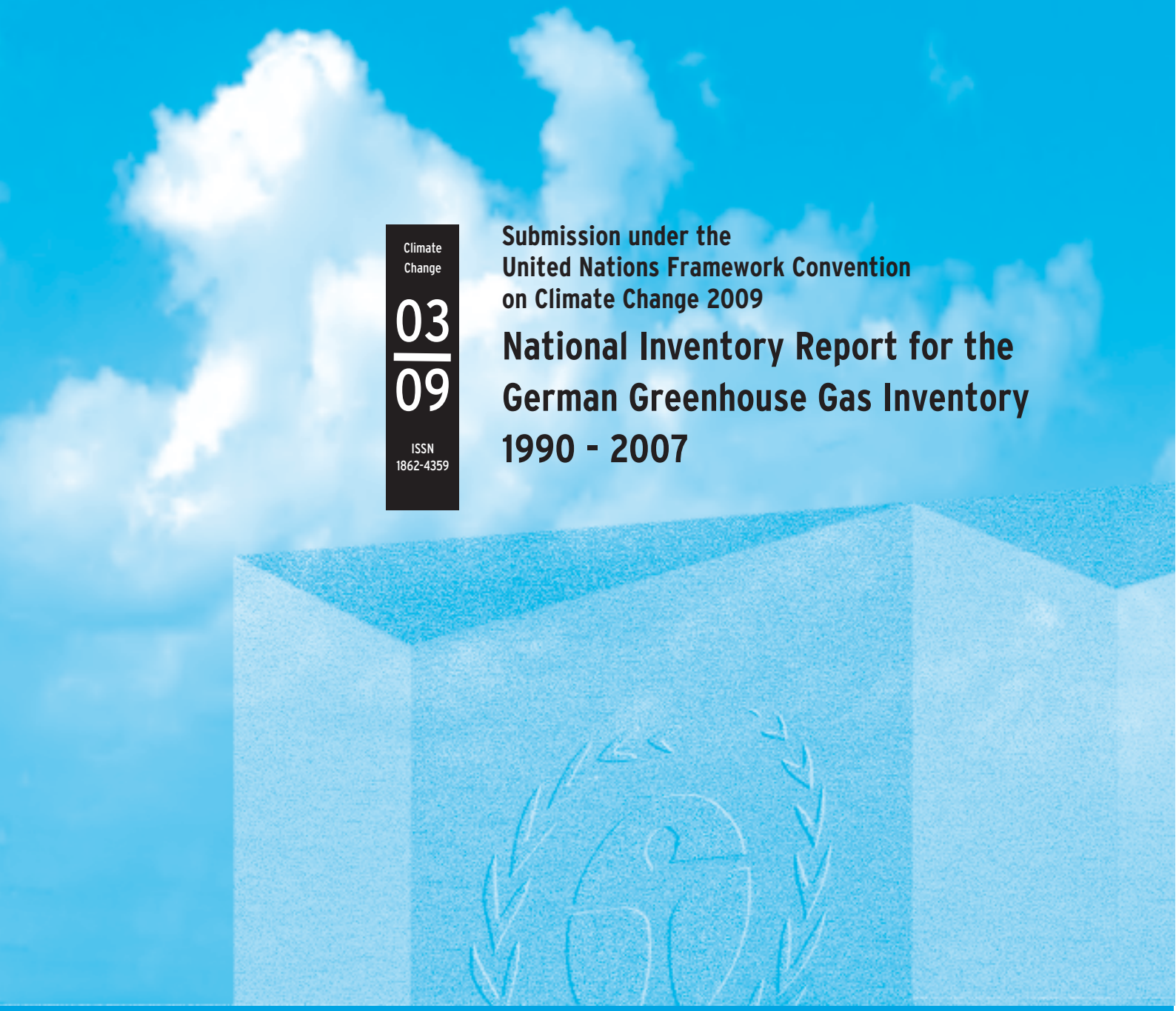
Climate Change

Climate Change
03/09
ISSN 1862-4359

Submission under the
United Nations Framework Convention
on Climate Change 2009

National Inventory Report for the German Greenhouse Gas Inventory 1990 - 2007



Umwelt Bundes Amt
Für Mensch und Umwelt

Climate Change
03/09
ISSN 1862-4359

Submission under the
United Nations Framework Convention
on Climate Change 2009

National Inventory Report for the German Greenhouse Gas Inventory 1990 - 2007

Federal Environment Agency, Germany

This publication is only available as download under
http://www.umweltbundesamt.de

