective to explain any measurement differences in the BHD.

Subsequent correlation analysis of the data, without the three outliers mentioned, was expected to show the extent to which other characteristics – namely, tree age, tree species and tree height – influence the size of differences between measurements of EA and measurements of KT. At the same time, the numbers of data sets for which relevant measurements were available differ with regard to the various relevant characteristics.

For the correlation between the BHD difference and tree age, the Pearson method yields a coefficient of $r = 0.087$ (with $p = 0.118$). The Spearman's correlation measure paints a similar picture: $\rho = 0.015$, and that estimate does not differ significantly from zero ($p = 0.792$). Consequently, tree age is not likely to have a (systematic) influence on the precision of the BHD survey.

Tree species is   a nominally scaled characteristic for which a suitable measure of dependency had to be found. The coefficient "eta", which is calculated on the basis of a pivot table, is used in cases in which the presumably dependent characteristic (of the two characteristics) is interval-scaled (*Jürgen Janssen & Wilfried Laatz*: Statistische Datenanalyse mit SPSS für Windows ("Statistical data analysis with SPSS for Windows")). The value range extends between 0 and 1; there is no dependency at $\eta = 0$, and there is complete dependency at $\eta = 1$. For d_{BHD} versus tree species, $\eta = 0.409$ was obtained. With $\eta^2 = 0.167$, this means that tree species could explain 16.7 % of the variability of the BHD measurement differences. That measure does not take account of the fact, however, that the

various tree species were not represented with equal frequency in the control samples. The tree species with the largest shares also tend to show the largest variability with regard to the measurement differences. What is more, 86.5 % of the non-zero differences between EA and KT fall within the range -30 mm and + 30 mm. Consequently, the "tree species" characteristic is unlikely to have a systematic relationship with measurement values and measurement differences.

The correlation between d_{BHD} and tree height shows as few pronounced interrelationships as do the other characteristics combinations. For r, a value of 0.047 (p = 0.629) results, while ρ amounts to 0.023 (p = 0.811). In this case as well, there is no indication of a significant relationship between measurement accuracy and tree height.

For the characteristic "D7", a total of 1,782 measurement pairs were available. First of all, an ad-hoc comparison was carried out, directly within the database, of the measuring devices used by the two survey teams. In nine cases, the EA team used a relascope to measure high diameter, while the relevant KT used telescopic calipers. Only once did the opposite configuration occur: the EA used telescopic calipers, while the control team used a relascope.

For two data sets, there were no differences in the D7 measurements, while in the other eight cases $D7_{KT}$ was always larger than the corresponding EA figure. (N: 10; Min: -160 mm; Max: 0 mm; Mean: -67 mm; Median: -63 mm; standard deviation: 57.4 mm). Table 238 shows the statistical indexes for the entire D7 data group.

Table 238:   Statistics on difference in D7 measurements

N valid	1782
Mean	0.76 mm
Standard error in the mean	0.52 mm
Median	0.00 mm
Standard deviation	21.74 mm
Variance	472.66 mm²
Range	625.00 mm
Minimum	-255.00 mm
Maximum	370.00 mm

In 95.2 % of all cases (1,696), the D7 measurements agreed. With regard to the KT measurements, the EA data show a mean D7 overestimation of 0.76 mm, with a standard deviation of 21.7 mm. Both mean-comparison tests show no indication of significant differences between the two sets of measurements.

To make it possible to estimate whether there could be any relationship between large deviations in BHD and D7 measurements, correlation studies were also carried out in this area. While the coefficient pursuant to Pearson shows a value of 0.24, that is significant on the 0.01 level, and that could be indicative of a weak interrelationship, the coefficient estimation pursuant to Spearman, at -0.04, is not significant and supports no such conclusion. It is thus unlikely that an erroneously determined BHD would have to entail a similarly erroneous D7 value (or vice versa).

A total of 2,177 height-measurement pairs were available for determination of the height-measurement error. In 2,016 – or 92.6 % – of those cases, the same height was measured. Table 239 shows other key figures for this data group.

Table 239:   Statistics on differences in height measurements

N valid	2177
Mean	0.16 dm
Standard error in the mean	0.16 dm
Median	0.00 dm
Standard deviation	7.43 dm
Variance	55.15 dm²
Range	132.00 dm
Minimum	-65.00 dm
Maximum	67.00 dm

On average, the EA teams' height measurements were 0.16 dm higher than those of the KT team. That figure is linked with a standard deviation of 7.4 dm. Outlier analysis is difficult, since nearly every decimetre class is represented between the extremes. In 10 cases, deviation contributions of more than 50 dm were found.

Once again, it was not possible to identify any significant differences between the two measurement series; both the t test and the Wilcoxon test suggest that the zero hypothesis (both measurement teams obtain the same measurements) should be retained.

The correlation analysis between the BHD difference and the height difference produced an overall picture with inconsistency similar to that of the picture for the D7 high diameter. The Pearson's correlation coefficient is significant at the 0.01 level, and it has a value of 0.28, which would be indicative of little positive coupling between the two measurement errors. The non-parametric alternative pursuant to Spearman yields a value of only 0.037. What is more, that value is not significant. Once again, therefore, it cannot be assumed that an erroneous BHD measurement necessarily entails an erroneous height measurement (and vice versa).

19.5.1.2.2   *Error budget*

Finally, the error sources and error frameworks described in Chapters 7.2.5.1 to 7.2.5.5 are combined to a form a total error budget. For the old German Länder, and for the period 1987 – 2002, a complete budget can be prepared. For the old German Länder, Table 240 shows the total error budget for C-stocks estimation for the 1987, while Table 241 shows the corresponding figure for 2002. The total error budget for C-stocks changes between 1987 and 2002, in the old German Länder, is shown in Table 242. For the period 2002 – 2008, the data permit such an error budget only for the class *Forest Land remaining Forest Land*. The total error budget for the C-stocks and C-changes estimates for the land-use class *Forest Land remaining Forest Land*, between 2002 and 2008 in Germany, is summarised in Table 243.

Table 240:   Total error budget for C-stocks estimation for the year 1987, in the old German Länder

1987															
	area		**above-ground**					**below-ground**				**carbon**		**overall**	
LULUCF classes	**[ha]**	**error [%]**	**biomass stock [t]**	**se [%]**	**vef [%]**	**rd [%]**	**error total [%]**	**biomass stock [t]**	**se [%]**	**root-shoot-ratio [%]**	**error total [%]**	**carbon stock [t]**	**carbon error [%]**	**error total [%]**	**error emission factor [%]**
Forest Land remaining Forest Land	7,599,965	0.93	1,235,448,107	1.07	2.99	9.19	9.73	351,236,001	1.05	25.37	25.39	793,342,054	2.00	9.64	9.68
Forest Land converted to Cropland	5,290	26.51	272,142	55.12	2.12	13.7	56.84	92,680	55.59	32.36	64.32	182,411	2.00	45.48	52.64
Forest Land converted to Grassland	24,634	14.18	351,457	45.42	2.81	8.65	46.32	121,383	43.11	24.19	49.43	236,420	2.00	36.75	39.39
Forest Land converted to Settlements	39,688	11.14	3,047,746	18.73	2.14	7.92	20.45	920,259	18.49	22.43	29.07	1,984,003	2.00	17.21	20.5
Forest Land converted to Wetlands	9,133	24.85	90,532	69.85	3.08	24.49	74.08	28,229	64.93	32.34	72.54	59,380	2.00	59.08	64.10
Forest Land converted to Other Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Cropland converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Grassland converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Settlements converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Wetlands converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Other Land converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
KP Aforestation	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
KP Deforestation	78,744	8.01	3,761,878	16.33	2.14	8.21	18.4	1,162,550	16.01	23.09	28.10	2,462,214	2.00	15.67	17.60

Table 241:   Total error budget for C-stocks estimation for the year 2002, in the old German Länder

2002														
	area		**above-ground**					**below-ground**				**carbon**		**overall**
LULUCF classes	**[ha]**	**error [%]**	**biomass stock [t]**	**se [%]**	**vef [%]**	**rd [%]**	**error total [%]**	**biomass stock [t]**	**se [%]**	**root-shoot-ratio [%]**	**error total [%]**	**carbon stock [t]**	**carbon error [%]**	**error total [%]**	**error emission factor [%]**
Forest Land remaining Forest Land	7,599,965	0.93	1,452,377,845	1.04	2.84	8.63	9.15	413,033,737	1.03	23.86	23.88	932,705,791	2.00	9.09	9.14
Forest Land converted to Cropland	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Forest Land converted to Grassland	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Forest Land converted to Settlements	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Forest Land converted to Wetlands	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Forest Land converted to Other Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Cropland converted to Forest Land	28,425	13.59	691,595	26.46	2.11	8.05	27.74	267,035	25.41	29.27	38.76	479,315	2.00	22.83	26.57
Grassland converted to Forest Land	52,974	8.61	1,956,486	15.37	2.07	7.76	17.35	683,983	14.8	26.61	30.45	1,320,235	2.00	15.21	17.48
Settlements converted to Forest Land	28,967	13.32	1,223,087	20.9	2.00	6.83	22.08	429,918	20.93	25.24	32.79	826,502	2.00	18.54	22.83
Wetlands converted to Forest Land	16,469	15.92	454,997	28.42	1.04	6.65	29.21	167,610	28.31	17.95	33.52	311,303	2.00	23.26	28.18
Other Land converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
KP Aforestation	126,834	6.00	4,326,165	10.47	2.7	6.96	12.86	1,548,546	10.23	24.79	26.81	2,937,355	2.00	11.98	13.4
KP Deforestation	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–

Table 242: Total error budget for C-stocks changes between 1987 and 2002, in the old German Länder

	1987 – 2002														
	area		above-ground					below-ground				carbon		overall	
LULUCF classes	[ha]	error [%]	biomass stock [t]	se [%]	vef [%]	rd [%]	error total [%]	biomass stock [t]	se [%]	root-shoot-ratio [%]	error total [%]	carbon stock [t]	carbon error [%]	error total [%]	error emission factor [%]
Forest Land remaining Forest Land	7,599,965	0.93	216,929,738	2.94	2.06	6.29	7.25	61,797,736	2.68	17.38	17.59	139,363,737	2.00	7.14	7.20
Forest Land converted to Cropland	5,290	26.51	272,142	55.12	2.12	13.7	56.84	92,680	55.59	32.36	64.32	182,411	2.00	45.48	52.64
Forest Land converted to Grassland	24,634	14.18	351,457	45.42	2.81	8.65	46.32	121,383	43.11	24.19	49.43	236,420	2.00	36.75	39.39
Forest Land converted to Settlements	39,688	11.14	3,047,746	18.73	2.14	7.92	20.45	920,259	18.49	22.43	29.07	1,984,003	2.00	17.21	20.50
Forest Land converted to Wetlands	9,133	24.85	90,532	69.85	3.08	24.49	74.08	28,229	64.93	32.34	72.54	59,380	2.00	59.08	64.10
Forest Land converted to Other Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
Cropland converted to Forest Land	28,425	13.59	691,595	26.46	2.11	8.05	27.74	267,035	25.41	29.27	38.76	479,315	2.00	22.83	26.57
Grassland converted to Forest Land	52,974	8.61	1,956,486	15.37	2.07	7.76	17.35	683,983	14.80	26.61	30.45	1,320,235	2.00	15.21	17.48
Settlements converted to Forest Land	28,967	13.32	1,223,087	20.90	2.00	6.83	22.08	429,918	20.93	25.24	32.79	826,502	2.00	18.54	22.83
Wetlands converted to Forest Land	16,469	15.92	454,997	28.42	1.04	6.65	29.21	167,610	28.31	17.95	33.52	311,303	2.00	23.26	28.18
Other Land converted to Forest Land	0	–	0	–	–	–	–	0	–	–	–	0	–	–	–
KP Aforestation	126,834	6.00	4,326,165	10.47	2.7	6.96	12.86	1,548,546	10.23	24.79	26.81	2,937,355	2.00	11.98	13.40
KP Deforestation	78,744	8.01	3,761,878	16.33	2.14	8.21	18.4	1,162,550	16.01	23.09	28.1	2,462,214	2.00	15.67	17.60

Table 243: Total error budget for estimation of C stocks and C-stock changes, in the category *Forest Land remaining Forest Land*, between 2002 and 2008 in Germany

	area		above-ground					below-ground				carbon		overall	
year	[ha]	error [%]	biomass stock [t]	se [%]	vef [%]	rd [%]	error total [%]	biomass stock [t]	se [%]	root-shoot-ratio [%]	error total [%]	carbon stock [t]	carbon error [%]	error total [%]	error emission factor [%]
2002	10,548,814	0.74	1,896,308,201	2.01	1.76	7.14	7.63	540,084,766	1.98	19.15	19.25	1,218,196,483	2.00	7.58	7.62
2008	10,548,814	0.74	1,940,334,277	2.00	1.71	6.86	7.35	553,315,973	1.97	18.48	18.59	1,246,825,125	2.00	7.33	7.36
2002-2008	10,548,814	0.74	44,026,076	27.20	1.23	24.49	36.62	13,231,207	22.98	32.34	39.67	28,628,642	2.00	29.68	29.69

19.5.1.3   Forest Land converted to Other Land

19.5.1.3.1   Source category description

Forest areas converted to other forms of land use are smaller overall than the new forest areas. At the same time, they had higher average biomass stocks prior to conversion. In conversion, such stocks are normally removed, and thus they are considered C emissions.

The IEF derived from biomass losses, and from the areas achieved in each relevant year since 1987, decreased continuously from 1990 to 2003. This does not reflect any true trend, however; it results simply in that areas have been listed separately only since 1987, and not for the past 20 years, as called for by the IPCC (1990). As a result, the area has increased in each report year.

In addition to biomass, C stocks in dead wood and forest-floor litter, and part of the carbon in the soil, are lost in deforestation. Burning of biomass, in conversion of forest, as well as mineralisation processes occurring via plowing and turning of topsoil, can cause both CO_2 emissions and additional greenhouse-gas emissions.

19.5.1.3.2   Methodological issues

19.5.1.3.2.1   Deforestation areas

The deforestation area for the year 2008 is somewhat less than half as large as the new-afforestation area (174.121 kha and 422.100 kha). The C emissions that must be assigned to these areas are higher, as a result of their stock accumulations, than C binding by new forest lands.

19.5.1.3.2.2   Stock losses on deforested areas

In the old German Länder, individual-tree-based extrapolation was carried out for this category (cf. Chapter 7.2.4.1.3). The C emissions that must be assigned to these areas are higher, as a result of their stock accumulations, than C binding by new forest lands. All in all, total stocks of 3,355.920 Gg C were lost from biomass in this category in 2008. As a simplification, it was assumed that C stocks are emitted into the atmosphere in the year in which they are converted.

In light of the great variability, by area, of dead-wood, litter and soil stocks, these figures are subject to very large uncertainties. The total relevant emissions could be more precisely estimated by linking the BWI points affected by deforestation with soil maps or with the nearest BZE points.

Table 244:   Losses from dead wood, litter and soil, in connection with deforestation, for 2008

Category	Carbon-stocks loss [Gg C]
Dead wood	115.109
Forest-floor litter	931.046
Mineral soil	86.721
Organic soil	10.988
Total	**1143.864**

19.5.2   Cropland, grassland, wetlands, settlements and other areas (5.B/5.C/5.D/5.E/5.F)

19.5.2.1   Land-area distribution and allocation of usage categories

A "wall-to-wall" approach developed in recent years was used in identification of land-use categories and land-use changes in Germany. For identification and spatial allocation of land-use categories, complete-coverage digital maps and data records were used, in a GIS-technology framework. Via comparison with data records of various relevant years, land-use changes throughout Germany were identified. All such data was georeferenced. The resulting data records were then linked with land maps and with official statistical data. This made it possible, ultimately, to estimate the carbon-stock changes in the soil and in biomass. A transition was made this year in processing of the data sets. Processing was carried out using the PostgreSQL database system, with an added PostGIS module, and with scripts of our own developed especially for this purpose. For the overall system, and its calculation processes, this approach ensures transparency, consistency, comparability and completeness.

19.5.2.1.1   Data sources and their adaptation

The following data sources were used for LULUCF reporting:

- Basic digital landscape model of ATKIS® (AdV).
- Data sets for 2000, 2005, 2006, 2007, 2008
- Administrative-boundaries database of ATKIS®
- CORINE LAND COVER (BMU). Data sets for 1990, 2000
- Digital soil map of Deutschland, 1:1.000.000 (BUEK 1000) (BGR 1997)
- Data from Federal Forest Inventories I and II (BMELV)
- Data from official German statistics (*Federal Statistical Office*)
    - Main soil-use survey (Bodennutzungshaupterhebung) 1991, 1999, 2003, 2007
    - Harvest survey, 1989 – 2008
    - Data from the district reforms of 1998 and 2009

For determination of emission factors

Soil:

- Literature

Biomass:

- Main soil-use survey (Bodennutzungshaupterhebung) 1991, 1999, 2003, 2007 (*Federal Statistical Office*)

- Harvest survey, 1989 – 2008 (*Federal Statistical Office*)
- Data from district reform of 1998, 2009 (*Federal Statistical Office*)
- Statistical Yearbook (Statistisches Jahrbuch) (BMELV 2007)
- Data from Federal Forest Inventories I and II (BMELV)
- Literature

In order to make it possible for all data to be compared and used/mixed in calculations, the georeferenced area data of all pertinent systems were normed using the administrative-boundaries data records in the ATKIS® system (VG 250).

ATKIS®, the "official topographic-cartographic information system of Germany" ("Amtliches Topographisch-Kartographisches Informationssystem Deutschlands"), of the Working Committee of the Surveying Authorities of the States of the Federal Republic of Germany (AdV; Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder), is the heart of the system for showing land use and land-use changes. The ATKIS® system uses digital landscape and terrain models to represent the earth's surface. The "basic digital landscape model" (Basis–Digitale Landschaftsmodell; Basis-DLM) serves as the basis for the digital landscape models and other information provided in German LULUC reporting. "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[86]). 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 Basis-DLM data are collected by the surveying authorities of the Länder. The data are completely revised every five years or as otherwise necessary. For areas of central current interest, especially with regard to changes – for example, settlement and transport areas – efforts are normally made to transfer relevant data into the ATKIS® system within 3 – 12 months. Since Länder data are not revised as of any national key date, new survey data of the Länder are transmitted to the BKG, and entered into the ATKIS® system, on an ongoing basis. 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.

---

[86] ATKIS® Objektartenkatalog (object-type catalogue; last checked, 16 September 2009)URL:
http://www.atkis.de/dstinfo/dstinfo.dst_start?dst_oar=4101&inf_sprache=deu&c1=1&dst_typ=25&dst_ver=dst&dst_land=ADV

For these reasons, Basis-DLM data records have been available to the reporting agency, on an annual basis, only since 2005. By chance, it proved possible to obtain a data record for the year 2000, from the "early days of ATKIS®". No ATKIS® data now exist for years prior to 2000. For those years, CORINE-Landcover data have been used. In compilation of data from official land-use statistics, problems arose that are due to the political development in Germany after 1989. Since German reunification did not take place until October 1990, the first standardised statistical survey of agricultural area and land use for all of Germany was not carried out until 1991. For this reason, complete-coverage statistical data on land use and harvest yields are available only for the period since 1991. What is more, a number of administrative boundaries of German districts were modified – especially in the new German Länder – as a result of German reunification; consequently, reference areas for statistical data for 1999 differ from those for data from earlier years. In the district changes, some districts were completely eliminated, some were created and still others were reorganised (in some cases, districts were formed from more than 10 sub-districts). Consequently, data for the period since 1999 – including ATKIS® and CORINE data – are not comparable with data from earlier years, i.e. with such data in the form in which they were provided. For this reason, the areas of the districts as listed in official statistics from the period 1990 - 1998 were recalculated, using the district-distribution key of the 1998 district reform, and brought into line with data records for the period since 1999. Ultimately, it proved possible to place CORINE data for identification of land use and land-use changes, for the period 1990 – 2000, into a suitable relationship with relevant official statistical data. In 2007, the state of Saxony-Anhalt carried out another district reform. This led to the merging of several districts. Via a translation key (with district indexes), this new correlation was added to the database and made compatible with relevant earlier versions.

19.5.2.1.2   *Determination of land-use changes and use-change-related area shifts*

Since the IPCC reporting categories "Cropland", "Forest land", "Grassland", "Wetlands", "Settlements" and "Other Land" have no direct correspondences among the object types of the Basis-DLM, that system's ATKIS® categories have to be manually correlated with the IPCC reporting categories. In addition, new "IPCC shapefiles" have to be created, via GIS processing, that contain the polygons pursuant to the IPCC reporting categories (cf. Tab. Y). To this end, the PostgresSQL database system, with PostGis, was used. The necessary extensive GIS processing was controlled via scripts, of our own development, written in SQL. With this approach, all procedures for manipulating the relevant data records are transparent, consistent and comparable.

As a result of the transition in the IT systems used, the GIS data sets no longer have to be processed separately for each of Germany's Landkreis administrative districts (439). Thanks to the large capacity of the new systems, the data can be processed for all of Germany, in a single calculation step.

In 2008, a significant change was made in allocation of object types to the various relevant categories. In the framework of Kyoto reporting, the object types for the ATKIS® category "forest" had to be brought into line with the definition of "forest" used in the Federal Forest Inventory. As a result, object type 4108, which previously was reported under "forest", is now part of the category "other land".

Table 245:   Allocation of main-object-type key numbers and attributes within ATKIS®, and key numbers within the CORINE-Landcover nomenclature for ground-cover types, to the IPCC land-use categories

IPCC category	ATKIS® object-type key	CORINE nomenclature
Forest land	4107/ and attributes	311/312/313/324
Cropland	4101/4103/4109 and attributes	211/221/222/242/243
Grassland	4102/4104 and attributes	231/321/322/421
Wetlands	4105/4106 and attributes	411/412
Settlements	2100 – 3543 and attributes	111/112/121/122/123/124/131/ 132/133/141/142
Other land	4110/4120/4198/4199/4108 and attributes	331/332/333/334/335

Via a range of complex and involved calculations, each year's set of ATKIS® data was correlated with land uses within the IPCC-category framework (with the data still carrying the considerably more differentiated object-type key used by ATKIS®). The resulting polygonal data records were then linked with data records from the BÜK 1000 soil-survey map system, which is also georeferenced. This procedure makes it possible to correlate each land-use area with its pertinent soil association, including relevant characteristics.

For determination of land-use changes, these data were then intersected with the corresponding data – prepared in a similar manner – for the following year. The result of this step is a selection of all those areas on which land use has changed from the first year to the next. As a result of data-availability constraints, the periods 1990 – 2000 and 2000 – 2005 had to be processed in combined form. For the years 2006, 2007 and 2008, calculations and recalculations were carried out on a single-year basis.

Carbon emissions and storage were derived from the changes in carbon stocks as reflected in the thus-processed data for mineral soils, as well as via data on organic soil fractions, obtained via main-soil associations.

Here as well, the necessary calculations and correlations were carried out with the help of task-dedicated programme scripts of our own development, in the interest of minimising manipulation errors and of ensuring the transparency and comparability of all results. As a final step, the results were then combined within the Excel format, for transmission to the Central System of Emissions (CSE).

19.5.2.1.3   *Organic soil area*

The areas and distribution of organic soils were shown via the 1:1,000,000-scale soil-survey map (BUEK 1000), with georeferencing. Main-soil associations 6 and 7 – primarily fens and raised bogs – were chosen. This listing procedure is inadequate, since the IPCC definition for organic soils is oriented to the relevant WRB definition (FAO, 1998), which is considerably broader than the German terminology for organic soils pursuant to the "KA 5" mapping instructions (Arbeitsgruppe Boden (working group on soils) 2005). Due to a lack of the necessary suitable digital and analog soil maps, it is currently not possible to list Germany's organic soils in keeping with the relevant IPCC definition. The listing of the country's organic soils is thus incomplete. The "organic soils" project is expected to remedy this situation by 2013 and produce a 1:200,000-scale, georeferenced map, in keeping with the IPCC definition, of Germany's organic soils.

Georeferenced correlation of land uses for the years 2000 – 2007 was carried out with the help of the BÜK 1000 soil-survey map and the ATKIS® data; for the years 1990 – 2000, it was

carried out with BÜK 1000 and the CORINE data (modified and normed with the help of ATKIS[®]).

19.5.2.2   Determination of carbon stocks, and of their changes as a result of land-use changes

Data on spatial distribution of soil communities in Germany is available in the form of a digital soil map on a scale of 1: 1,000,000 (BUEK 1000). The soil map has been prepared via proportionate allocation of discrete profile data (obtained at individual points in the landscape) on land units (polygons) within the map area. The profiles provide quantitative information on a range of key factors measured. This information provided the basis for estimating the carbon stocks in agricultural soils. Calculation was carried out using the map's/legend's data for the lead profiles of the 71 main-soil units, data that included specific C_{org} content measurements, humus, raw-density and skeleton classes and profile and horizon descriptions. With this data, and under the assumption that the map's values, in each case, are representative of the entire relevant legend/map unit, C_{org} stocks were calculated. To this end, the C_{org} content figures were multiplied by the relevant raw densities and horizon depths and the relevant skeleton portions were deducted. The horizon stocks were added to a depth of 30 cm. The range of carbon stocks was determined via the figures in the relevant legend/map unit pursuant to the KA 4 mapping instructions (ARBEITSGRUPPE BODEN, 1994). In each case, the aforementioned algorithm was used to calculate a minimum value (lowest possible C_{ORG} content for the class, lowest possible storage density, maximum skeleton content) and a maximum value (highest possible C_{ORG} content for the class, highest possible storage density, minimum skeleton content). The range obtained in this manner is the measure for the potential spreading of results.

A geo-information system (GIS) was used to assign the individual soil units to the individual polygons of the relevant land-use units. The BUEK 1000 survey map was overlaid with polygons of district boundaries, as well as with the ATKIS[®] and CORINE-Landcover data records. For each of the thus-resulting polygons, carbon stocks to a depth of 30 cm were then calculated.

19.5.2.3   Changes in carbon stocks in the soil and in biomass

19.5.2.3.1   *Derivation of EF for mineral soil in connection with land-use change*

The emission factors for changes in carbon stocks in the soil, resulting from use changes, were drawn from the literature. To this end, a number of studies, including several reviews, were evaluated. From these studies, those studies were selected that directly considered carbon stocks following land-use changes, or whose data permitted relevant derivation. Of these studies, in turn, only those were used for EF derivation that apply criteria, for soil, climate and other parameters (for example, soil depth of about 30cm) that are at least somewhat comparable to those required for German reporting (ANKEN et al., 2004; BLANK & FORSBERG, 1989; BOUMA & HOLE 1971; BOWMAN et al., 1990; BURKE et al., 1995; BUYANOVSKY et al., 1987; CAMBARDELLA & ELLIOT., 1992 & 1993; CAMPBELL et al,1989; CHAN AND MEAD, 1988; CONANT et al., 2001; DAVIDSON & ACKERMANN, 1993; DEGRYZE et al., 2004; FRANZLUEBBERS et al., 1999; FRANZLUEBBERS et al, 2000; GEBHART et al, 1994; GUO & GIFFORD, 2002; HART et al, 1988; HORNE et al., 1992; IHORI et al., 1995; JASTROW & LUSSENHOP, 1998; LARIONOVA et al., 2003; LAWS

& EVANS, 1949; LIEBIG et al., 2004; MANN, 1986; MARTENS et al., 2003; MURTY et al., 2002; POST & KWON, 2000; POTTER et al., 1999; REEDER et al., 1998; ROSS AND HUGHES, 1985; SKEMSTAD et al., 1994; TIESSEN et al., 1982; VORNEY et al., 1981 etc.).

In spite of the wide distribution of absolute results it shows, the literature review supports the oft-heard assumption that conversion of grassland to cropland leads to losses of soil carbon stocks, and that conversion of cropland to grassland enriches soil carbon stocks. Nonetheless, results can be adduced that support the opposite assumption. The breadth of the spectrum of results complicates evaluation, although very close relationships can be found via simple or multiple regression ($r^2 > 0.9$). The results that are produced in this manner, however, show little plausibility and always include 0 within their 95 % confidence intervals.

For this reason, the annual carbon losses and additions, measured in percent of original stocks, and calculated via the difference between outset and final stocks and via the duration of the relevant trial, were compared to the relevant values for the total trial duration, in order to obtain annual loss percentages, as a function of trial duration and total loss from, or additions to, the original stocks. The results are shown in Figure 43 and Figure 44.

$$y=0{,}3778+(30{,}0488/x)$$
$$r^2=0{,}936; n=18$$
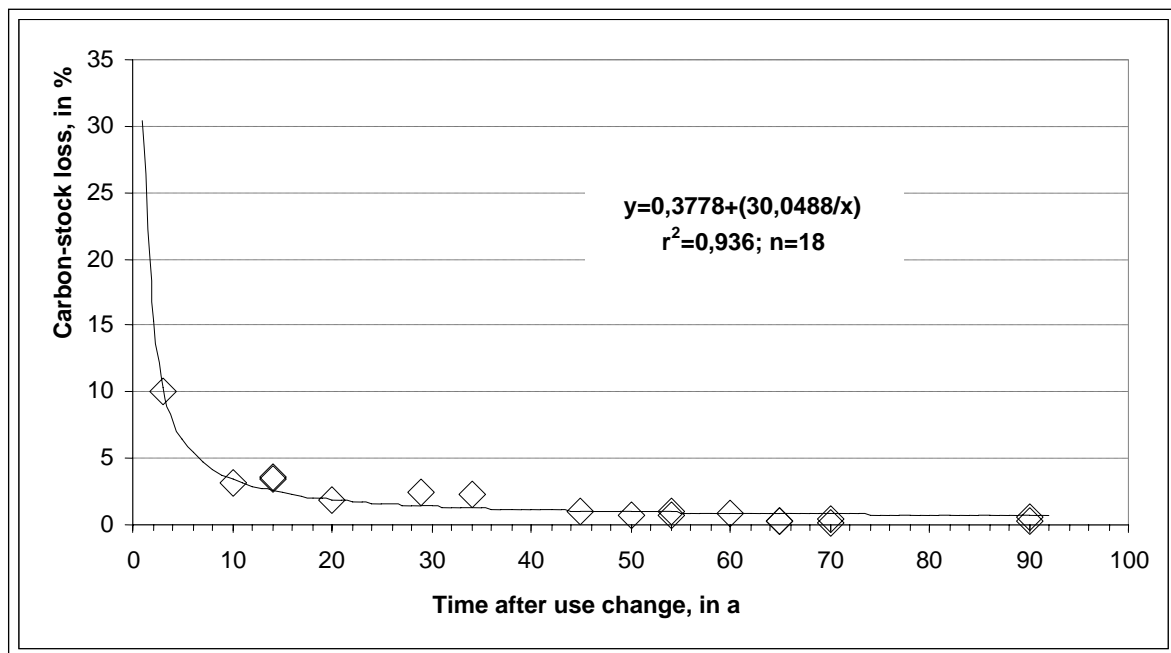
Figure 43:   Relationship between annual percentage losses from outset carbon stocks and trial duration following land-use changes (grassland, permanent cultivations, fallow land or forest to cropland (annual crops))..
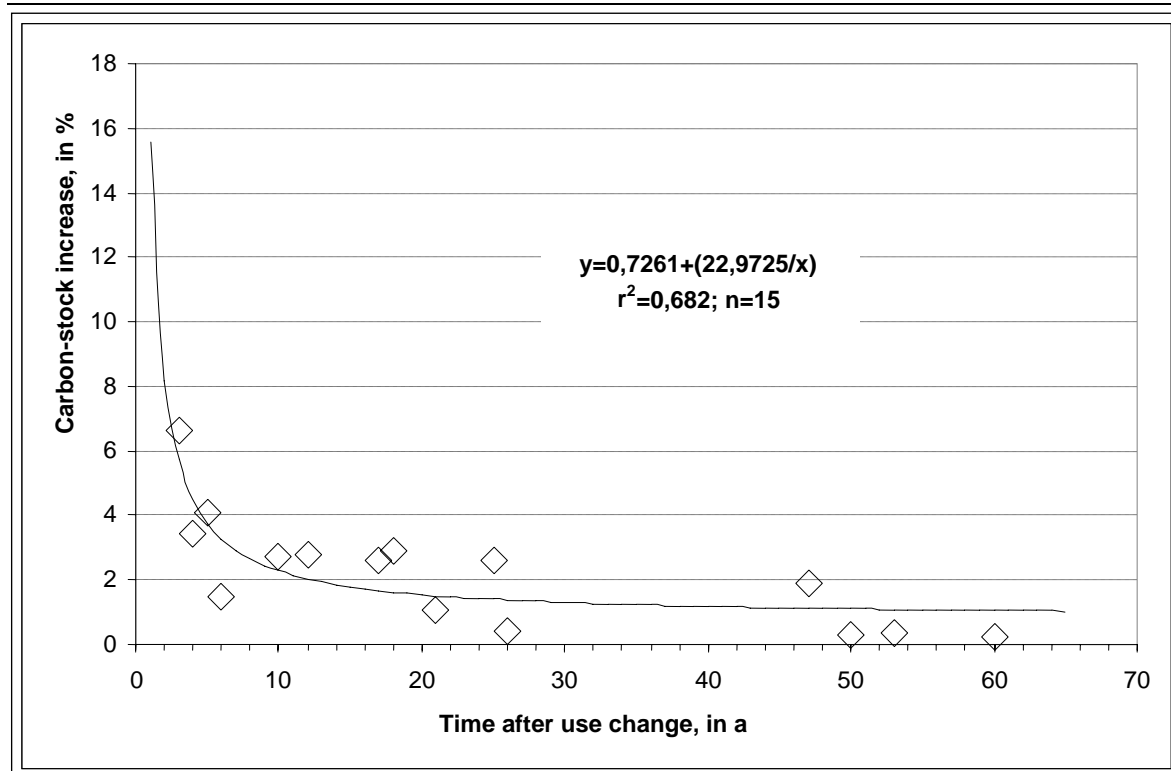
Figure 44:   Relationship between annual percentage additions to outset carbon stocks and trial duration following land-use changes (cropland (annual crops) to grassland, permanent cultivations, fallow land or forest).

The highly significant inverse functions show that the largest changes in carbon stocks resulting from land-use changes occur in the first years – and mostly in the very first year – following the land-use changes. This means that in subsequent years changes in soil cropland are small in comparison to those of the first year. This applies both to carbon losses (normally, from conversion of cropland to grassland) and to carbon additions (normally, grassland to cropland). At the same time, the losses in the first year are nearly twice the size of the additions. These results, along with other calculations (using multiple regression), also show that changes in carbon stocks, in respect to 20-year periods, and after the first year, amount to only about 5 % of the original stocks in the case of additions, and to only about 1% in the case of losses.

This implies that the time period specified by IPCC GPG LULUCF (2003), as a basis for calculation of additions and losses, is too long in the case of losses and too short in the case of additions. The contribution from stock changes is thus applied in the first year following the relevant land-use change, and it is applied only once, for the year for which it is determined. As a result, German reporting does not include the floating average for 20 years (pursuant to IPCC, 2003), because a) the average does not seem relevant, for technical reasons, and b) the tasks of obtaining the necessary high degree of spatial disaggregation of changes over 20 years, and of maintaining and managing the relevant data within a suitable IT environment, would require an unreasonable level of overhead. Apart from these considerations, usage changes in agriculture tend to take place in the short-to-medium term, so that further changes prior to establishment of the "final balance" may be assumed (cf. Chapter 19.5.2.6.1). Consequently, a general consideration indicates that the procedure chosen is actually the closer approximation to the real situation.

From the formulae shown in Figure 43 and Figure 44, and with the rule that stock changes are to be applied once, in the year for which they are determined (x=1), the emission factors for soil carbon shown in Table 246 result:

Table 246:   Percentage carbon-stock changes in the first year following land-use changes

Initial\Final	Forest	Crop$_{an.}$	Crop$_{peran.}$	Grass	Wetland	Settle-ment	Other Land
Forest		-30.43	-15.21	k.V.	15.56	k.V.	k.V.
Crop$_{an.}$	15.56		7.78	15.56	15.56	k.V.	15.56
Crop$_{peran.}$	7.78	-15.21		7.78	15.56	k.V.	7.78
Grass	k.V.	-30.43	-15.21		15.56	k.V.	k.V.
Wetland	k.V.	-30.43	-15.21	k.V.		k.V.	k.V.
Settlement	k.V.	-30.43	-15.21	k.V.	15.56		k.V.
Other Land	k.V.	-30.43	-15.21	k.V.	k.V.	k.V.	

k.V.: no change (keine Veränderung); an.: annual; peran.: perennial

A programme script is used to allocate these factors to land-use-change areas, and to calculate the relevant changes in carbon stocks. The script calculates the changes in soil-carbon stocks for each change polygon – and for each type of land-use change, with the "before" and "after" land uses coded via the ATKIS® object-type key. The "before and after" carbon-stock changes resulting for individual polygons, via subtraction, are then summed at the national level – again, for each type of land-use change. They are then assigned to the relevant reporting categories pursuant to CRF and listed as the sums to be reported for the pertinent categories. This procedure ensures that the data are handled in a consistent manner over the years – i.e. it assures data transparency, consistency and comparability.

19.5.2.3.2   Derivation of calculation factors (emission factors) for biomass

19.5.2.3.2.1   Forest, permanent cultivations, wetlands and woods in settled areas

In each case, carbon stocks in forest biomass were estimated on the basis of the mean value, as determined for Germany in the Federal Forest Inventory, for the relevant report year. (With regard to the relevant methods and derivation, cf. Chapter 7.2.4.1)

Table 32:   Mean carbon stocks in forest biomass (in Gg C/ha), for the relevant report years

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
[Mg C/ha]	94.37	95.97	97.57	99.18	100.78	102.38	103.99	105.59	107.19	108.80
Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	
[Mg C/ha]	110.40	112.00	112.84	113.29	113.73	114.17	114.61	115.05	115.50	

For woody permanent cultivations (such as vineyards and orchards), and for woody plants within settled areas, the IPCC default factor (63 t/ha; GPG-LULUCF 2003) was used. Carbon stocks in biomass of wetlands were defined as 30 t/ha, on the basis of expert judgement.

19.5.2.3.2.2   Grassland and non-perennial crops

Emission factors for carbon stocks in above-ground biomass of grassland and non-perennial crops were derived on the basis of results of the 1999 main survey of soil use (Bodennutzungshaupterhebung), of harvest estimates and of figures from the literature. The calculation was carried out at the district level for wheat, rye, winter barley, summer barley, oats, triticale, silo corn, feed plants (clover, lucerne, lupin, grass), potatoes, sugar beets and cash crops (primarily rape). The figures for the areas under cultivation with the various

relevant crops (ha), and those for harvest yields (t/ha), were taken from the 1991, 1995, 1999, 2003 and 2007 main surveys of soil use (Bodennutzungshaupterhebungen) and from harvest surveys for the period 1989 – 2008 (*Federal Statistical Office*). Here and there, some figures were lacking for harvest yields in individual districts; in such cases, average annual values were used instead. For the relevant Länder (states), such values were obtained from the relevant tables in official Länder statistics; for Germany as a whole, they were obtained from the Statistical Yearbook (Statistisches Jahrbuch; BMVEL, 2003, 2007). In each case, the biomass, in t/district, was obtained by multiplying the area under cultivation by the applicable harvests. The harvest figures given by the main survey of soil uses (BOHE) were adjusted to take account of residual moisture content. For grain, a residual moisture content of 14 % was assumed. The corresponding figures for other crops were as follows: silo corn, 28 %; potatoes, 78 %; and sugar beets, 77 %.

Biomass of straw, leaves and crop parts, and of roots, were calculated from harvest yields with the help of suitable factors (straw: straw / grain ratios; roots: root-stubble / grain ratios) as well as of suitably dimensioned size data (Table 247).

Table 247:   Factors and dimensioned size data for determining total biomass of plants from harvests.