Publisher: Federal Environment Agency (Umweltbundesamt)
P.O.B. 14 06
06813 Dessau-Roßlau
Tel.: +49-340-2103-0
Telefax: +49-340-2103 2285
Internet: http://www.umweltbundesamt.de

Edited by: Section I 2.6
Michael Strogies, Patrick Gniffke

Dessau-Roßlau, April 2009

Contact

This report was produced in the framework of work of the National Co-ordination Agency (Single Entity) for the *National System of Emissions Inventories* (*Nationales System Emissionsinventare*; NaSE), sited within the Federal Environment Agency (UBA). Contributions for the chapters on agriculture, and on land use, land-use changes and forestry, were prepared by the Johann Heinrich von Thünen Institute (vTI).

The electronic version of this report, along with the pertinent emissions data in the Common Reporting Format (CRF) (Version 1.10, based on the CSE database, and last revised as of 12 November 2008), is available on the Web site of the Federal Environment Agency:
http://www.umweltbundesamt.de/emissionen/publikationen.htm

Authors

Overall control of the project: Michael Strogies, Patrick Gniffke (UBA I 2.6)

For the individual chapters [i.p. = in part]:

Summary	Patrick Gniffke (UBA I 2.6)
Chapter 1.1	Rosemarie Benndorf (UBA I 2.1)
Chapter 1.2.1, 1.2.3 i.p.,1.2.4, 1.3 i.p.	Dirk Günther (UBA I 2.6)
Chapter 1.2.3.3, 1.2.5.6	Robert Kludt (UBA I 2.6)
Chapter 1.2.5 i.p., 1.6	Stephan Schiller (UBA I 2.6)
Chapter 1.7., 1.8	Detlef Rimkus (UBA I 2.6)
Chapter 1.5, 2, 3.1.8, 3.1.10-12	Michael Strogies (UBA I 2.6)
Chapter 3.1	Petra Icha (UBA I 2.5), Kathrin Werner / Marion Dreher (UBA I 2.5), Kristina Juhrich (UBA I 2.6),
Chapter 3.1.1 – 3.1.3, 3.1.4.6	Petra Icha (UBA I 2.5), Rolf Beckers (UBA III 2.3)
Chapter 3.1.4.1	Petra Icha (UBA I 2.5), Sebastian Plickert (UBA III 2.2)
Chapter 3.1.4.2 - 3.1.4.3, 3.1.4.5, 3.1.4.7 - 3.1.4.11	Petra Icha (UBA I 2.5)
Chapter 3.1.4.4	Petra Icha (UBA I 2.5), Almut Reichart (UBA III 2.3)
Chapter 3.1.4.2 - 3.1.4.3, 3.1.4.5	Petra Icha (UBA I 2.5), Kathrin Werner (UBA I 2.5),
Chapter 3.1.4.4	Petra Icha (UBA I 2.5), Kathrin Werner (UBA I 2.5), Almut Reichart (UBA III 2.3)
Chapter 3.1.4.7 - 3.1.4.11	Petra Icha (UBA I 2.5), Kathrin Werner (UBA I 2.5)
Chapter 3.1.5.1	Frank Wetzel (UBA I 3.2)
Chapter 3.1.5.2 - 3.1.5.5	Gunnar Gohlisch, Andrea Kolodziej (UBA I 3.1)
Chapter 3.1.6 + 3.1.7	Anja Behnke (UBA III 2.3), Reinhard Böhnke (UBA I 2.5)
Chapter 3.1.9.1	Falk Heinen, Frank Wetzel (UBA I 3.2)
Chapter 3.1.9.2	Volker Brenk (UBA I 3.2)
Chapter 3.2.1	Jürgen Ilse (Gesamtverband Steinkohle (Association of the German hard-coal mining industry)), Christian Böttcher (UBA I.2.6); Sebastian Plickert (UBA III 2.1)
Chapter 3.2.2	Edda Hoffmann (UBA III 2.3), Stephan Bernt (UBA III 2.3); Christian Böttcher (UBA I.2.6)
Chapter 4.1.1 - 4.1.3	Maja Bernicke (UBA III 2.2)
Chapter 4.1.4	Birgit Brahner (UBA III 2.3)
Chapter 4.1.5 & 4.1.6	Rainer Remus (UBA III 2.2)
Chapter 4.1.7	Sandra Leuthold (UBA III 2.2)