	Straw	**Leaves / crop parts**	**Roots**
Wheat	1.2		0.24
Rye	1.7		0.34
Winter barley	1.05		0.32
Spring barley	1.05		0.21
Oats	1.4		0.35
Feed plants			4.22
Triticale	1.7		0.30
Rape	1.9		0.40
Silo corn	1		0.06
Potatoes		0.4 t/ha	0.11
Sugar beets		0.8 t/ha	0.06

Sources: Die Landwirtschaft 1998; FISCHER 1988; OEHMICHEN 1990; RUHR-STICKSTOFF AG 1985

Grassland biomass is determined on the basis of annual harvest yields for the relevant Länder. It was assumed that harvesting/mowing takes place three times annually. For determination of total biomass, harvest yields were divided by three (to take account of thrice-annual mowing). The resulting quotients were then multiplied by a factor of 4.2, since underground plant parts account for about 80 % of grasses' total biomass. The sum of the so-resulting value and the pertinent grassland yield represents the total "grassland" biomass per area unit.

For calculation of biomass carbon stocks, average carbon stocks of 45 % were assumed (carbon content of individual plant parts and types, 37 – 60 %; whole plants, 44 – 48 % (OSOWSKI et al., 2004)). The sum of all parameters yields the carbon stocks for total biomass of agricultural land, at the district level. For individual areas, ATKIS® shows only uses, and not specific crops cultivated. For this reason, district-specific, average, biomass carbon-stock values (in t/ha) had to be determined. For each year, those values are then used, as $EF_{initial}$, as a basis for all further calculations in connection with land-use changes for the year. In each case, the district-specific value was determined by dividing the district's total biomass stocks by its cropland area. Biomass calculations were carried out pursuant to IPCC GPG LULUCF (2003), with the help of a programme script developed for that purpose. The programme assigns biomass factors, before and after the land-use changes, to the

relevant polygons, and in keeping with the pertinent usage keys; calculates the biomass carbon stocks before (decrease) and after (increase) the use changes; forms the pertinent differences; sums the results at the national level, for the different types of land-use changes; and outputs the results in the relevant CRF categories. This approach ensures the transparency, consistency and comparability of all results over the years.

19.5.2.4   Liming

The annual figures for liming were taken from official statistics (STATISTISCHES BUNDESAMT, Fachserie 4, Reihe 8.2). The methods by which they were obtained are described in DÄMMGEN et al. 2009a. The relevant quantity is calculated as the sum of applied limes and calcium ammonium nitrate. With regard to the latter, it is assumed that the nitrogen content amounts to 27 % and, as a result, the ammonium nitrate content is 77.1 % and the calcium carbonate content is 22.9 %. The emissions are derived from figures for product sales. Because companies have a statutory duty to supply information, the data collection is complete. The data does not provide direct information on the annual use of fertilisers in agriculture and forestry. For this reason, figures cannot be differentiated with regard to types of application (dolomite or lime) or to the spreading sites (cropland or grassland). Differences can occur between amounts sold and amounts actually used:

- due to changes in commercial stocks
- due to use of fertiliser outside of agriculture and forestry, e.g. on private land, gardens, sports facilities.

19.5.2.5   Determination of N_2O emissions following conversion to cropland

N_2O emissions, following conversion of other use forms to cropland, were determined pursuant to IPCC-GPG (2003). To this end, the carbon-stock changes determined for the various individual polygons were divided by the C/N ratios for the pertinent soils, to obtain the changes in nitrogen stocks. The resulting changes were then combined with the default value of 0.0125 t N_2O-N/t N; this yielded the relevant N_2O emissions.

19.5.2.6   Uncertainties

19.5.2.6.1   Area designation

The errors in land-use designations are very small. They result from errors in the relevant outset data records. Quality assurance and control of ATKIS[®] data records are carried out by the Federal Agency for Cartography and Geodesy (BKG). The listed error for precision in point positions in the B-DLM amounts to ± 3 m. The "wall-to-wall" approach used, along with georeferencing of individual polygons and use of unique identification numbers, ensures that no double-counting of areas takes place.

The many different transformation and calculation steps involved in using ATKIS[®] data produce an average error, in offsetting and rounding-off, of 0.31 % (and a median of 0.13). This error varies over the years, and within the various land-use categories, between 0.02 % and 3 %; the median is 0.03. The largest error, 3 %, occurs in the category "settlements" for the years 2000 – 2005. It is due to the difficulties encountered in reconciling the object-type keys of the 2000 version of ATKIS[®] (the "old" version) with those of the 2005 version.

Another error results from data records for the ATKIS[®] 1:250,000-scale administrative boundaries, which are used for norming all systems. Those data are considerably less precise than the Basis-DLM data. They lead to errors in peripheral areas of the national territory, errors amounting to a total of considerably < 1 %.

Another error – one whose absolute size cannot yet be estimated – is caused by the differences in the evaluation scales used with ATKIS[®] data (1:25,000; survey scale down to 1:5,000) and with Corine data (1:250,000). Differences in the sources of the data – ATKIS[®] is based on land-surveying data, while CORINE is based on satellite remote-sensing data (primarily from the Landsat programme) – also play an important role. For example, CORINE data exhibit considerable misassessments, especially with regard to agricultural areas. In that database, grassland percentages are considerably underestimated (by about 26 %), while cropland percentages are considerably overestimated (by about 16 %) (GENSIOR 2004). The CORINE database 2000 was brought into line, as far as possible, with the ATKIS® database 2000. That process led to inconsistency in the results for the periods before and after the year 2000, however, since the resolution used by the CORINE system in recording land-use changes is far lower than that used by the ATKIS® system.

19.5.2.6.2   Mineral soils: area designations and carbon and nitrogen stocks

The provisional C_{org}-stock estimates for agriculture are based on the only existing complete-coverage soil map for all of Germany, which is drawn to a scale of 1: 1,000.000 (BUEK 1000). That map integrates soil information over large areas and aggregates indexes within classes. Consequently, the scattering for data on changes in carbon stocks, as estimated from these figures, is very wide. The range of stock changes in the soil varies between 45 % - 53 % of the reported average value. The curve corrections for determining emission factors (Figure 43 and Figure 44) are highly significant; they explain 93.6 % and 68.2 %, respectively, of the variance. For grassland / forest / fallow land to cropland, the standard error for the estimate is 0.6 %$_*$a^{-1} of the original carbon stocks; for cropland to grassland / forest / fallow land, it amounts to 1.01 %$_*$a^{-1}. The confidence intervals for α = 0.05 are 46 % and 39 %. To address the broad scattering seen in results for carbon-stock changes as a result of land use, the next report will use improved response functions, differentiated by soil type and moisture levels, for determination of carbon-stock changes.

As a result of the procedure used for estimating N_2O, the errors occurring in determination of carbon stocks propagate themselves. In addition, the uncertainty increases via use of the default procedure, which is based on assumptions that need to be scientifically improved.

At present, it is not possible to determine the uncertainties more precisely, since all parameters that actually influence N_2O formation and release vary strongly from area to area and, pursuant to GPG (2003), are not to be used in determination of uncertainties.

19.5.2.6.3   Organic soils: area designations and greenhouse-gas emissions

The errors in determination of emissions from organic soils are very large, possibly ranging up to 75 % - > 100 %. The reasons for such error are found in the relevant emission factors, which are derived from the literature (errors of 75 - > 100 %), and in the still-inadequate classification of organic soils.

Due to differences in definition of organic soils – between the IPCC definition and that of the German mapping instructions ("Deutsche Kartieranleitung") – to date, only some organic

soils have been included in German emissions estimation. In Germany, the term "organic soils" is usually understood to mean bogs (a total of about 18,000 km^2). In the IPCC rules (IPCC 2003, 2006), organic soils are defined as "histosols", in keeping with the approach used by the World Reference Base for Soil Resources (WRB (FAO 1998)). Germany has a total area of about 67,000 km^2 of soil communities that can contain large amounts of histosols that are not bogs. As a result, in German reporting, a considerable portion of the country's organic soils are not being taken into account – in a contravention of the applicable rules. For the soils in question, type classifications and area designations (pursuant to WRB), and emission factors, are lacking.

19.5.2.6.4   *Biomass: area designations and carbon stocks*

The errors arising in biomass determination – errors arising via the estimation procedure used for the present report (determination of an average carbon emission factor for each district; use of Länder harvest data for grassland and of default values for woody plants) – cannot be determined until area-based data for the relevant biomass are available and country-specific emission factors for woody plants have been obtained.

19.5.2.7   **Planned improvements**

The following measures will be carried out in the coming years in the interest of improving the LULUCF inventory:

The reporting basis for the key source "organic soils" will be improved via the project "organic soils – determination and provision of activity data and emission factors for LULUCF/AFOLU climate reporting" ("organische Böden" – Ermittlung und Bereitstellung von Aktivitätsdaten und Emissionsfaktoren für die Klimaberichterstattung LULUCF/AFOLU") Since 2009, that project has been generating activity data for organic soils pursuant to the relevant IPCC definition. In addition, it will determine national emission factors for CO_2, N_2O and CH_4, differentiated by soil type, climate region and land use. Those factors will then be used for parametrisation and validation of pertinent mathematical models. The results of that project will enter into reporting (NIR 2013) on an ongoing basis.

The emission factors for mineral soils will be improved via:

- Derivation of improved response functions that are differentiated by soil type and moisture level (NIR 2011)
- A national inventory of soil carbon on non-forest areas (NIR 2013)
- The research project "grassland tilling, grassland-restoration tilling, grassland establishment – determination of changes in carbon and nitrogen stocks of Germany's agricultural soils as a result of land use and land-use change, for derivation of emission factors for LULUCF climate reporting" ("Grünlandumbruch, Grünlanderneuerungsumbruch, Etablierung von Grünland – Ermittlung der Veränderungen im Kohlenstoff- und Stickstoffhaushalt von landwirtschaftlich genutzten Böden Deutschlands infolge von Landnutzung und Landnutzungsänderung, zur Ableitung von Emissionsfaktoren für die Klimaberichterstattung LULUCF"; NIR 2013)
- Evaluation of results for all German long-term soil-survey sites
- The results of those studies will also be used for parametrisation and validation of pertinent mathematical models.

Determination of emission factors for biomass outside of forests, via the projects:

- "Methodical survey of biomass of woody perennials outside of forests" ("Methodische Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Wäldern"), which will determine carbon stocks in the biomass of fruit trees, vines and hedges, and derive emission factors for the plants in question (NIR 2012)
- "Survey of C storage in urban trees" ("Erfassung der C-Speicherleistung von Stadtbäumen"). That project will survey stocks of woody plants in settlement areas, along with their carbon stocks and their changes (NIR 2013)

"Biomass, harvest yields" ("Biomasse, Ernteerträge"), for improved, maximally area-specific determination of carbon stocks in biomass, following implementation of InVeKoS data within the reporting system (NIR 2012/2013).

Georeferenced allocation of management and biomass data to agricultural areas identified via ATKIS®, via application of InVeKoS (integrated administrative and control system) data. Methodical studies via the preliminary study "development of methods for land-use analysis and for description and assessment of measures for reducing greenhouse-gas emissions in the agricultural sector" ("Methodenentwicklung für die Landnutzungsanalyse und zur Abbildung und Bewertung von Maßnahmen zur Minderung von Treibhausgasemissionen im Agrarsektor"; NIR 2012/2013).

Improvement of processing of ATKIS® data:

- Improvement of calculation algorithms (NIR 2011, ongoing)
- Further development of the standardised system for data storage and processing (NIR 2011, ongoing)
- Reduction and quantification of uncertainties, via the project "Quantification of uncertainties, inventory improvement" ("Quantifizierung der Unsicherheiten, Inventarverbesserung"), which will use high-resolution CIR aerial photographs (NIR 2012)

Improvement of reconstruction of land use and land-use changes for the years 1990 – 2000, via further adaptation of CORINE data to ATKIS® data, and via high-resolution aerial photographs, in the project "Quantification of uncertainties, inventory improvement") (NIR 2011)

Improvement of activity data for settlement and transport areas, and derivation of emission factors for soils in those land-use categories, via

- A national inventory of soil carbon on non-forest areas (NIR 2013/14)
- The research project "Changes in soil-carbon stocks as a result of land use and land-use changes" ("Bodenkohlenstoffvorratsänderungen infolge Landnutzung und Landnutzungswechsel"), for determination of the spatial and chronological variability of qualitative and quantitative changes in organic soil substance resulting from land use and land-use changes, and for determination of regionally specific emission factors structured as empirical models and dependent on soil type, climate, hydrology, land use and cultivation/management (NIR 2013, ongoing)
- "Survey of C storage in urban trees" ("Erfassung der C-Speicherleistung von Stadtbäumen"). That project will survey stocks of woody plants in settlement areas, along with their carbon stocks and their changes (NIR 2012).

19.6   Other detailed methodological descriptions for the source category "Waste and wastewater" (6)

19.6.1   Waste (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.

No.	CRF	Definition of time series					Uncertainties data					
		Source description					**Base year 1990** [4]		**2002**			
		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]	Distribu-tion 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, type of operation, material, equipment, 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; 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 with the sectoral approach and relevant information on the national energy balance is found 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. The 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 248:   Overview, for completeness, of sources and sinks whose emissions are not estimated (NE)

Source category	Greenhouse gas	Explanation
1.AA.3.B Road Transportation	CO2, CH4, N2O	consumption data for Petroleum is no longer provided in Energy Balances
1.AA.3.B Road Transportation	CH4, N2O	no EF available for estimating CH4 & N2O emissions from lubricants
1.AA.3.C Railways	CO2	CO2 emissions are set to NE in order to not being included in national totals. Thus, CO2 from biodiesel used in German Railways is not yet included in the total of CO2 from biomass (1.C.3) as well!
1.AA.3.D Navigation	CO2	CO2 emissions are set to NE in order to not being included in national totals. Thus, CO2 from biodiesel used in German domestic navigation is not yet included in the total of CO2 from biomass (1.C.3) as well! 2004 value: 18,98 Gg
1.C1.B Marine	CO2, CH4, N2O	no data available for the use of lubricants in maritime navigation
5 Forest Land converted to Other Land-Use Categories	CH4	see subcategories
5 Grassland converted to Other Land-Use Categories	CH4	see subcategories
5.A.1 Forest Land remaining Forest Land	CH4, N2O	According to IPCC GPG (2003, p.1.11) countries are not required "to prepare estimates for categories contained in appendices,..." .
5.D.2 Land converted to Wetlands	CH4, N2O	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
5.E.1 Settlements remaining Settlements	CH4, N2O	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
5.E.2 Land converted to Settlements	CH4, N2O	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
5.F.2 Land converted to Other Land	CH4, N2O	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
5.G C from lime to forest	CH4, N2O	CH4 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	CO2, CH4, N2O	According to IPCC GPG 2003 HWP do not have to be reported (p.1.11 chp.1.7).

Table 249:   Overview, for completeness, of sources and sinks that are reported elsewhere (included elswhere, IE)

Source category	Greenhouse gas	Explanation
1.AA.2.A Iron and Steel	CO2	Emissions are reported under 2.C.1
1.AA.2.A Iron and Steel	N2O, CH4	Emissions are reported under 1.A.1 and 1.A.2 (blast furnace gas)
1.AA.2.B Non-Ferrous Metals	CO2, CH4, N2O	reported under 1A2f other (unspecified industrial power plants) because of confidential data
1.AA.2.C Chemicals	CO2, CH4, N2O	reported under 1A2f other (unspecified industrial power plants)
1.AA.2.D Pulp, Paper and Print	CH4	reported under 1A2f other (unspecified industriel) because of confidential data
1.AA.2.D Pulp, Paper and Print	CO2, CH4, N2O	reported under 1A2f other (unspecified industrial power plants)
1.AA.2.D Pulp, Paper and Print	CO2, N2O	reported under 1A2f other (unspecified industriel)
1.AA.2.E Food Processing, Beverages and Tobacco	CO2, CH4, N2O	reported under 1A2f other (unspecified industriel power plants)
1.B.1.A.2.2 Post-Mining Activities	CH4	considered in 1.B.1.A.2.1
1.B.1.B Solid Fuel Transformation	CO2	considered in 1.A.1.C
1.B.2.B.1 Exploration	CO2, CH4	considered in 1.B.2.a.i
1.B.2.B.5.1 at industrial plants and power stations	CH4	considered in 1.B.2.B.5.2
1.B.2.C.1.1 Oil	CO2, CH4	included in 1.B.2.A.ii
1.B.2.C.1.2 Gas	CO2, CH4	included in 1.B.2.B.iv
1.B.2.C.1.3 Combined	CO2, CH4	included in 1.B.2.A.ii and in 1.B.2.B.iv
1.B.2.C.2.3 Combined	CO2, CH4	considered in 1.B.2.C.2.1. and 1.B.2.C.2.2.
2.A.3 Limestone and Dolomite Use	CO2	allocation: 1.A.1.a, 2.A.1 and 2.A.2, 2.A.7, 2.C.1
2.A.4.2 Soda Ash Use	CO2	allocation: in using categories, mainly 2.A.7.1
2.A.7.2a - Ceramic production	CO2	see 2.A.7.2b bricks an tiles
2.C.1.2 Pig Iron	CH4	is considered in CRF 1A2
2.C.1.2 Pig Iron	CO2	is considered in oxygen steel
2.C.1.3 Sinter	CO2, CH4	is considered in CRF 1A2
2.C.1.4 Coke	CO2, CH4	is considered in CRF 1A1c
2.F.1 Refrigeration and Air Conditioning Equipment	SF6, HFCs, PFCs	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.3 Fire Extinguishers	HFCs	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.4 Aerosols/ Metered Dose Inhalers	HFCs	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.7 Semiconductor Manufacture	SF6, HFCs, PFCs	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.8 Electrical Equipment	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
2.F.P1 Production	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
3.D.3 N2O from Aerosol Cans	N2O	Emissions of N2O used in Aerosol cans of cream are aggregated in technical use of N2O in 3.D.4 Other Use of N2O.
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 are included in category 5.A. carbon stock change in biomass.
5.A.2 Land converted to Forest Land	CO2, CH4, N2O	Included in 5.A.1.
5.A.2.1 Cropland converted to Forest Land	Carbon	Included in gains.
5.A.2.2 Grassland converted to Forest Land	Carbon	Included in gains.

Source category	Greenhouse gas	Explanation
5.A.2.3 Wetlands converted to Forest Land	Carbon	Included in gains.
5.A.2.4 Settlements converted to Forest Land	Carbon	Included in gains.
5.A.2.5 Other Land converted to Forest Land	Carbon	Included in gains.
5.B.1 Cropland remaining Cropland	Carbon	Included in biomass.
5.B.1 Cropland remaining Cropland	CO2	Included in limestone.
5.B.2.1 Forest Land converted to Cropland	Carbon	Included in biomass.
5.B.2.1 Forest Land converted to Cropland	N2O	Included in mineral soils.
5.B.2.2 Grassland converted to Cropland	Carbon	Inlcuded in biomass.
5.B.2.2 Grassland converted to Cropland	N2O	Included in mineral soils.
5.B.2.3 Wetlands converted to Cropland	Carbon	Included in biomass.
5.B.2.3 Wetlands converted to Cropland	N2O	Included in mineral soils.
5.B.2.4 Settlements converted to Cropland	Carbon	included in biomass
5.B.2.4 Settlements converted to Cropland	N2O	included in mineral soils
5.B.2.5 Other Land converted to Cropland	Carbon	Included in biomass.
5.B.2.5 Other Land converted to Cropland	N2O	Included in mineral soils.
5.C.1 Grassland remaining Grassland	Carbon	Included in biomass.
5.C.1 Grassland remaining Grassland	CO2	Included in Cropland.
5.C.1 Grassland remaining Grassland	CO2	Included in limestone.
5.C.2.1 Forest Land converted to Grassland	Carbon	Included in biomass.
5.C.2.2 Cropland converted to Grassland	Carbon	Included in biomass.
5.C.2.3 Wetlands converted to Grassland	Carbon	Included in biomass.
5.C.2.4 Settlements converted to Grassland	Carbon	Included in biomass.
5.C.2.5 Other Land converted to Grassland	Carbon	Included in biomass.
5.D.1 Wetlands remaining Wetlands	Carbon	Included in biomass.
5.D.2.1 Forest Land converted to Wetlands	Carbon	Included in biomass.
5.D.2.2 Cropland converted to Wetlands	Carbon	Included in biomass.
5.D.2.3 Grassland converted to Wetlands	Carbon	Included in biomass.
5.D.2.4 Settlements converted to Wetlands	Carbon	Included in biomass.
5.D.2.5 Other Land converted to Wetlands	Carbon	Included in biomass.
5.E.1 Settlements remaining Settlements	Carbon	Included in biomass.
5.E.2.1 Forest Land converted to Settlements	Carbon	Included in biomass.
5.E.2.2 Cropland converted to Settlements	Carbon	Included in biomass.
5.E.2.3 Grassland converted to Settlements	Carbon	Included in biomass.
5.E.2.4 Wetlands converted to Settlements	Carbon	Included in biomass.
5.E.2.5 Other Land converted to Settlements	Carbon	Included in biomass.
5.F.2.1 Forest Land converted to Other Land	Carbon	Included in biomass.
5.F.2.2 Cropland converted to Other Land	Carbon	Included in biomass.
5.F.2.3 Grassland converted to Other Land	Carbon	Included in biomass.
5.F.2.4 Wetlands converted to Other Land	Carbon	Included in biomass.
5.F.2.5 Settlements converted to Other Land	Carbon	Included in biomass.
C from lime to forest	CO2	As data cannot be differentiated with regard to types of application (dolomite or lime) dolomite use is included on limestone use.
Car Tyres	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
Ceramics	CO2, CH4, N2O	reported under 1A2f other (unspecified industrial power plants) because of confidential data

Source category	Greenhouse gas	Explanation
Double glaze windows	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
Glass Wares	CO2, CH4, N2O	reported under 1A2f other (unspecified industrial power plants) because of confidential data
lime	CO2, CH4, N2O	reported under 1A2f other (unspecified industrial power plants) because of confidential data
Magnesium production	SF6	SF6 emissions are reported under 2.C.4 Aluminium and Magnesium Foundries
N2O for Medical Using	N2O	The emissions from the production of N2O for the use as Anasthetikum are included in the emissions from the use of Anasthetica in 3D
Shoes	PFCs, SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
Trace gas	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.

22 ANNEX 6: ADDITIONAL INFORMATION TO BE CONSIDERED AS PART OF THE NIR SUBMISSION (WHERE RELEVANT) OR AS OTHER USEFUL REFERENCE INFORMATION

22.1 Additional information about inventory preparation and about 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 Environment Agency, Section I 4.6[87] "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.

---

[87] 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) 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 departments 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 sources. 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 of 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 source 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 sources 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 sources), 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 (Chapters 1-5) 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 rates** 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 sources 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, co-ordinating and globally organising reporting. 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 documentation 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

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

Für deliverers of emission calculations, the minimum standards fort he documentation additionaly encompass the following parts:

1. Description of the pertinent calculation methods and reasons why the methods were selected;
2. Assumptions and criteria pertaining to selection of activity data and emission factors;
3. Documentation pertaining to emission factors and their sources, with detailed references to the relevant numbers and pages in original sources;
4. Calculation models;
5. 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 of 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 45). Additional relevant information is provided in the QSE manual, Chapter 4.3.
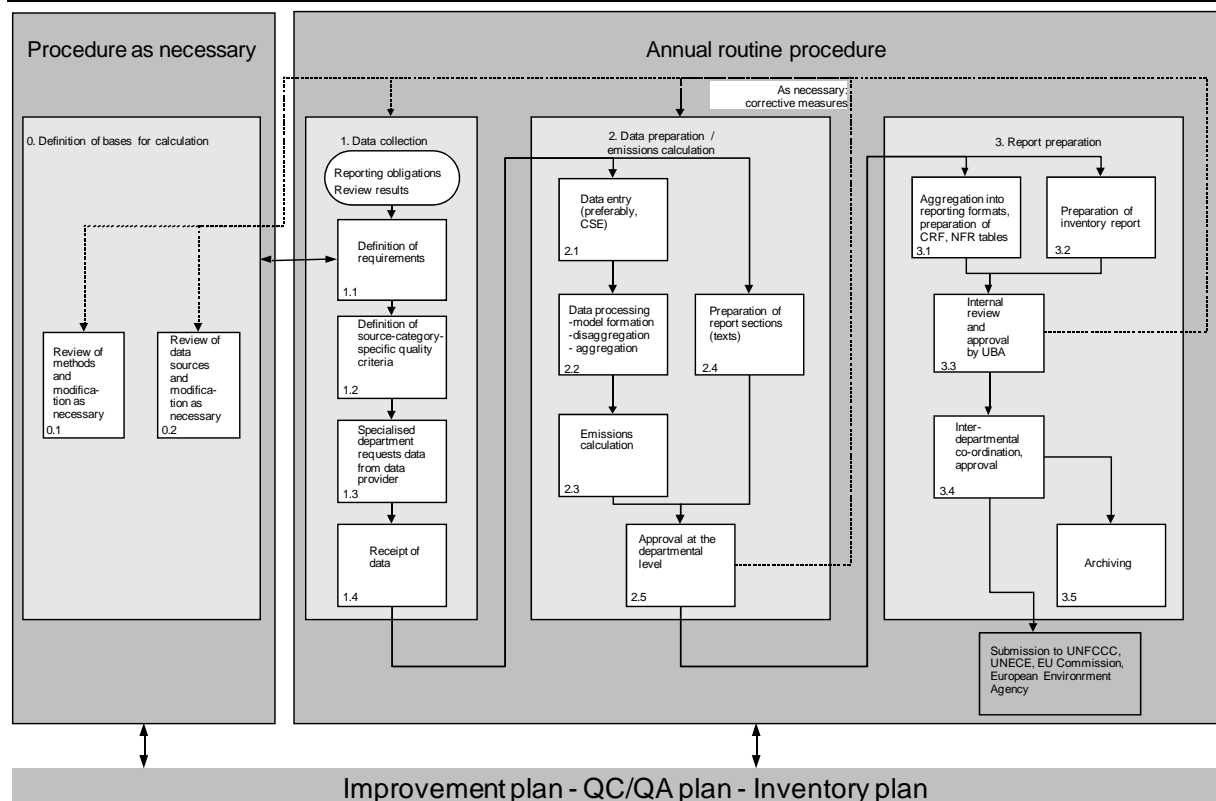
Figure 45:   Overview of the overall emissions-reporting process

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 fulfills and achieves 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

- 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
- 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
- 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
- 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
- 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   QK-Plan, QS-Plan und Inventarplan

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 46), 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
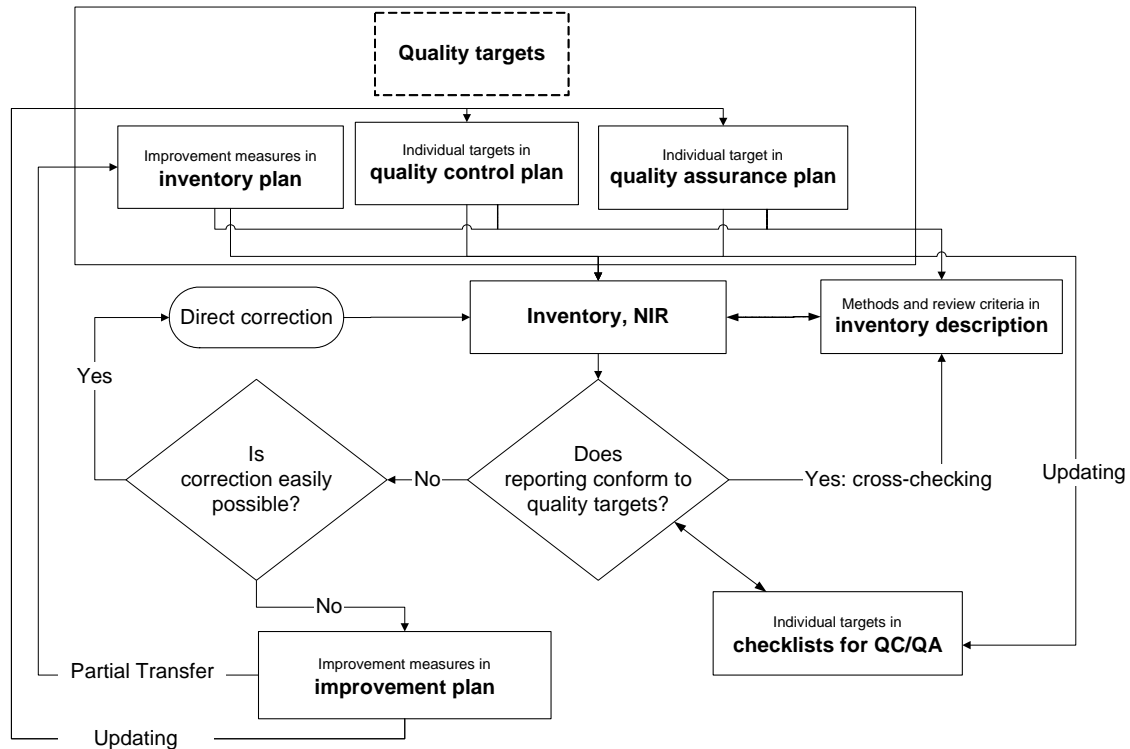

Figure 46:   Control and documentation in the framework of the NaSE and the QSE

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 commitee. 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 source 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. 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 250. 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 250:   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 251:   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.

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.

Process No.	Sub-process name	Individual goal	Optional goal
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 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). | |

Process No.	Sub-process name	Individual goal	Optional goal
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 the CSE)	All of the EF have been entered into the 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).	

Process No.	Sub-process name	Individual goal	Optional goal
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	

2.5		("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 is recorded within the same structure in which it is 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 14f – 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 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; 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 affected Federal Environment Agency employees.
- 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 2008

UNFCCC SEF application
Version 1.2

Workflow

Unlock file

Completeness Check

Consistency Check

Lock file

Functions

Mandatory data

Import XML

Reset SEF

Settings

Party:	Germany
ISO:	DE
Submission year:	2009
Reported year:	2008
Commitment period:	1
Completeness check:	NO
Consistency check:	NO
File locked:	NO
Lock timestamp:	
Submission version number:	2
Submission type:	

Party	Germany
Submission year	2009
Reported year	2008
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**	**ICERs**
Party holding accounts	NO	NO	NO	NO	NO	NO
Entity holding accounts	NO	NO	NO	NO	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	NO	NO	NO	NO	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	NO	NO	NO	NO	NO	NO

		Party	Germany
		Submission year	2009
		Reported year	2008
		Commitment period	1

Table 2 (a). Annual internal transactions

Transaction type	Additions Unit type						Subtractions Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Article 6 issuance and conversion												
Party-verified projects		NO					NO		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							215	NO	NO	100425	NO	NO
Sub-total		NO	NO				215	NO	NO	100425	NO	NO

Transaction type	Retirement Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Retirement	NO	NO	NO	NO	NO	NO

		Party	Germany
		Submission year	2009
		Reported year	2008
		Commitment period	1

Add registry   Delete registry

Table 2 (b). Annual external transactions

	Additions Unit type						Subtractions Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Transfers and acquisitions												
CDM	NO	NO	NO	8304830	NO	NO	NO	NO	NO	NO	NO	NO
AT	10811330	NO	NO	505000	NO	NO	4633602	NO	NO	495141	NO	NO
BE	268465	NO	NO	NO	NO	NO	145175	NO	NO	107041	NO	NO
CH	NO	NO	NO	11486947	NO	NO	NO	NO	NO	661752	NO	NO
CZ	8147068	NO	NO	NO	NO	NO	5000	NO	NO	47301	NO	NO
DK	5621350	NO	NO	760001	NO	NO	7968545	NO	NO	146744	NO	NO
ES	4088426	NO	NO	NO	NO	NO	2545515	NO	NO	89134	NO	NO
FI	62400	NO	NO	307979	NO	NO	1072079	NO	NO	26000	NO	NO
FR	4386967	NO	NO	1127448	NO	NO	7298126	NO	NO	147476	NO	NO
GB	63038368	NO	NO	24017240	NO	NO	64352120	NO	NO	4620417	NO	NO
HU	NO	NO	NO	30000	NO	NO	575000	NO	NO	640000	NO	NO
IE	5	NO	NO	NO	NO	NO	31005	NO	NO	NO	NO	NO
IT	200001	NO	NO	NO	NO	NO	61101	NO	NO	90133	NO	NO
LU	65000	NO	NO	NO	NO	NO	NO	NO	NO	80342	NO	NO
NL	13427580	NO	NO	1545530	NO	NO	13325646	NO	NO	392253	NO	NO
PL	NO	NO	NO	NO	NO	NO	739102	NO	NO	700053	NO	NO
PT	397117	NO	NO	NO	NO	NO	NO	NO	NO	53508	NO	NO
SE	195096	NO	NO	627927	NO	NO	819088	NO	NO	57000	NO	NO
SI	40000	NO	NO	NO	NO	NO	NO	NO	NO	204000	NO	NO
SK	282000	NO	NO	NO	NO	NO	1000	NO	NO	13000	NO	NO
Sub-total	111031173	NO	NO	48712902	NO	NO	103572104	NO	NO	8571295	NO	NO

Additional information

Independently verified ERUs							NO					

Table 2 (c). Total annual transactions

	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Total (Sum of tables 2a and 2b)	111031173	NO	NO	48712902	NO	NO	103.572.319	NO	NO	8671720	NO	NO

Party   Germany
Submission year   2009
Reported year   2008
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	ICERs
Party holding accounts	4,43E+09	NO	NO	NO	NO	NO
Entity holding accounts	4,45E+08	NO	NO	40041182	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	215	NO	NO	100425	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
ICER replacement account for expiry	NO	NO	NO	NO		
ICER replacement account for reversal of storage	NO	NO	NO	NO		NO
ICER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	4,88E+09	NO	NO	40141607	NO	NO

Party   Germany
Submission year   2009
Reported year   2008
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	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
Issuance pursuant to Article 3.7 and 3.8	4,87E+09											
Non-compliance cancellation							NO	NO	NO	NO		
Carry-over	NO	NO		NO								
Sub-total	4,87E+09	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)	1,11E+08	NO	NO	48712902	NO	NO	1,04E+08	NO	NO	8671720	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	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	1,11E+08	NO	NO	48712902	NO	NO	1,04E+08	NO	NO	8671720	NO	NO
Total	4,98E+09	NO	NO	48712902	NO	NO	1,04E+08	NO	NO	8671720	NO	NO

Table 5 (b). Summary information on replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs
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

Year	Retirement					
	Unit type					
	AAUs	**ERUs**	**RMUs**	**CERs**	**tCERs**	**ICERs**
Year 1 (2008)	NO	NO	NO	NO	NO	NO
Year 2 (2009)	NO	NO	NO	NO	NO	NO
Year 3 (2010)	NO	NO	NO	NO	NO	NO
Year 4 (2011)	NO	NO	NO	NO	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	NO	NO	NO	NO	NO	NO

Table 6 (a). Memo item: Corrective transactions relating to additions and subtractions

	Additions						Subtractions					
	Unit type						Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	ICERs	AAUs	ERUs	RMUs	CERs	tCERs	ICERs

Table 6 (c). Memo item: Corrective transactions relating to retirement

	Retirement					
	Unit type					
	AAUs	**ERUs**	**RMUs**	**CERs**	**tCERs**	**ICERs**

Table 6 (b). Memo item: Corrective transactions relating to replacement

	Requirement for replacement		Replacement					
	Unit type		Unit type					
	tCERs	**ICERs**	**AAUs**	**ERUs**	**RMUs**	**CERs**	**tCERs**	**ICERs**

22.2.3 *Detailed information about the National System and about changes in the National System*

All such information was provided in the previous chapters.

22.2.4   Additional detailed information regarding the National Registries and accounting (bookkeeping) for Kyoto units

22.2.4.1   LIST OF TRANSACTIONS FORWARDING CER FROM THE CDM REGISTRY TO ACCOUNTS IN THE GERMAN REGISTRY

Transaction	Time of transaction	Type	Source Account	Destination Account	Total
December 2008					
CDM4672	15.12.2008 11:43	03-00	CDM-110-1000	DE-121-2095-0	63,051
CDM4517	04.12.2008 11:55	03-00	CDM-110-1000	DE-121-2095-0	28,330
November 2008					
CDM4419	28.11.2008 10:43	03-00	CDM-110-1000	DE-121-2095-0	20,685
CDM4420	28.11.2008 10:38	03-00	CDM-110-1000	DE-121-2095-0	7,357
CDM4421	28.11.2008 10:31	03-00	CDM-110-1000	DE-121-2095-0	15,220
CDM4105	10.11.2008 14:32	03-00	CDM-110-1000	DE-121-2095-0	78,676
CDM4094	06.11.2008 17:46	03-00	CDM-110-1000	DE-121-1914-0	278,747
CDM4084	06.11.2008 17:19	03-00	CDM-110-1000	DE-121-1914-0	244,762
October 2008					
CDM3902	22.10.2008 11:31	03-00	CDM-100-2057-0	DE-120-1365-0	30,000
CDM3903	22.10.2008 11:30	03-00	CDM-100-2083-0	DE-121-1914-0	4,919,758
CDM3901	22.10.2008 11:26	03-00	CDM-100-2008-0	DE-121-2095-0	2,137,524
CDM3900	22.10.2008 11:25	03-00	CDM-100-2182-0	DE-121-3591-0	146,744
CDM3899	22.10.2008 11:24	03-00	CDM-100-2166-0	DE-121-1956-0	127,476
CDM3905	22.10.2008 11:16	03-00	CDM-100-2132-0	DE-121-1931-0	70,000
CDM3904	22.10.2008 11:14	03-00	CDM-100-2104-0	DE-120-185-0	71,500
CDM3898	22.10.2008 11:10	03-00	CDM-100-2130-0	DE-120-511-0	65,000
				Total	8,304,830

22.2.4.2   LIST OF RECONCILIATION RESULTS

Snapshot day & time	Reconciliation status	Action Begin date & time	Action end date & time	Remarks
10/10/2008 11:39	ITL Completed	10.10.08 11:19 AM	10.10.08 11:39 AM	
10/10/2008 19:50	ITL Completed	10.10.08 7:30 PM	10.10.08 7:50 PM	
11/10/2008 19:50	ITL Start Request Denied	10.12.08 11:06 PM	10.12.08 11:06 PM	ITL problem
14/10/2008 14:47	ITL Completed	10.14.08 2:27 PM	10.14.08 2:47 PM	
17/10/2008 14:27	ITL Completed	10.17.08 2:07 PM	10.17.08 2:27 PM	
18/10/2008 03:50	ITL Completed	10.18.08 3:30 AM	10.18.08 3:50 AM	
19/10/2008 03:50	ITL Completed	10.19.08 3:30 AM	10.19.08 3:50 AM	
20/10/2008 03:50	ITL Completed	10.20.08 3:30 AM	10.20.08 3:50 AM	
21/10/2008 03:50	ITL Completed	10.21.08 3:30 AM	10.21.08 3:50 AM	
22/10/2008 03:50	ITL Completed	10.22.08 3:30 AM	10.22.08 3:50 AM	
23/10/2008 03:50	ITL Completed	10.23.08 3:30 AM	10.23.08 3:50 AM	
24/10/2008 03:50	ITL Completed	10.24.08 3:30 AM	10.24.08 3:50 AM	
25/10/2008 03:50	ITL Completed	10.25.08 3:30 AM	10.25.08 3:50 AM	
26/10/2008 02:50	ITL Completed	10.26.08 2:30 AM	10.26.08 2:50 AM	
27/10/2008 02:50	ITL Completed	10.27.08 2:30 AM	10.27.08 2:50 AM	
28/10/2008 02:50	ITL Completed	10.28.08 2:30 AM	10.28.08 2:50 AM	
29/10/2008 02:50	ITL Completed	10.29.08 2:30 AM	10.29.08 2:50 AM	
30/10/2008 02:50	ITL Completed	10.30.08 2:30 AM	10.30.08 2:50 AM	
31/10/2008 02:50	ITL Completed	10.31.08 2:30 AM	10.31.08 2:50 AM	
01/11/2008 02:50	ITL Completed with	11.1.08 2:30 AM	11.3.08 9:04 AM	CITL problem

Snapshot day & time	Reconciliation status	Action Begin date & time	Action end date & time	Remarks
	Manual Intervention			
03/11/2008 02:50	ITL Completed with Manual Intervention	11.3.08 2:30 AM	11.3.08 2:30 AM	The recon from 01/11/2008 was still pending
03/11/2008 10:43	ITL Completed	11.3.08 10:23 AM	11.3.08 10:43 AM	
04/11/2008 02:50	ITL Completed	11.4.08 2:30 AM	11.4.08 2:50 AM	
05/11/2008 02:50	ITL Completed	11.5.08 2:30 AM	11.5.08 2:50 AM	
06/11/2008 02:50	ITL Completed	11.6.08 2:30 AM	11.6.08 2:50 AM	
07/11/2008 02:50	ITL Completed	11.7.08 2:30 AM	11.7.08 2:50 AM	
08/11/2008 02:50	ITL Completed	11.8.08 2:30 AM	11.8.08 2:50 AM	
09/11/2008 02:50	ITL Completed	11.9.08 2:30 AM	11.9.08 2:50 AM	
10/11/2008 02:50	ITL Completed	11.10.08 2:30 AM	11.10.08 2:50 AM	
11/11/2008 02:50	ITL Completed	11.11.08 2:30 AM	11.11.08 2:50 AM	
12/11/2008 02:50	ITL Completed with Manual Intervention	11.12.08 2:30 AM	11.12.08 9:32 AM	Communication problems, solved the same day
12/11/2008 10:43	ITL Completed	11.12.08 10:23 AM	11.12.08 10:44 AM	
13/11/2008 02:50	ITL Completed	11.13.08 2:30 AM	11.13.08 2:50 AM	
14/11/2008 02:50	ITL Completed	11.14.08 2:30 AM	11.14.08 2:50 AM	
15/11/2008 02:50	ITL Completed	11.15.08 2:30 AM	11.15.08 2:50 AM	
16/11/2008 02:50	ITL Completed	11.16.08 2:30 AM	11.16.08 2:50 AM	
17/11/2008 02:50	ITL Completed	11.17.08 2:30 AM	11.17.08 2:50 AM	
18/11/2008 02:50	ITL Completed	11.18.08 2:30 AM	11.18.08 2:50 AM	
19/11/2008 02:50	ITL Completed	11.19.08 2:30 AM	11.19.08 2:50 AM	
20/11/2008 02:50	ITL Completed	11.20.08 2:30 AM	11.20.08 2:50 AM	
21/11/2008 02:50	ITL Completed	11.21.08 2:30 AM	11.21.08 2:50 AM	
22/11/2008 02:50	ITL Completed	11.22.08 2:31 AM	11.22.08 2:50 AM	
23/11/2008 02:50	ITL Completed	11.23.08 2:30 AM	11.23.08 2:50 AM	
24/11/2008 02:50	ITL Completed	11.24.08 2:29 AM	11.24.08 2:50 AM	
25/11/2008 02:50	ITL Completed	11.25.08 2:30 AM	11.25.08 2:50 AM	
26/11/2008 02:50	ITL Completed	11.26.08 2:30 AM	11.26.08 2:50 AM	
28/11/2008 02:50	ITL Completed	11.28.08 2:30 AM	11.28.08 2:50 AM	
29/11/2008 02:50	ITL Completed	11.29.08 2:30 AM	11.29.08 2:51 AM	
30/11/2008 02:50	ITL Completed	11.30.08 2:30 AM	11.30.08 2:50 AM	
01/12/2008 02:50	ITL Completed	12.1.08 2:30 AM	12.1.08 2:50 AM	
02/12/2008 02:50	ITL Completed	12.2.08 2:30 AM	12.2.08 2:50 AM	
03/12/2008 02:50	ITL Completed	12.3.08 2:30 AM	12.3.08 2:50 AM	
04/12/2008 02:50	ITL Completed	12.4.08 2:30 AM	12.4.08 2:50 AM	
05/12/2008 02:50	ITL Completed	12.5.08 2:29 AM	12.5.08 2:50 AM	
06/12/2008 02:50	ITL Completed	12.6.08 2:30 AM	12.6.08 2:51 AM	
07/12/2008 02:50	ITL Completed	12.7.08 2:30 AM	12.7.08 2:51 AM	
08/12/2008 02:50	ITL Completed	12.8.08 2:30 AM	12.8.08 2:50 AM	
09/12/2008 02:50	ITL Completed	12.9.08 2:30 AM	12.9.08 2:50 AM	
10/12/2008 02:50	ITL Completed	12.10.08 2:29 AM	12.10.08 2:50 AM	
11/12/2008 02:50	ITL Completed	12.11.08 2:30 AM	12.11.08 2:50 AM	
12/12/2008 02:50	ITL Completed	12.12.08 2:30 AM	12.12.08 2:50 AM	
13/12/2008 02:50	ITL Completed	12.13.08 2:30 AM	12.13.08 2:50 AM	
14/12/2008 02:50	ITL Completed	12.14.08 2:30 AM	12.14.08 2:50 AM	
15/12/2008 02:50	ITL Completed	12.15.08 2:30 AM	12.15.08 2:50 AM	
16/12/2008 02:50	ITL Completed	12.16.08 2:29 AM	12.16.08 2:50 AM	
17/12/2008 02:50	ITL Completed	12.17.08 2:30 AM	12.17.08 2:50 AM	

Snapshot day & time	Reconciliation status	Action Begin date & time	Action end date & time	Remarks
18/12/2008 02:50	ITL Completed	12.18.08 2:30 AM	12.18.08 2:50 AM	
19/12/2008 02:50	ITL Completed	12.19.08 2:30 AM	12.19.08 2:50 AM	
20/12/2008 02:50	ITL Completed	12.20.08 2:30 AM	12.20.08 2:50 AM	
21/12/2008 02:50	ITL Completed	12.21.08 2:30 AM	12.21.08 2:50 AM	
22/12/2008 02:50	ITL Completed	12.22.08 2:30 AM	12.22.08 2:50 AM	
23/12/2008 02:50	ITL Completed	12.23.08 2:30 AM	12.23.08 2:50 AM	
24/12/2008 02:50	ITL Completed	12.24.08 2:30 AM	12.24.08 2:50 AM	
25/12/2008 02:50	ITL Completed	12.25.08 2:30 AM	12.25.08 2:50 AM	
26/12/2008 02:50	ITL Completed	12.26.08 2:30 AM	12.26.08 2:50 AM	
27/12/2008 02:50	ITL Completed	12.27.08 2:30 AM	12.27.08 2:50 AM	
28/12/2008 02:50	ITL Completed	12.28.08 2:30 AM	12.28.08 2:50 AM	
29/12/2008 02:50	ITL Completed	12.29.08 2:30 AM	12.29.08 2:50 AM	
30/12/2008 02:50	ITL Completed	12.30.08 2:30 AM	12.30.08 2:50 AM	
31/12/2008 02:50	ITL Completed	12.31.08 2:30 AM	12.31.08 2:50 AM	
01/01/2009 02:50	ITL Completed	1.1.09 2:30 AM	1.1.09 2:50 AM	

22.2.4.3   SCREENSHOTS OF PUBLICLY AVAILABLE INFORMATION

22.2.4.4   Publicly available information for each account

Account identifier

Account name

Account type

Account holder

Primary authorized representative

- Role
- Name
- Person Identifier
- Additional address
- Address
- Postal Code and City
- Country
- Tel
- Tel 2
- Fax
- Email

Secondary authorized representative

- Contact information please see Primary authorized representative

Additional authorized representative

- Contact information please see Primary authorized representative

Permit identifier

Allowances (tradable unit types for this account)

Publicly available information for each JI project

- Project name
- Project location
- Years of ERU issuance
- Downloadable reports

Publicly available holding information

(will be publicly available from 15 January 2010 onwards)

- The total quantity of ERU, CER, AAU and RMU in each account at the beginning of the year
- The total quantity of AAU issued on the basis of the assigned amount pursuant to Article 3, paragraphs 7 and 8
- The total quantity of ERU issued on the basis of Article 6 projects
- The total quantity of ERU, CER, AAU and RMU acquired from other registries and the identity of the transferring accounts and registries
- The total quantity of RMU issued on the basis of each activity under Article 3, paragraphs 3 and 4
- The total quantity of ERU, CER, AAU and RMU transferred to other registries and the identity of the acquiring accounts and registries
- The total quantity of ERU, CER, AAU and RMU cancelled on the basis of activities under Article 3, paragraphs 3 and 4
- The total quantity of ERU, CER, AAU and RMU cancelled following determination by the Compliance Committee that the Party is not in compliance with its commitment under Article 3, paragraph 1
- The total quantity of other ERU, CER, AAU and RMU cancelled
- The total quantity of ERUs, CERs, AAUs and RMUs retired
- The total quantity of ERUs, CERs, and AAUs carried over from the previous commitment period
- Current holdings of ERUs, CERs, AAUs and RMUs in each account

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

GG emissions / sinks, in CO_2 equivalents (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Net CO_2 emissions / storage	1,016,438	978,446	929,323	919,174	904,006	903,407	926,278	894,733	888,729	861,727	864,733	893,191	921,759	922,193	905,049	887,701	897,128	871,887	862,488
CO_2 emissions (not including LULUCF)	1,036,716	999,132	951,257	941,051	926,037	925,413	948,235	917,188	910,954	884,198	886,900	903,720	887,987	885,635	872,476	853,540	861,339	833,926	833,092
CH_4	103,299	98,019	93,685	92,924	88,116	84,839	81,885	78,035	72,761	71,906	67,959	64,623	61,102	57,604	53,687	51,474	49,498	48,146	47,745
N_2O	79,989	77,173	77,821	75,525	75,972	75,749	77,602	74,597	61,291	57,641	57,572	59,593	58,376	57,532	59,960	57,775	56,654	59,028	60,166
HFCs	4,369	4,013	4,190	6,160	6,330	6,469	5,855	6,392	6,962	7,204	6,483	7,892	8,795	8,625	9,235	9,990	10,527	11,141	11,469
PFCs	2,708	2,333	2,102	1,961	1,650	1,750	1,714	1,368	1,471	1,240	781	717	787	849	820	707	569	528	531
SF_6	4,785	5,118	5,634	6,405	6,993	7,220	6,932	6,905	6,705	5,314	5,082	4,950	4,242	4,384	4,559	4,898	5,510	5,567	5,846

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total emissions / storage, including LULUCF	1,211,588	1,165,101	1,112,755	1,102,149	1,083,067	1,079,434	1,100,266	1,062,031	1,037,919	1,005,032	1,002,611	1,030,966	1,055,062	1,051,186	1,033,310	1,012,544	1,019,887	996,296	988,246
Total emissions, not including CO_2 from LULUCF	1,231,865	1,185,787	1,134,688	1,124,025	1,105,098	1,101,440	1,122,223	1,084,485	1,060,143	1,027,503	1,024,777	1,041,495	1,021,290	1,014,628	1,000,738	978,383	984,097	958,335	958,850

GG 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	2005	2006	2007	2008
1. Energy	989,661	954,664	906,537	899,329	876,956	873,671	900,328	863,577	855,689	833,135	829,786	849,911	833,559	829,783	813,301	796,201	800,687	769,714	772,788
2. Industrial processes	118,227	113,722	113,928	112,110	120,504	120,565	116,740	119,288	105,573	97,229	100,447	99,139	99,210	99,354	102,581	99,533	103,065	108,976	104,894
3. Solvent and other product use	5,396	5,407	5,192	5,109	4,421	4,458	4,375	4,369	4,362	4,042	3,723	3,441	3,371	3,282	3,391	3,402	3,345	3,316	3,316
4. Agriculture	78,046	71,498	69,159	68,839	66,713	68,405	68,929	68,115	68,045	68,899	68,697	68,234	66,172	65,050	65,958	65,359	64,056	63,763	66,203
5. Land use, land-use changes & forestry	-20,165	-20,579	-21,798	-21,765	-21,922	-21,901	-21,846	-22,349	-22,120	-22,367	-22,061	-9,732	34,569	37,364	33,371	34,959	36,450	38,961	30,185
CO_2	-20,277	-20,686	-21,934	-21,876	-22,031	-22,006	-21,957	-22,455	-22,224	-22,471	-22,166	-10,530	33,772	36,558	32,572	34,161	35,790	37,961	29,396
N_2O & CH_4	113	108	136	112	109	105	111	106	104	104	105	798	798	806	799	798	661	1,000	789
6. Waste	40,423	40,388	39,736	38,526	36,395	34,234	31,740	29,031	26,369	24,093	22,020	19,973	18,180	16,352	14,708	13,090	12,283	11,566	10,859

Table 253:   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	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CO_2 emissions (not including LULUCF)	84.2	84.3	83.8	83.7	83.8	84.0	84.5	84.6	85.9	86.1	86.5	86.8	86.9	87.3	87.2	87.2	87.5	87.0	86.9
CH_4	8.4	8.3	8.3	8.3	8.0	7.7	7.3	7.2	6.9	7.0	6.6	6.2	6.0	5.7	5.4	5.3	5.0	5.0	5.0
N_2O	6.5	6.5	6.9	6.7	6.9	6.9	6.9	6.9	5.8	5.6	5.6	5.7	5.7	5.7	6.0	5.9	5.8	6.2	6.3
HFCs	0.4	0.3	0.4	0.5	0.6	0.6	0.5	0.6	0.7	0.7	0.6	0.8	0.9	0.9	0.9	1.0	1.1	1.2	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
SF_6	0.4	0.4	0.5	0.6	0.6	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.6	0.6	0.6
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

GG 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
1. Energy	80.3	80.5	79.9	80.0	79.4	79.3	80.2	79.6	80.7	81.1	81.0	81.6	81.6	81.8	81.3	81.4	81.4	80.3	80.6
2. Industrial processes	9.6	9.6	10.0	10.0	10.9	10.9	10.4	11.0	10.0	9.5	9.8	9.5	9.7	9.8	10.3	10.2	10.5	11.4	10.9
3. Solvent and other product use	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
4. Agriculture	6.3	6.0	6.1	6.1	6.0	6.2	6.1	6.3	6.4	6.7	6.7	6.6	6.5	6.4	6.6	6.7	6.5	6.7	6.9
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	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6. Waste	3.3	3.4	3.5	3.4	3.3	3.1	2.8	2.7	2.5	2.3	2.1	1.9	1.8	1.6	1.5	1.3	1.2	1.2	1.1
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

Table 254:   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	2005	2006	2007	2008
Net CO_2 emissions / storage	1,016,438	978,446	929,323	919,174	904,006	903,407	926,278	894,733	888,729	861,727	864,733	893,191	921,759	922,193	905,049	887,701	897,128	871,887	862,488
CO_2 emissions (not including LULUCF)	1,036,716	999,132	951,257	941,051	926,037	925,413	948,235	917,188	910,954	884,198	886,900	903,720	887,987	885,635	872,476	853,540	861,339	833,926	833,092
CH_4	4,919	4,668	4,461	4,425	4,196	4,040	3,899	3,716	3,465	3,424	3,236	3,077	2,910	2,743	2,557	2,451	2,357	2,293	2,274
N_2O	258	249	251	244	245	244	250	241	198	186	186	192	188	186	193	186	183	190	194
HFCs (CO_2 equivalent)	4,369	4,013	4,190	6,160	6,330	6,469	5,855	6,392	6,962	7,204	6,483	7,892	8,795	8,625	9,235	9,990	10,527	11,141	11,469
PFCs (CO_2 equivalent)	2,708	2,333	2,102	1,961	1,650	1,750	1,714	1,368	1,471	1,240	781	717	787	849	820	707	569	528	531
SF_6 (CO_2 equivalent)	4,785	5,118	5,634	6,405	6,993	7,220	6,932	6,905	6,705	5,314	5,082	4,950	4,242	4,384	4,559	4,898	5,510	5,567	5,846
CO	12,178	9,949	8,605	7,792	6,844	6,582	6,193	6,074	5,684	5,310	5,039	4,771	4,473	4,264	4,062	3,829	3,807	3,763	3,741
NMVOC	3,736	3,186	2,913	2,671	2,193	2,076	1,984	1,943	1,902	1,746	1,580	1,484	1,409	1,339	1,349	1,328	1,295	1,273	1,267
NO_X	2,877	2,654	2,494	2,385	2,239	2,149	2,067	1,984	1,938	1,908	1,846	1,763	1,668	1,605	1,563	1,503	1,509	1,442	1,380
SO_2	5,311	3,921	3,197	2,852	2,386	1,713	1,447	1,203	964	791	637	632	585	570	555	524	532	506	498

Table 255:   Changes in emissions of directly and indirectly acting 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
Net CO_2 emissions / storage	0.0	-3.7	-8.6	-9.6	-11.1	-11.1	-8.9	-12.0	-12.6	-15.2	-14.9	-12.1	-9.3	-9.3	-11.0	-12.7	-11.7	-14.2	-15.1
CO_2 emissions (not including LULUCF)	0.0	-3.6	-8.2	-9.2	-10.7	-10.7	-8.5	-11.5	-12.1	-14.7	-14.5	-12.8	-14.3	-14.6	-15.8	-17.7	-16.9	-19.6	-19.6
CH_4	0.0	-5.1	-9.3	-10.0	-14.7	-17.9	-20.7	-24.5	-29.6	-30.4	-34.2	-37.4	-40.8	-44.2	-48.0	-50.2	-52.1	-53.4	-53.8
N_2O	0.0	-3.5	-2.7	-5.6	-5.0	-5.3	-3.0	-6.7	-23.4	-27.9	-28.0	-25.5	-27.0	-28.1	-25.0	-27.8	-29.2	-26.2	-24.8
HFCs (CO_2 equivalent)						0.0	-9.5	-1.2	+7.6	+11.4	+0.2	+22.0	+36.0	+33.3	+42.8	+54.4	+62.7	+72.2	+77.3
PFCs (CO_2 equivalent)						0.0	-2.1	-21.8	-15.9	-29.1	-55.3	-59.0	-55.0	-51.5	-53.1	-59.6	-67.5	-69.8	-69.7
SF_6 (CO_2 equivalent)						0.0	-4.0	-4.4	-7.1	-26.4	-29.6	-31.4	-41.3	-39.3	-36.9	-32.2	-23.7	-22.9	-19.0
Changes in total GG emissions and storage																			
Total emissions with respect to EU burden-sharing[88]	-0.0	-3.8	-7.9	-8.8	-10.3	-10.6	-8.9	-12.0	-14.0	-16.6	-16.8	-15.5	-17.1	-17.7	-18.8	-20.6	-20.1	-22.2	-22.2
CO	0.0	-18.3	-29.3	-36.0	-43.8	-45.9	-49.1	-50.1	-53.3	-56.4	-58.6	-60.8	-63.3	-65.0	-66.6	-68.6	-68.7	-69.1	-69.3
NMVOC	0.0	-14.7	-22.0	-28.5	-41.3	-44.4	-46.9	-48.0	-49.1	-53.3	-57.7	-60.3	-62.3	-64.2	-63.9	-64.5	-65.3	-65.9	-66.1
NO_X	0.0	-7.8	-13.3	-17.1	-22.2	-25.3	-28.2	-31.0	-32.7	-33.7	-35.8	-38.7	-42.0	-44.2	-45.7	-47.8	-47.6	-49.9	-52.0
SO_2	0.0	-26.2	-39.8	-46.3	-55.1	-67.7	-72.8	-77.3	-81.8	-85.1	-88.0	-88.1	-89.0	-89.3	-89.5	-90.1	-90.0	-90.5	-90.6

---

[88] Defined base-year emissions of 1,232,430 Gg CO_2 equivalent; cf. Chapter 0.2

Table 256:   Changes in emissions of directly and indirectly acting 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
Net CO_2 emissions / storage	0.0	-3.7	-5.0	-1.1	-1.7	-0.1	+2.5	-3.4	-0.7	-3.0	+0.3	+3.3	+3.2	+0.0	-1.9	-1.9	+1.1	-2.8	-1.1
CO_2 emissions (not including LULUCF)	0.0	-3.6	-4.8	-1.1	-1.6	-0.1	+2.5	-3.3	-0.7	-2.9	+0.3	+1.9	-1.7	-0.3	-1.5	-2.2	+0.9	-3.2	-0.10
CH_4	0.0	-5.1	-4.4	-0.8	-5.2	-3.7	-3.5	-4.7	-6.8	-1.2	-5.5	-4.9	-5.4	-5.7	-6.8	-4.1	-3.8	-2.7	-0.8
N_2O	0.0	-3.5	+0.8	-3.0	+0.6	-0.3	+2.4	-3.9	-17.8	-6.0	-0.1	+3.5	-2.0	-1.4	+4.2	-3.6	-1.9	+4.2	+1.9
HFCs (CO_2 equivalent)	0.0	-8.1	+4.4	+47.0	+2.8	+2.2	-9.5	+9.2	+8.9	+3.5	-10.0	+21.7	+11.4	-1.9	+7.1	+8.2	+5.4	+5.8	+3.0
PFCs (CO_2 equivalent)	0.0	-13.8	-9.9	-6.7	-15.9	+6.1	-2.1	-20.2	+7.5	-15.7	-37.0	-8.2	+9.7	+7.8	-3.4	-13.9	-19.4	-7.3	+0.5
SF_6 (CO_2 equivalent)	0.0	+7.0	+10.1	+13.7	+9.2	+3.3	-4.0	-0.4	-2.9	-20.7	-4.4	-2.6	-14.3	+3.4	+4.0	+7.4	+12.5	+1.0	+5.0
Changes in total GG emissions and storage																			
Total emissions / storage, including LULUCF	0.0	-3.8	-4.5	-1.0	-1.7	-0.3	+1.9	-3.5	-2.3	-3.2	-0.2	+2.8	+2.3	-0.4	-1.7	-2.0	+0.7	-2.3	-0.8
Total emissions, not including CO_2 from LULUCF	0.0	-3.7	-4.3	-0.9	-1.7	-0.3	+1.9	-3.4	-2.2	-3.1	-0.3	+1.6	-1.9	-0.7	-1.4	-2.2	+0.6	-2.6	+0.05
CO	0.0	-18.3	-13.5	-9.4	-12.2	-3.8	-5.9	-1.9	-6.4	-6.6	-5.1	-5.3	-6.3	-4.7	-4.7	-5.7	-0.6	-1.1	-0.6
NMVOC	0.0	-14.7	-8.6	-8.3	-17.9	-5.3	-4.4	-2.1	-2.1	-8.2	-9.5	-6.1	-5.1	-4.9	+0.7	-1.6	-2.5	-1.7	-0.5
NO_x	0.0	-7.8	-6.0	-4.4	-6.1	-4.0	-3.8	-4.0	-2.3	-1.5	-3.2	-4.5	-5.4	-3.8	-2.6	-3.8	+0.4	-4.4	-4.3
SO_2	0.0	-26.2	-18.5	-10.8	-16.4	-28.2	-15.5	-16.9	-19.9	-17.9	-19.5	-0.7	-7.6	-2.5	-2.6	-5.6	+1.4	-4.8	-1.7

Table 257:   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
1. Energy	0.0	-3.5	-8.4	-9.1	-11.4	-11.7	-9.0	-12.7	-13.5	-15.8	-16.2	-14.1	-15.8	-16.2	-17.8	-19.5	-19.1	-22.2	-21.9
2. Industrial processes	0.0	-3.8	-3.6	-5.2	1.9	2.0	-1.3	0.9	-10.7	-17.8	-15.0	-16.1	-16.1	-16.0	-13.2	-15.8	-12.8	-7.8	-11.3
3. Solvent and other product use	0.0	0.2	-3.8	-5.3	-18.1	-17.4	-18.9	-19.0	-19.2	-25.1	-31.0	-36.2	-37.5	-39.2	-37.2	-37.0	-38.0	-38.5	-38.5
4. Agriculture	0.0	-8.4	-11.4	-11.8	-14.5	-12.4	-11.7	-12.7	-12.8	-11.7	-12.0	-12.6	-15.2	-16.7	-15.5	-16.3	-17.9	-18.3	-15.2
5. Land use, land-use changes & forestry	0.0	2.0	8.2	7.9	8.7	8.6	8.3	10.8	9.6	10.9	9.3	-51.6	-270.8	-284.5	-264.8	-272.7	-280.1	-292.5	-249.1
CO_2 *(net sink)*	0.0	2.0	8.2	7.9	8.7	8.5	8.3	10.7	9.6	10.8	9.3	-48.1	-266.5	-280.3	-260.6	-268.5	-276.5	-287.2	-245.0
N_2O & CH_4	0.0	-1.5	7.4	-0.2	-1.0	-2.2	-0.4	-2.2	-2.6	-2.6	-2.2	1.184.4	1.184.4	1.187.2	1.184.7	1.184.5	947.0	1.528.8	1.165.4
6. Waste	0.0	-0.1	-1.7	-4.7	-10.0	-15.3	-21.5	-28.2	-34.8	-40.4	-45.5	-50.6	-55.0	-59.5	-63.6	-67.6	-69.6	-71.4	-73.1

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
1. Energy	0.0	-3.5	-5.0	-0.8	-2.5	-0.4	3.1	-4.1	-0.9	-2.6	-0.4	2.4	-1.9	-0.5	-2.0	-2.1	0.6	-3.9	0.4
2. Industrial processes	0.0	-3.8	0.2	-1.6	7.5	0.1	-3.2	2.2	-11.5	-7.9	3.3	-1.3	0.1	0.1	3.2	-3.0	3.5	5.7	-3.7
3. Solvent and other product use	0.0	0.2	-4.0	-1.6	-13.5	0.8	-1.9	-0.1	-0.1	-7.3	-7.9	-7.6	-2.0	-2.7	3.3	0.3	-1.7	-0.9	0.0
4. Agriculture	0.0	-8.4	-3.3	-0.5	-3.1	2.5	0.8	-1.2	-0.1	1.3	-0.3	-0.7	-3.0	-1.7	1.4	-0.9	-2.0	-0.5	3.8
5. Land use, land-use changes & forestry	0.0	2.0	6.0	-0.2	0.7	-0.1	-0.2	2.3	-1.0	1.1	-1.4	-55.8	-453.1	8.1	-10.7	4.8	4.3	6.9	-22.6
CO_2 *(net sink)*	0.0	2.0	6.0	-0.3	0.7	-0.1	-0.2	2.3	-1.0	1.1	-1.4	-52.5	-420.7	8.3	-10.9	4.9	4.8	6.1	-22.6
N_2O & CH_4	0.0	-1.5	9.0	-7.1	-0.8	-1.2	1.8	-1.8	-0.5	0.0	0.4	1.213.4	0.0	0.2	-0.2	0.0	-18.5	55.6	-22.3
6. Waste	0.0	-0.1	-1.6	-3.0	-5.5	-5.9	-7.3	-8.5	-9.2	-8.6	-8.6	-9.3	-9.0	-10.1	-10.1	-11.0	-6.2	-5.8	-6.1

23   ANNEX 7: TABLE 6.1 OF THE IPCC GOOD PRACTICE GUIDANCE

In German greenhouse-gas inventories, uncertainties have not 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. At the same time, additional uncertainties have been determined via experts' assessments and added to the CSE database. An uncertainties data set, determined predominantly via experts' assessments, is now available. A complete data set, which is required for calculations, is obtained via the following: in cases in which experts' assessments are not yet available, uncertainties from data reported in the relevant technical literature, and uncertainties derived via adjustment procedures, using IPCC Conservativeness Factors[89] , are used. The expert-assessment process is being continued on an ongoing basis, 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 and Table 6.2 of the IPCC Good Practice Guidance, in Table 258 and Table 259.

---

[89] FCCC/SBSTA/2003/10/Add.2, Annex III, p. 24-27

Table 258:   Table 6.1 of the IPCC Good Practice Guidance - Details

IPCC Source	Fuel Category	Gas	Base year emissions	2008 emissions	Combined Uncertainty as % of total nat. emissions in 2008	Tier1 Level Assesment	Uncertainty introduced into the trend in total
Category			[Gg CO₂ equi.]	[Gg CO₂ equi.]	[%]	[%]	[%]
1A1a Public electricity and Heat production	all fuels	N2O	3610,0	3.534,1	0,1	0,5	0,1
1A1a Public electricity and Heat production	all fuels	CO2	335781,5	316.924,2	1,4	9,0	1,5
1A1a Public electricity and Heat production	all fuels	CH4	185,8	1.778,8	0,1	0,6	0,1
1A1b Petroleum Refining	all fuels	N2O	121,9	67,1	0,0	0,0	0,0
1A1b Petroleum Refining	all fuels	CO2	20005,9	21.611,6	0,1	0,8	0,1
1A1b Petroleum Refining	all fuels	CH4	13,3	7,9	0,0	0,0	0,0
1A1c Manufacture of Solid Fuels and Other Energy Industries	all fuels	N2O	684,2	185,7	0,0	0,0	0,0
1A1c Manufacture of Solid Fuels and Other Energy Industries	all fuels	CO2	59066,1	13.310,8	0,1	0,7	0,1
1A1c Manufacture of Solid Fuels and Other Energy Industries	all fuels	CH4	85,3	24,1	0,0	0,0	0,0
1A2a Manufacturing Industries and Construction: Iron and Steel	all fuels	N2O	158,3	117,1	0,0	0,0	0,0
1A2a Manufacturing Industries and Construction: Iron and Steel	all fuels	CO2	12577,9	11.377,5	0,1	0,5	0,1
1A2a Manufacturing Industries and Construction: Iron and Steel	all fuels	CH4	54,6	61,3	0,0	0,0	0,0
1A2b Manufacturing Industries and Construction: Non-Ferrous Metals	all fuels	N2O	17,8	9,0	0,0	0,0	0,0
1A2b Manufacturing Industries and Construction: Non-Ferrous Metals	all fuels	CO2	1599,7	1.667,0	0,0	0,1	0,0
1A2b Manufacturing Industries and Construction: Non-Ferrous Metals	all fuels	CH4	1,2	1,5	0,0	0,0	0,0
1A2d Manufacturing Industries and Construction: Pulp, Paper and Print	all fuels	N2O	2,9	11,5	0,0	0,0	0,0
1A2d Manufacturing Industries and Construction: Pulp, Paper and Print	all fuels	CO2	3,6	17,2	0,0	0,0	0,0
1A2d Manufacturing Industries and Construction: Pulp, Paper and Print	all fuels	CH4	0,5	2,2	0,0	0,0	0,0
1A2e Manufacturing Industries and Construction: Food Processing	all fuels	N2O	25,6	1,7	0,0	0,0	0,0
1A2e Manufacturing Industries and Construction: Food Processing	all fuels	CO2	1989,2	154,7	0,0	0,0	0,0
1A2e Manufacturing Industries and Construction: Food Processing	all fuels	CH4	3,8	0,1	0,0	0,0	0,0
1A2f Manufacturing Industries and Construction: Other	all fuels	N2O	1242,7	710,7	0,0	0,1	0,0
1A2f Manufacturing Industries and Construction: Other	all fuels	CO2	138312,0	81.299,9	0,3	1,7	0,3
1A2f Manufacturing Industries and Construction: Other	all fuels	CH4	184,5	491,3	0,0	0,2	0,0
1A3a Transport: Civil Aviation	liquid fuels	N2O	31,0	23,3	0,0	0,0	0,0
1A3a Transport: Civil Aviation	liquid fuels	CO2	3021,6	2.233,7	0,0	0,1	0,0
1A3a Transport: Civil Aviation	liquid fuels	CH4	2,0	1,9	0,0	0,0	0,0
1A3b Transport: Road Transportation	all fuels	N2O	608,4	962,7	0,0	0,3	0,1
1A3b Transport: Road Transportation	all fuels	CO2	150358,3	144.872,9	1,3	8,4	1,4
1A3b Transport: Road Transportation	all fuels	CH4	1271,1	139,2	0,0	0,0	0,0
1A3c Transport: Railways	all fuels	N2O	12,6	5,0	0,0	0,0	0,0
1A3c Transport: Railways	all fuels	CO2	2879,3	1.142,9	0,0	0,1	0,0
1A3c Transport: Railways	all fuels	CH4	2,3	0,5	0,0	0,0	0,0
1A3d Transport: Navigation	liquid fuels	N2O	8,6	1,8	0,0	0,0	0,0
1A3d Transport: Navigation	liquid fuels	CO2	2049,8	401,5	0,0	0,1	0,0
1A3d Transport: Navigation	biomass	CH4	1,7	0,3	0,0	0,0	0,0

IPCC Source	Fuel Category	Gas	Base year emissions	2008 emissions	Combined Uncertainty as % of total nat. emissions in 2008	Tier1 Level Assesment	Uncertainty introduced into the trend in total
Category			[Gg CO$_2$ equi.]	[Gg CO$_2$ equi.]	[%]	[%]	[%]
1A3e Transport: Other Transportation	all fuels	N2O	26,5	18,5	0,0	0,0	0,0
1A3e Transport: Other Transportation	all fuels	CO2	4302,3	3.675,7	0,2	1,0	0,2
1A3e Transport: Other Transportation	all fuels	CH4	9,8	3,6	0,0	0,0	0,0
1A4a Other Sectors: Commercial/Institutional	all fuels	N2O	144,2	115,4	0,0	0,0	0,0
1A4a Other Sectors: Commercial/Institutional	all fuels	CO2	63949,6	40.136,9	0,3	1,9	0,3
1A4a Other Sectors: Commercial/Institutional	all fuels	CH4	1216,1	57,2	0,0	0,0	0,0
1A4b Other Sectors: Residential	all fuels	N2O	801,9	406,4	0,0	0,1	0,0
1A4b Other Sectors: Residential	all fuels	CO2	129474,0	104.411,6	0,8	5,4	0,9
1A4b Other Sectors: Residential	all fuels	CH4	1200,4	587,0	0,0	0,2	0,0
1A4c Other Sectors: Agriculture/Forestry/Fisheries	all fuels	N2O	40,5	34,6	0,0	0,0	0,0
1A4c Other Sectors: Agriculture/Forestry/Fisheries	all fuels	CO2	10917,1	6.298,6	0,1	0,5	0,1
1A4c Other Sectors: Agriculture/Forestry/Fisheries	all fuels	CH4	176,9	25,8	0,0	0,0	0,0
1A5 Other: Include Military fuel use under this category	all fuels	N2O	70,4	9,5	0,0	0,0	0,0
1A5 Other: Include Military fuel use under this category	all fuels	CO2	11798,8	1.305,5	0,0	0,0	0,0
1A5 Other: Include Military fuel use under this category	all fuels	CH4	235,6	4,4	0,0	0,0	0,0
1B1a Fugitive Emissions from Fuels: Coal Mining and Handling	solid fuels	CH4	18415,2	3.744,8	0,5	3,3	0,6
1B1b Fugitive Emissions from Fuels: Solid Fuel Transformation	solid fuels	CH4	18,1	8,5	0,0	0,0	0,0
1B1c Fugitive Emissions from Fuels: Other (Abandoned Mines)		CH4	1806,8	105,4	0,0	0,1	0,0
1B2a Fugitive Emissions from Fuels: Oil	gaseous fuels	CO2	1,2	1,0	0,0	0,0	0,0
1B2a Fugitive Emissions from Fuels: Oil	gaseous fuels	CH4	857,2	319,9	0,0	0,0	0,0
1B2b Fugitive Emissions from Fuels: Natural Gas	gaseous fuels	CO2	1422,4	1.445,4	0,2	1,4	0,2
1B2b Fugitive Emissions from Fuels: Natural Gas	gaseous fuels	CH4	6782,3	6.896,5	0,1	0,4	0,1
1B2c Venting and Flaring	gaseous fuels	CO2	18,9	19,0	0,0	0,0	0,0
1B2c Venting and Flaring	gaseous fuels	CH4	0,3	0,3	0,0	0,0	0,0
2A1 Mineral Products: Cement Production		CO2	15145,8	13.444,1	0,0	0,3	0,0
2A2 Mineral Products: Lime Production		CO2	6135,0	5.660,9	0,1	0,4	0,1
2A7cer Mineral Products: Ceramic Production		CO2	531,1	335,1	0,0	0,1	0,0
2A7glass Mineral Products: Glass Production		CO2	695,6	753,7	0,0	0,0	0,0
2B1 Chemical Industry		CO2	4292,0	4.111,0	0,2	1,3	0,2
2B2 Chemical Industry		N2O	3384,4	2.839,4	0,0	0,1	0,0
2B3 Chemical Industry		N2O	18804,6	5.502,3	0,1	0,7	0,1
2B4 Chemical Industry		CO2	443,2	21,5	0,0	0,0	0,0
2B5 Chemical Industry		N2O	292,7	62,0	0,0	0,0	0,0
2B5 Chemical Industry		CO2	6869,8	10.299,5	0,1	0,6	0,1
2B5 Chemical Industry		CH4	0,3	0,4	0,0	0,0	0,0
2C1 Metal Production: Iron and Steel Production		CO2	48326,0	43.184,9	0,3	1,8	0,3
2C1 Metal Production: Iron and Steel Production		CH4	3,9	1,7	0,0	0,0	0,0
2C2 Ferroalloys Production		CO2	429,0	2,8	0,0	0,0	0,0

IPCC Source	Fuel Category	Gas	Base year emissions	2008 emissions	Combined Uncertainty as % of total nat. emissions in 2008	Tier1 Level Assesment	Uncertainty introduced into the trend in total
Category			[Gg CO$_2$ equi.]	[Gg CO$_2$ equi.]	[%]	[%]	[%]
2C3 Aluminium Production		PFC´s	1551,7	247,2	0,0	0,0	0,0
2C3 Aluminium Production		CO2	1011,9	828,3	0,0	0,1	0,0
2C4 SF6 Used in Aluminium and Magnesium Foundries		SF6	C	C	0,1	0,5	0,1
2C5 Other		HFC-134a	C	C	0,0	0,0	0,0
2E Production of Halocarbons and SF6		SF6	C	C	0,0	0,0	0,0
2E Production of Halocarbons and SF6		HFC´s	C	C	0,0	0,0	0,0
2F Industrial Processes		SF6	C	C	0,0	0,1	0,0
2F Industrial Processes		PFC´s	C	C	0,0	0,0	0,0
2F Industrial Processes		HFC´s	C	C	0,1	0,4	0,1
2G Other		SF6	609,5	273,8	0,0	0,0	0,0
3 Total Solvent and Other Product Use		CO2	3307,5	2.142,4	0,0	0,2	0,0
3D Total Solvent and Other Product Use		N2O	2088,5	1.174,0	0,0	0,3	0,1
4A_ Enteric Fermentation		CH4	13119,4	10.080,2	0,4	2,6	0,4
4A1 Enteric Fermentation		CH4	11747,1	8.178,4	0,2	1,3	0,2
4A2 Enteric Fermentation		CH4	1327,0	1.275,7	0,0	0,3	0,0
4B_ Manure Management		CH4	2484,2	2.398,9	0,1	0,6	0,1
4B1 Manure Management		CH4	1585,8	1.033,7	0,0	0,2	0,0
4B13a Manure Management: Other		N2O	1160,6	971,9	0,1	0,5	0,1
4B13b Manure Management: Other		N2O	73,2	107,7	0,0	0,1	0,0
4B13c Manure Management: Other		N2O	1135,0	768,3	0,0	0,2	0,0
4B13d Manure Management: Other		N2O	38,0	47,2	0,0	0,0	0,0
4B13e Manure Management: Other		N2O	351,4	352,2	0,0	0,1	0,0
4B2 Manure Management		CH4	99,2	138,5	0,0	0,0	0,0
4B8 Manure Management		CH4	2212,3	2.176,8	0,1	0,4	0,1
4D1a Agricultural Soils		N2O	33115,2	30.409,9	1,6	10,4	1,7
4D1b Agricultural Soils		N2O	7491,3	6.639,7	1,8	11,8	2,0
4D1c Agricultural Soils		N2O	2105,9	1.624,2	0,3	2,1	0,3
5A Forest Land		N2O	2,1	0,7	0,0	0,0	0,0
5A Forest Land		CO2	65693,7	23.056,2	0,4	2,9	0,5
5A Forest Land		CH4	9,1	3,3	0,0	0,0	0,0
5B Cropland		N2O	47,9	669,1	0,0	0,3	0,0
5B Cropland		CO2	27629,4	31.252,6	1,6	10,6	1,8
5C Grassland		CO2	13051,9	15.521,3	0,7	4,4	0,7
5D Wetlands		CO2	2190,5	2.596,8	0,1	0,8	0,1
5E Settlements		CO2	1879,3	7.601,4	0,3	2,2	0,4
5F Other Land		CO2	22,2	5.079,4	0,2	1,4	0,2
5G Other (please specify)		CO2	643,1	708,3	0,0	0,1	0,0
6A Solid Waste Disposal on Land		CH4	35910,0	7.518,0	0,1	0,6	0,1

IPCC Source	Fuel Category	Gas	Base year emissions	2008 emissions	Combined Uncertainty as % of total nat. emissions in 2008	Tier1 Level Assesment	Uncertainty introduced into the trend in total
Category			[Gg CO₂ equi.]	[Gg CO₂ equi.]	[%]	[%]	[%]
6B Wastewater Handling		N2O	2223,5	2.309,6	0,2	1,1	0,2
6B Wastewater Handling		CH4	2226,2	100,1	0,0	0,0	0,0
6D Other		N2O	14,0	363,1	0,0	0,1	0,0
6D Other		CH4	49,8	568,2	0,0	0,2	0,0
Total			1346500,14	1044540,76	3,8	100,0	4,1

Table 259:   Tabelle 6.2 der IPCC Good Practice Guidance - Details

IPCC Source	Fuel Category	Gas	Base year emissions	2008 emissions	2008 emissions [%]	Year t emissions [%]	Uncertainty as % of total emissions
Category			[Gg CO2 equi.]	[Gg CO2 equi.]	2,5% percentile	97,5% percentile	2008
1A1a Public electricity and Heat production	all fuels	N2O	3610,0	3534,1	-28,9	27,6	0,1
1A1a Public electricity and Heat production	all fuels	CO2	335781,5	316924,2	-4,3	4,5	1,4
1A1a Public electricity and Heat production	all fuels	CH4	185,8	1778,8	-38,2	48,9	0,1
1A1b Petroleum Refining	all fuels	N2O	121,9	67,1	-34,7	34,8	0,0
1A1b Petroleum Refining	all fuels	CO2	20005,9	21611,6	-5,5	5,6	0,1
1A1b Petroleum Refining	all fuels	CH4	13,3	7,9	-33,0	32,5	0,0
1A1c Manufacture of Solid Fuels and Other Energy Industries	all fuels	N2O	684,2	185,7	-32,4	33,5	0,0
1A1c Manufacture of Solid Fuels and Other Energy Industries	all fuels	CO2	59066,1	13310,8	-7,4	8,1	0,1
1A1c Manufacture of Solid Fuels and Other Energy Industries	all fuels	CH4	85,3	24,1	-47,4	62,0	0,0
1A2a Manufacturing Industries and Construction: Iron and Steel	all fuels	N2O	158,3	117,1	-41,4	42,7	0,0
1A2a Manufacturing Industries and Construction: Iron and Steel	all fuels	CO2	12577,9	11377,5	-6,2	6,7	0,1
1A2a Manufacturing Industries and Construction: Iron and Steel	all fuels	CH4	54,6	61,3	-26,5	28,2	0,0
1A2b Manufacturing Industries and Construction: Non-Ferrous Metals	all fuels	N2O	17,8	9,0	-62,9	62,4	0,0
1A2b Manufacturing Industries and Construction: Non-Ferrous Metals	all fuels	CO2	1599,7	1667,0	-9,8	10,7	0,0
1A2b Manufacturing Industries and Construction: Non-Ferrous Metals	all fuels	CH4	1,2	1,5	-63,8	66,3	0,0
1A2d Manufacturing Industries and Construction: Pulp, Paper and Print	all fuels	N2O	2,9	11,5	-97,5	149,4	0,0
1A2d Manufacturing Industries and Construction: Pulp, Paper and Print	all fuels	CO2	3,6	17,2	-5,6	5,6	0,0
1A2d Manufacturing Industries and Construction: Pulp, Paper and Print	all fuels	CH4	0,5	2,2	-42,2	42,4	0,0
1A2e Manufacturing Industries and Construction: Food Processing	all fuels	N2O	25,6	1,7	-60,0	88,0	0,0
1A2e Manufacturing Industries and Construction: Food Processing	all fuels	CO2	1989,2	154,7	-4,7	4,9	0,0
1A2e Manufacturing Industries and Construction: Food Processing	all fuels	CH4	3,8	0,1	-35,3	36,0	0,0
1A2f Manufacturing Industries and Construction: Other	all fuels	N2O	1242,7	710,7	-30,3	75,1	0,0
1A2f Manufacturing Industries and Construction: Other	all fuels	CO2	138312,0	81299,9	-3,1	3,3	0,3
1A2f Manufacturing Industries and Construction: Other	all fuels	CH4	184,5	491,3	-52,0	54,4	0,0
1A3a Transport: Civil Aviation	Aviation	N2O	31,0	23,3	-100,0	157,0	0,0

IPCC Source	Fuel Category	Gas	Base year emissions	2008 emissions	2008 emissions [%]	Year t emissions [%]	Uncertainty as % of total emissions
Category			[Gg CO2 equi.]	[Gg CO2 equi.]	2,5% percentile	97,5% percentile	2008
	Gasoline						
1A3a Transport: Civil Aviation	Aviation Gasoline	CO2	3021,6	2233,7	-8,0	8,1	0,0
1A3a Transport: Civil Aviation	Aviation Gasoline	CH4	2,0	1,9	-54,6	93,9	0,0
1A3b Transport: Road Transportation	all fuels	N2O	608,4	962,7	-91,9	319,7	0,3
1A3b Transport: Road Transportation	all fuels	CO2	150358,3	144872,9	-8,8	8,9	1,2
1A3b Transport: Road Transportation	all fuels	CH4	1271,1	139,2	-24,5	28,5	0,0
1A3c Transport: Railways	all fuels	N2O	12,6	5,0	-100,0	8,8	0,0
1A3c Transport: Railways	all fuels	CO2	2879,3	1142,9	-10,3	10,2	0,0
1A3c Transport: Railways	all fuels	CH4	2,3	0,5	-36,4	33,6	0,0
1A3d Transport: Navigation	Diesel Oil	N2O	8,6	1,8	-100,0	203,0	0,0
1A3d Transport: Navigation	Diesel Oil	CO2	2049,8	401,5	-46,0	46,3	0,0
1A3d Transport: Navigation	Diesel Oil	CH4	1,7	0,3	-49,0	60,3	0,0
1A3e Transport: Other Transportation	all fuels	N2O	26,5	18,5	-73,8	27,4	0,0
1A3e Transport: Other Transportation	all fuels	CO2	4302,3	3675,7	-43,3	44,0	0,2
1A3e Transport: Other Transportation	all fuels	CH4	9,8	3,6	-44,4	38,8	0,0
1A4a Other Sectors: Commercial/Institutional	all fuels	N2O	144,2	115,4	-44,7	44,2	0,0
1A4a Other Sectors: Commercial/Institutional	all fuels	CO2	63949,6	40136,9	-7,0	7,4	0,3
1A4a Other Sectors: Commercial/Institutional	all fuels	CH4	1216,1	57,2	-58,6	60,6	0,0
1A4b Other Sectors: Residential	all fuels	N2O	801,9	406,4	-28,7	29,5	0,0
1A4b Other Sectors: Residential	all fuels	CO2	129474,0	104411,6	-7,6	8,0	0,8
1A4b Other Sectors: Residential	all fuels	CH4	1200,4	587,0	-63,5	68,6	0,0
1A4c Other Sectors: Agriculture/Forestry/Fisheries	all fuels	N2O	40,5	34,6	-57,1	54,5	0,0
1A4c Other Sectors: Agriculture/Forestry/Fisheries	all fuels	CO2	10917,1	6298,6	-11,7	11,6	0,1
1A4c Other Sectors: Agriculture/Forestry/Fisheries	all fuels	CH4	176,9	25,8	-47,3	51,5	0,0
1A5 Other: Include Military fuel use under this category	all fuels	N2O	70,4	9,5	-52,6	71,5	0,0
1A5 Other: Include Military fuel use under this category	all fuels	CO2	11798,8	1305,5	-4,3	4,6	0,0
1A5 Other: Include Military fuel use under this category	all fuels	CH4	235,6	4,4	-28,2	37,3	0,0
1B1a Fugitive Emissions from Fuels: Coal Mining and Handling	Solid Fuels	CH4	18415,2	3744,8	-65,4	139,4	0,5
1B1b Fugitive Emissions from Fuels: Solid Fuel Transformation	Solid Fuels	CH4	18,1	8,5	-10,2	10,2	0,0
1B1c Fugitive Emissions from Fuels: Other (Abandoned Mines)	Solid Fuels	CH4	1806,8	105,4	-70,2	151,9	0,0
1B2a Fugitive Emissions from Fuels: Oil	Liquid Fuels	CO2	1,2	1,0	-137,5	137,1	0,0
1B2a Fugitive Emissions from Fuels: Oil	Liquid Fuels	CH4	857,2	319,9	-11,0	11,2	0,0
1B2b Fugitive Emissions from Fuels: Natural Gas	Gaseous Fuels	CO2	1422,4	1445,4	-146,4	145,9	0,2
1B2b Fugitive Emissions from Fuels: Natural Gas	Gaseous Fuels	CH4	6782,3	6896,5	-8,8	9,2	0,1
1B2c Venting and Flaring		CO2	18,9	19,0	-144,9	144,1	0,0
1B2c Venting and Flaring		CH4	0,3	0,3	-28,1	28,3	0,0
2A1 Mineral Products: Cement Production	Clinker	CO2	15145,8	13444,1	-3,1	3,1	0,0

IPCC Source	Fuel Category	Gas	Base year emissions	2008 emissions	2008 emissions [%]	Year t emissions [%]	Uncertainty as % of total emissions
Category			[Gg CO2 equi.]	[Gg CO2 equi.]	2,5% percentile	97,5% percentile	2008
	Production						
2A2 Mineral Products: Lime Production	Limestone and Dolomite	CO2	6135,0	5660,9	-5,0	5,1	0,0
2A7cer Mineral Products: Ceramic Production	Bricks and Tiles	CO2	531,1	335,1	-27,9	31,2	0,0
2A7glass Mineral Products: Glass Production	Glass Products	CO2	695,6	753,7	-6,1	6,2	0,0
2B1 Chemical Industry	Ammonia Production	CO2	4292,0	4111,0	-48,6	48,6	0,2
2B2 Chemical Industry	Nitric Acid Production	N2O	3384,4	2839,4	-5,0	5,0	0,0
2B3 Chemical Industry	Adipic Acid Production	N2O	18804,6	5502,3	-20,7	21,0	0,1
2B4 Chemical Industry	Carbide Production	CO2	443,2	21,5	-13,6	14,2	0,0
2B5 Chemical Industry	Other	N2O	292,7	62,0	-75,1	78,8	0,0
2B5 Chemical Industry	Other	CO2	6869,8	10299,5	-10,0	9,9	0,1
2B5 Chemical Industry	Other	CH4	0,3	0,4	-14,7	15,0	0,0
2C1 Metal Production: Iron and Steel Production	Steel (integrated production)	CO2	48326,0	43184,9	-6,5	6,6	0,3
2C1 Metal Production: Iron and Steel Production	Other	CH4	3,9	1,7	-9,8	9,9	0,0
2C2 Ferroalloys Production	Ferroalloys	CO2	429,0	2,8	-8,3	8,6	0,0
2C3 Aluminium Production		PFC´s	1551,7	247,2	-13,2	13,1	0,0
2C3 Aluminium Production		CO2	1011,9	828,3	-14,5	14,7	0,0
2C4 SF6 Used in Aluminium and Magnesium Foundries		SF6	C	C	-16,3	10,5	0,0
2C5 Other		HFC-134a	C	C	-1,5	1,5	0,0
2E Production of Halocarbons and SF6			C	C	-2,8	2,8	0,0
2F Industrial Processes	Consumption of Halocarbons and SF6	SF6	C	C	-6,1	5,9	0,0
2F Industrial Processes	Consumption of Halocarbons and SF6	PFC´s	C	C	-17,4	14,6	0,0
2F Industrial Processes	Consumption of Halocarbons and SF6	HFC´s	C	C	-4,7	4,8	0,1
3 Total Solvent and Other Product Use		CO2	3307,5	2142,4	-12,1	12,1	0,0
3D Total Solvent and Other Product Use		N2O	2088,5	1174,0	-46,4	47,4	0,0
4A0 Enteric Fermentation	Dairy Cattle	CH4	13119,4	10080,2	-39,3	39,7	0,4

IPCC Source	Fuel Category	Gas	Base year emissions	2008 emissions	2008 emissions [%]	Year t emissions [%]	Uncertainty as % of total emissions
Category			[Gg CO2 equi.]	[Gg CO2 equi.]	2,5% percentile	97,5% percentile	2008
4A1 Enteric Fermentation	Non-Dairy Cattle	CH4	11747,1	8178,4	-25,1	25,0	0,2
4A2 Enteric Fermentation	Other Animals (buffalo, sheep, goats, horses, swine)	CH4	1327,0	1275,7	-29,6	37,5	0,0
4B0 Manure Management	Dairy Cattle	CH4	2484,2	2398,9	-39,4	39,7	0,1
4B1 Manure Management	Non-Dairy Cattle	CH4	1585,8	1033,7	-26,4	26,8	0,0
4B13a Manure Management: Other	Dairy Cows	N2O	1160,6	971,9	-100,0	253,5	0,2
4B13b Manure Management: Other	Other Animals (buffalo, sheep, goats, horses)	N2O	73,2	107,7	-100,0	317,9	0,0
4B13c Manure Management: Other	Other Cattle	N2O	1135,0	768,3	-99,9	240,3	0,2
4B13d Manure Management: Other	Poultry	N2O	38,0	47,2	-13,7	14,8	0,0
4B13e Manure Management: Other	Swine	N2O	351,4	352,2	-88,6	252,3	0,1
4B2 Manure Management	Other Animals (buffalo, sheep, goats, horses, poultry)	CH4	99,2	138,5	-26,7	39,7	0,0
4B8 Manure Management	Swine	CH4	2212,3	2176,8	-29,8	30,8	0,1
4D1a Agricultural Soils	Direct Soil Emissions	N2O	33115,2	30409,9	-59,7	36,5	1,9
4D1b Agricultural Soils	Indirect Emissions	N2O	7491,3	6639,7	-95,9	380,0	2,4
4D1c Agricultural Soils	Pasture, Range and Paddock Manure	N2O	2105,9	1624,2	-80,8	213,4	0,3
5A Forest Land		N2O	2,1	0,7	-38,6	38,7	0,0
5A Forest Land		CO2	65693,7	23056,2	20,7	-20,6	0,5
5A Forest Land		CH4	9,1	3,3	-38,6	38,7	0,0
5B Cropland		N2O	47,9	669,1	-60,8	62,1	0,0
5B Cropland		CO2	27629,4	31252,6	-55,9	56,6	1,7
5C Grassland		CO2	13051,9	15521,3	-65,9	66,0	1,0
5D Wetlands		CO2	2190,5	2596,8	-60,6	60,5	0,2
5E Settlements		CO2	1879,3	7601,4	-61,9	62,0	0,4
5F Other Land		CO2	22,2	5079,4	60,3	-61,9	0,3
5G Other (please specify)		CO2	643,1	708,3	-19,3	19,2	0,0
6A Solid Waste Disposal on Land	Managed	CH4	35910,0	7518,0	-12,3	12,4	0,1

IPCC Source	Fuel Category	Gas	Base year emissions	2008 emissions	2008 emissions [%]	Year t emissions [%]	Uncertainty as % of total emissions
Category			[Gg CO2 equi.]	[Gg CO2 equi.]	2,5% percentile	97,5% percentile	2008
	Waste Disposal on Land						
6B Wastewater Handling	Domestic and Commercial Wastewater	N2O	2223,5	2309,6	-47,9	75,2	0,2
6B Wastewater Handling	Domestic and Commercial Wastewater	CH4	2226,2	100,1	-48,0	75,6	0,0
6D Other	Other	N2O	14,0	363,1	-78,2	143,4	0,0
6D Other	Other	CH4	49,8	568,2	-31,2	40,2	0,0
Total				1.026.947,0	-4,7	5,4	

Uncertainties for source categories have been determined successively, within the framework of UBA sections' data deliveries for current emissions reporting. Furthermore, 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.

Uncertainties in the source category Agriculture (CRF 4) are 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. In interim years, uncertainties are to be reported in keeping with the Tier 1 method.

24 REFERENCES

AGEB, 2003: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanzen der Bundesrepublik Deutschland - Jahre 1990-1999, Verlags- und Wirtschaftsgesellschaft der Elekrizitätswerke, 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, 2006: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanz für die Bundesrepublik Deutschland, URL: www.ag-energiebilanzen.de (Aufruf: 07.11.2005), Köln, Berlin.

AGEB, 2009: Arbeitsgemeinschaft Energiebilanzen (Hrsg.): Energiebilanz für die Bundesrepublik Deutschland
URL: http://www.ag-energiebilanzen.de/viewpage.php?idpage=63,
 (Aufruf: 19.10.2009), Köln, Berlin.

AGFW 2006 / 2007: Arbeitgemeinschaft für Wärme und Heizkraftwirtschaft_AGFW_e.V. 2007 Vorabinformation zum Hauptbericht der Fernwärmeversorgung (noch unveröffentlicht und vorläufig- geplante Erscheinung 12-2007)

AMD, 2002/2003**:** Amd Saxony LLC&Co. KG, Dresden, Umweltbericht. S. 16

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

AUST, o.J.: Vorlesungsscript TC-7: Abwasserbehandlung, siehe http://www.fh-nuernberg.de/tc/lab-aust/lim/wasserbeh_1_kap5_3.pdf

BAFA 2007: Bundesamt für Wirtschaft und Ausfuhrkontrolle, Monatliche Erdgasbilanz, www.bafa.de.

BAFA 2008: Bundesamt für Wirtschaft und Ausfuhrkontrolle, Mineralöldaten, URL: http://www.bafa.de/bafa/de/energie/mineraloel/amtliche_mineraloeldaten/index.html.

BASt, 2007: Bundesanstalt für Straßenwesen: Unterreihe Verkehrstechnik; V 164: "Straßenverkehrszählung 2005: Ergebnisse", Thorsten Kathmann, Hartmut Ziegler, Bernd Thomas; 62 Seiten; Bergisch Gladbach, 2007

BAFA, 2009: Bundesamt für Wirtschaft und Ausfuhrkontrolle, Amtliche Mineralöldaten für die Bundesrepublik Deutschland,
URL: http://www.bafa.de/bafa/de/energie/mineraloel/amtliche_mineraloeldaten/index. html, (Aufruf: 19.10.2009), Eschborn.

BATZ, 1995: Kokereien und Produktemissionen. Mündliche Mitteilung. Umweltbundesamt.

BENNDORF, R., 1999: Situation in Deutschland, ACCC-Workshop „N_2O und das Kyoto-Ziel", Umweltbundesamt (Berlin), Wien

BLE (Bundesanstalt für Landwirtschaft und Ernährung), 2008. Waldbrandstatistik der Bundesrepublik Deutschland für das Jahr 2008.

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

BMLFUW, 2005: Abschätzung der Auswirkungen des Tanktourismus auf den Treibstoffverbrauch und die Entwicklung der CO2-Emissionen in Österreich.; Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft; Wien; 2005

BMU, 1990: Eckwerte der ökologischen Sanierung und Entwicklung in den neuen Ländern, Bonn

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, 2007: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten der Bundesrepublik Deutschland. Landwirtschaftsverlag GmbH, Münster-Hiltrup

BMELV (Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz) (Hrsg.), 2008. Aufnahmeanweisung für die Inventurstudie 2008 (IS08) (2008), Bonn, 55 S.

BMVg, 2009: Bundesministerium der Verteidigung: Energieeinsatz zur Wärmeversorgung der Bundeswehr (unveröffentlicht).

BMWA, o.J.: Bundesministerium für Wirtschaft und Arbeit: Der Bergbau in der Bundesrepublik Deutschland. Laufende Reihe.

BPB, 2002: Bundeszentrale für politische Bildung. Projektgruppe Zukunft der Wirtschaft, Die Zukunft der Wirtschaft, Landwirtschaft und Ernährung, herausgegeben von Margarete Wohlan

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.

BUWAL, 2003: Anthropogene VOC-Emissionen Schweiz 1998 und 2001, jetzt erhältlich als BUWAL 2007: Anthropogene VOC-Emissionen Schweiz 1998, 2001 und 2004 über http://www.bafu.admin.ch/voc/01265/index.html?lang=de

BV Glas, 2009: Jahresbericht des Bundesverband Glasindustrie e.V., mit statistischem Anhang

BV Kalk, 2009 (Bundesverband der deutschen Kalkindustrie e.V.): Kalk Daten nationaler Inventarbericht; am 23. Juni 2009 per E-Mail an das UBA übermittelt.

BVE, 2009: Bundesvereinigung der Deutschen Ernährungsindustrie e.V. Internetseiten, 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

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, 2005: Dämmgen, U.: Statistical Data for Animal Numbers in German Emission Inventories. Landbauforschung Völkenrode, special issue 291, 223-229

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.

DÄMMGEN et al, 2009a: Dämmgen, U.; Haenel, H.-D.; Rösemann, C.; Conrad, J.; Lüttich, M.; Döhler, H.; Eurich-Menden, B.; Laubach, P., Müller-Lindenlauf, M.; Osterburg, B.; Strogies, M.: Calculations of Emissions from German Agriculture - National Emission Inventory Report (NIR) 2009 for 2007. vTI Agricultural and Forestry Research, Special Issue 324, 9-385

DÄMMGEN et al, 2009b: Dämmgen, U.; Haenel, H-D.; Rösemann, C.; Hutchings, N.J.; Brade, W.; Lebzien, P.: Improved national calculation procedures to assess energy requirements, nitrogen and VS excretions of dairy cows in the German emission model GAS-EM. (Accepted for publication in vTI Agricultural and Forestry Research 59)

DÄMMGEN et al, 2009c: Dämmgen, U.; Haenel, H-D.; Rösemann, C.; Brade, W.; Müller-Lindenlauf, M.; Eurich-Menden, B.: An improved data base for the assessment of energy requirements, nitrogen and VS excretions of dairy cows in the German emission model GAS-EM as well as ammonia emission factors. (In preparation for vTI Agricultural and Forestry Research)

DÄMMGEN et al, 2009d: Dämmgen, U.; Haenel, H-D.; Rösemann, C.; Eurich-Menden, B.: Ammonia emission factors related to total ammoniacal nitrogen in the mass flow model depicting pig production. (In preparation for vTI Agricultural and Forestry Research)

DÄMMGEN & LÜTTICH, 2005: Dämmgen, U.; Lüttich, M.: The Derivation of Nitrogen Excretions for Dairy Cows from Available Statistical Data.. Landbauforschung Völkenrode, special issue 291, 231-243

DAV, 2009: Deutscher Asphaltverband e.V., Schieffelingsweg 6, 53123 Bonn, Veröffentlichung zur Asphaltproduktion in Deutschland, http://www.asphalt.de/site/startseite/aktuelles/asphaltproduktion/ (Dokument asphaltp08.pdf), Aufruf April 2009

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.

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

DIN, 1995: Deutsches Institut für Normung e.V.: DIN 1319 Grundlagen der Messtechnik, Teil 3: Auswertung von Messungen einer einzelnen Meßgröße, Messunsicherheit, Teil 4: Auswertung von Messungen, Meßunsicherheit, Beuth-Verlag GmbH

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

DLR, 1999: Deutsches Zentrum für Luft- und Raumfahrt (Hrsg.), Entwicklung und Bewertung vereinfachter Verfahren zur Bestimmung von Abgasemissionen aus Flugtriebwerken im Reiseflug, Köln, 1999

DMT 2005: Freundliche persönliche Mitteilung von Herrn Meiners, Deutsche Montan Technologie. 28.09.2005. Gelsenkirchen.

DÖPELHEUER, 2002: Anwendungsorientierte Verfahren zur Bestimmung von CO, HC und Ruß aus Luftfahrttriebwerken, Dissertationsschrift des DLR, Institut für Antriebstechnik, Köln, 2002

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, 2006b: 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.

EMEP, 2003: Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook, 3rd Edition September 2003 UPDATE, EEA, Copenhagen, 2003

EMEP, 2004: 2004 Emission Inventory Review.
http://www.emep.int/REVIEW/2004/KeySource_Analysis_2002. html

EMEP, 2005a: European Environment Agency: EMEP/CORINAIR Emission Inventory Guidebook - 2005. Technical report No 30., Stand: 31.12.2005
URL: reports.eea.europa.eu/EMEPCORINAIR4/en/

EMEP, 2006: Atmospheric Emission Inventory Guidebook. Chapter 1090 Manure Management Regarding Nitrogen Compunds. Draft.

ETC/ACC, 2007 – Comparison of Eurocontrol's Pagoda estimates with national GHG inventories, Jakob Graichen, Technical Workshop on emissions from aviation and maritime transport, 4-5 October 2007, Oslo, Norway 2007

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

FAO, 1998: World Reference Base for Soil Resources. Rome, Italy.

FAO, 2007: FAO Statistical Yearbook 2004 Vol.1/1 URL: http://www.fao.org/statistics/yearbook/vol_1_1/index.asp. September 2007

FAO, 2009: FAO Statistical Yearbook 2007-2008 ; Table D1: Dietary energy protein and fat consumption URL: http://www.fao.org/economic/ess/publications-studies/statistical-yearbook/fao-statistical-yearbook-2007-2008/en/

FAO, o.J.: Tabellen auf Homepage unter http://faostat.fao.org/default.jsp und persönlicher Austausch UBA mit FAO

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, 1982: Fichtner Beratende Ingenieure: Maßnahmen zur Intensivierung der Abwärmenutzung in der Industrie, Forschungsvorhaben FKZ ETS8011A/1 im Auftrag des BMFT, Teil A: Ermittlung des theoretisch denkbaren Abwärmepotentials, S I. 4-8

FISCHER, 1997: Klimawirksame Emissionen durch PKW-Klimaanlagen. Diplomarbeit an der TU Berlin, FB 10, ISS-Fahrzeugtechnik.

FISCHER, D. von, 1988: Hinweise für den Feldfutterbau sowie den Zwischenfruchtbau zur Futternutzung und Gründüngung. 11. Auflage. Landwirtschaftskammer Rheinland, Bonn.

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.

GDA, 2009: Gesamtverband der Aluminiumindustrie e.V. – Fachverband Primäraluminium: Vorab-Auszug aus dem Monitoringbericht über die Fortschritte bei der Reduktion der CF4/C2F6 Emissionen der deutschen Primäraluminiumindustrie für das Jahr 2008, Mitteilung per E-Mail vom 18.09.2009 von Herrn Rainer Buchholz (Wirtschaftsvereinigung Metalle e.V.) via Herrn Salomon (BMU).

GfE (2006): Gesellschaft für Ernährungsphysiologie, Ausschuss für Bedarfsnormen: Energie- und Nährstoffbedarf landwirtschaftlicher Nutztiere. Nr. 10. Empfehlungen zur Energie- und Nährstoffversorgung von Schweinen. Frankfurt/M., DLG, 247 pp

GICON, 2008: Implementierung der Bilanz der Emissionsursachen auf Basis der MESAP-Datenbank Bachmann, Thomas; Kalies, Heiko GICON, Großmann Ingenieur Consult GmbH Niederlassung Leipzig 2008

HAENEL et al, 2010: Haenel, H.-D.; Rösemann, C.; Dämmgen, U.; Döhler, H.; Eurich-Menden, B.; Laubach, P., Müller-Lindenlauf, M.; Osterburg, B.; Calculations of Emissions from German Agriculture - National Emission Inventory Report (NIR) 2010 for 2008. In Vorbereitung für vTI Agriculture and Forestry Research (Landbauforschung).

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

HORTIGATE, 2005: Freilandgemüse-Düngung nach Durchschnittswerten. URL: http://www.hortigate.de/scripts/WebObjects.dll/Hortigate.woa/2/wo/idbb6dt87xLy8HiX AzJ5zw/5.13.1.23.1.1.25.1.5.5

HVG, 2008: Effiziente Bereitstellung aktueller Emissionsdaten für die Luftreinhaltung. Teilvorhaben 02: Bereitstellung aktueller Emissionsdaten für die Glas- und Mineralfaserindustrie., Forschungsbericht in Veröffentlichung

ICAO, 2009: International Civil Aviation Organisation: Engine Exhaust Emissions Data Bank, URL: http://www.caa.co.uk/docs/702/ICAO_Engine_Emissions_Databank-Issue_16A%20%20(090204).xls (Aufruf September 2009)

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, 2004: Lambrecht, U., Knörr, W. u.a., IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Entwicklung eines Modells zur Berechnung der Luftschadstoffemissionen und des Kraftstoffverbrauchs von Verbrennungsmotoren in mobilen Geräten und Maschinen, im Auftrag des Umweltbundesamtes, FKZ 299 45 113, Heidelberg.

IFEU, 2009: Knörr, W. et al, IFEU - Institut für Energie- und Umweltforschung Heidelberg gGmbH: Fortschreibung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2030, sowie TREMOD 5.03, 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.

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, 2004: Handbuch Emissionsfaktoren des Straßenverkehrs 2.1- Dokumentation, Bern, 188.8.2004

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

IPCC, 2001: Intergovernmental Panel on Climate Change: Corrigendum of Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm

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, 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.

KNIGGE, W.; SCHULZ, H. (1966): Grundriss der Forstbenutzung. Paul Parey Verlag, Hamburg und Berlin, 584 S.

KÖNIG G, BRUNDA M, PUXBAUM H, HEWITT CN, DUCKHAM SC, RUDOLPH J, 1995: Relative contribution of oxigenated hydrocarbons to the total biogenic VOC emissions of selected Mid-European agricultural and natural plant species. Atmospheric Environment 29, 861-874

KÖNIG, H.-C., 2007. Waldbrandschutz - Kompendium für Forst und Feuerwehr, 1. Fachverlag Matthias Grimm, Berlin, 197 pp.

KOLLMANN, F. 1982: Technologie des Holzes und der Holzwerkstoffe. Springer-Verlag, Berlin, Heidelberg, New York

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

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/63ED15ADE8FC F595C1256B7B004C6250 , Zugriff Mai 2005

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 Table 12, S. 56

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

MÜLLER-WESTERMEIER et al, 2008: Die Witterung in Deutschland.

MWV, 2006: Mineralölwirtschaftsverband, „Mineralölzahlen 2005".

MWV, 2009: Mineralölwirtschaftsverband: „Mineralölzahlen 2008"
URL: http://www.mwv.de/cms/front_content.php?idcat=10, (Aufruf: 19.10.2009), und MWV Jahresbericht Mineralölzahlen 2008
URL: http://www.mwv.de/cms/upload/pdf/jahresberichte/2008_JB.pdf, (Aufruf: 19.10.2009), Berlin.

OECD/IEA, 2009: CO_2-Emissions from fuel combustion 2009 Edition, OECD & IEA, Paris, ISBN 9789264061026

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, 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 360 16 019, Berlin, August 2009.

ÖKO-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, 2004: Emissionen, Aktivitätsraten und Emissionsfaktoren von fluorierten Treibhausgasen (F-Gasen) in Deutschland für die Jahre 1995-2002, Gutachten im Auftrag des Umweltbundesamtes, Berlin, FKZ 201 41 261/01. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennummer&Suchwort=2902

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, 2009a: Emissionen fluorierter Treibhausgase in Deutschland 2006 und 2007 - Inventarermittlung 2006/2007 (F-Gase) Daten von HFKW, FKW und SF6 für die nationale Berichterstattung gemäß Klimarahmenkonvention für die Berichtsjahre 2006 und 2007 sowie Prüfung der Datenermittlung über externe Datenbanken , Gutachten im Auftrag des Umweltbundesamtes, Dessau, FKZ 3707 42 300. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennummer&Suchwort=3833

ÖKO-RECHERCHE, 2009b: HFKW-haltige Treibhausgase in PU-Montageschaum; Bewertung der Emissionsreduktionspotentiale von Montageschäumen im Hinblick auf eine Konkretisierung der Regelungen nach §9(1) der Verordnung (EG) 842/2006, Gutachten im Auftrag des Umweltbundesamtes, Dessau, FKZ 363 01 196. URL: http://www.umweltbundesamt.de/uba-info-medien/mysql_medien.php?anfrage=Kennummer&Suchwort=3830

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

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.

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.

PROGNOS, 2000: Anwendung des IPCC-Referenzverfahrens zur Ermittlung der verbrennungsbedingten CO_2-Emissionen in Deutschland, Forschungsprojekt des UBA, FKZ 29744850, 2000

RAND, 2003: RAND Europe Berlin: Entwicklung eines Vorschlages für die Absenkung des derzeit gültigen internationalen Grenzwertes für Stickoxidemissionen von Flugzeugen unter Berücksichtigung der aktuellen und zukünftigen technischen Möglichkeiten, erstellt im Auftrag des Umweltbundesamtes, FKZ 201 45 108/ 01, Berlin, 2003

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

SACHS, L. 1984: Angewandte Statistik. Bd. 6. Aufl., Springer-Verlag, Berlin, Heidelberg, New York, Tokyo.

SACHS, 1992: Angewandte Statistik: Anwendung statistischer Methoden. Springer, Berlin / Heidelberg

SCHMIDT, R., 2001: Enantiomeranalytik chiraler Inhalationsanästhetika und ihrer Zersetzungsprodukte mittels GC, Fakultät für Chemie und Pharmazie, Tübingen

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

SCHOLZ, Reinhard 2003: Gutachten: Kohlenstoffbedarf und resultierende Kohlendioxid-Emission beim Hochofenprozess, TU Clausthal.

SCHWITZGEBEL et al. 2007: Schwitzgebel, F., Dunger, K., Stümer, W. (2007): Waldinventurstudie 2008 - Informationsquelle zur Kohlenstoff-Einbindung. AFZ-Der Wald 23/07.

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.

SMITH et al., 2000: Smith KA, Dobbie KE, Ball BC, Bakken LR, Sitaula BK, Hansen S, Brumme R, Borken W, Christensen S, Priemé A, Fowler D, MacDonald JA, Skiba U, Klemedsson L, Kasimir-Klemedsson A, Degórska A, Orlanski P: Oxidation of atmospheric methane in Northern European soils, comparison with other ecosystems, and uncertainties in the global terrestrial sink. Global Change Biol 6, 791-803

STATISTIK DER KOHLENWIRTSCHAFT e.V 2006: Statistik der Kohlenwirtschaft, „Herstellung von Braunkohlenbriketts, Braunkohlenkoks, Staub-, Trocken- und Wirbelschichtkohle nach Revieren", www.kohlenstatistik.de.

STATISTIK DER KOHLENWIRTSCHAFT e.V 2007: Statistik der Kohlenwirtschaft, „Herstellung von Braunkohlenbriketts, Braunkohlenkoks, Staub-, Trocken- und Wirbelschichtkohle nach Revieren", www.kohlenstatistik.de.

STATISTISCHES BUNDESAMT, 1989: CORINE Land Cover - Nomenklatur der Bodenbedeckungen. URL: http://www.destatis.de/stbis/oc_1110/f20/d/nomenkla.htm

STATISTISCHES BUNDESAMT, 1991-2005: Statistisches Bundesamt: Fachserien (Zeitschrift), siehe Einzelquellen

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 2006d: Statistisches Bundesamt, „Stromerzeugungsanlagen der Betriebe im Bergbau und Verarbeitenden Gewerbe".

STATISTISCHES BUNDESAMT 2008a: Statistisches Bundesamt, Statistik 066 „Monatsberichte über die Elektrizitätsversorgung / Dezember 2006" Tab. 3.2 und Tab. 5b.

STATISTISCHES BUNDESAMT, 2008b: Statistisches Bundesamt, Statistik 060: Auswertungen des Statistischen Bundesamtes der Budesrepublik Deutschland „Energieverwendung der Betriebe des Verarbeitenden Gewerbes sowie Bergbaus und Gewinnung von Steinen und Erden"

STATISTISCHES BUNDESAMT, 2008c: Statistisches Bundesamt, Statistik 067: Auswertungen des Statistischen Bundesamtes der Budesrepublik Deutschland „Stromerzeugungsanlagen der Betriebe des Verarbeitenden Gewerbes sowie Bergbaus und Gewinnung von Steinen und Erden"

STATISTISCHES BUNDESAMT, 2009: Statistisches Jahrbuch 2009, erschienen am 7.10.2009 unter https://www-ec.destatis.de/csp/shop/sfg/bpm.html.cms.cBroker.cls?CSPCHD=000000010000494v uiyD000000imwvZ1ubarHauRhq24UPnw--&cmspath=struktur,vollanzeige.csp&ID=1024348

STATISTISCHES BUNDESAMT, Fachserie 3 Reihe 3.2.1, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 3.2.1: Wachstum und Ernte

STATISTISCHES BUNDESAMT, Fachserie 3 Reihe 3, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 4: Viehbestand und tierische Erzeugung

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: 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, 2003: Statistisches Bundesamt, Fachserie 19, Reihe 2.1: Öffentliche Wasserversorgung und Abwasserbeseitigung, Klärschlamm (für die Jahre 1991, 1995, 1998, 2001), Wiesbaden

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

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 (GMBI). Nr. 25 - 29 vom 30.7. 2002 S. 511ff.

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, 1994: Daten zur Umwelt 1992/1993, S. 563, Berlin, Schmidt, E.-Verlag

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, 2001a: Umweltbundesamt: UBA-Text 17/01: Maßnahmen zur verursacherbezogenen Schadstoffreduzierung des zivilen Flugverkehrs

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, 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, 2009: Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen 2009, Nationaler Inventarbericht zum Deutschen Treibhausgasinventar 1990-2007, Umweltbundesamt 2009

UMEG 2004: Umweltmessungen, Umwelterhebungen und Gerätesicherheit 2004: Emissionsfaktoren-Handbuch, Emissionserklärung 2004 Baden-Württemberg

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, 2009: United Nations Framework Convention on Climate Change: National Inventory Submissions 2009 URL: http://unfccc.int/national_reports/ annex_i_ghg_inventories/national_inventories_submissions/items/4303.php

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

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 (Verein Deutscher Zementwerke e.V.): Zement – Produktionsdaten der deutschen Zementindustrie; am 24.8.2009 per E-Mail an das UBA übermittelt.

VIK, o.J.: Verband der Industriellen Energie- und Kraftwirtschaft e.V : Statistik der Energiewirtschaft, Verlag Energieberatung , Essen, Fortlaufende Jahrgänge

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

VOLZ et al. 2008: Volz, H.-J., Schobel, S., Wellbrock, N. & Hilbrig, L. (2008): Qualitätsmanagement bei der Bodenzustandserhebung im Wald (BZE II) auf Bundesebene. Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Berlin

WASTECONSULT INTERNATIONAL, 2009: Methanemissionen aus passiv entgasten Deponien und der Ablagerung von mechanisch-biologisch vorbehandelten Abfällen, FKZ: 360 16 015, Dezember 2009

WEG, 2000: Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V.: ERDGAS - ERDÖL. Entstehung, Suche, Förderung. Hannover. URL: http://www.erdoel-erdgas.de/Publikationen-68a.html

WEG, 2008: WEG Wirtschaftsverband Erdöl und Erdgasgewinnung e.V.: Jahresbericht 2008, Zahlen und Fakten. Hannover. URL: http://www.erdoel-erdgas.de/Publikationen-68a.html

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.htmlWEG, 2008b: WEG Bericht zur Schwefelgewinnung im Inland, URL: http://www.erdoel-erdgas.de/article/articleview/13/1/59/

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

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.

WIESEN, et al, 1994: Wiesen, P., Kleffmann, J., Kurtenbach, R., Becker, K.H.: Nitrous Oxide and Methane Emissions from Aero Engines, Geophys. Res. Lett., 21 (1994) 2027-2030

WIESEN et al, 1996: Wiesen, P., Kleffmann, J., Kurtenbach, R., Becker, K.H.: Emission of nitrous oxide and methane from aero engines: monitoring by tunable diode laser spectroscopy, Infrared Phys. and Technol. 37 (1996) 75-81

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.

YARA (2009) Kalkammonsalpeter http://fert.yara.de/de/products/product_range/nitrogen_fertilizers/calcium_amm_nit.html (Aufruf vom 28.07.2009)

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

ZIESING 2009: Ziesing, Hans Joachim: CO_2-Emissionen in Deutschland 2008:Im Abschwung. In: Energiewirtschaftliche Tagesfragen Jg. 59, Heft 4, Mai 2009