Chapter 4.1.8	Sebastian Plickert (UBA III 2.2)
Chapter 4.2.1 & 4.2.2	Birgit Brahner (UBA III 2.3)
Chapter 4.2.3	Johannes Drotleff (UBA III 2.3
Chapter 4.2.4	Birgit Brahner (UBA III 2.3)
Chapter 4.2.5	Birgit Brahner (UBA III 2.3), Johannes Drotleff (UBA III 2.3), Edda Hoffmann (UBA III 2.3)
Chapter 4.2.6	Maiya Shibasaki (IKP), Cecilia Tiemi Makishi (IKP), Stephan Schiller (UBA I 2.6)
Chapter 4.3.1 & 4.3.2	Sebastian Plickert (UBA III 2.2)
Chapter 4.3.3	Maja Bernicke (UBA III 2.2)
Chapter 4.3.4	Cornelia Elsner, Kerstin Martens (UBA III 1.4)
Chapter 4.3.5	N.N.
Chapter 4.4.1	Almut Reichart (UBA III 2.3)
Chapter 4.4.2	Dr. Zueleyha Iyimen-Schwarz (UBA I 1.4)
Chapter 4.5 - 4.6	Cornelia Elsner, Kerstin Martens (UBA III 1.4)
Chapter 5.1	Folke Dettling (UBA III 1.4)
Chapter 5.2	Maiya Shibasaki (IKP), Cecilia Tiemi Makishi (IKP), Stephan Schiller (UBA I 2.6)
Chapter 6 & 7	Johann Heinrich von Thünen Institute (vTI): Annette Freibauer
Chapter 8.1	Wolfgang Butz (UBA III 3.3)
Chapter 8.2	Dietmar Wunderlich, Christine Galander (UBA III 3.4)
Chapter 10	Michael Kotzulla (UBA I 2.6)
Chapter 11	Patrick Gniffke, Stephan Schiller (UBA I 2.6)
Annex 1, 4	Michael Strogies (UBA I 2.6)
Annex 2	Kathrin Werner (UBA I 2.5), Kristina Juhrich (UBA I 2.6), Marcus Machat (UBA E 1.1), Petra Icha (UBA I 2.5)
Chapter 13.7	Kristina Juhrich (UBA I 2.6)
Chapter 13.8 & 13.9	Michael Strogies (UBA I 2.6)
Annex 3	Authors in keeping with specialised responsibility in Chapter 3-8
Annex 3, Chapter 14.1.1	Marcus Machat (UBA E 1.1), Frank Zander (Institute for Energy and Environment (Institut für Energetik und Umwelt): IE gGmbH), Dr. Dieter Merten (IE gGmbH)
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 17.3	Kevin Hausmann (I 2.6)
Annex 7	Detlef Rimkus (UBA I 2.6)

Imprint

Published by: Umweltbundesamt (Federal Environment Agency), Wörlitzer Platz 1, 06844 Dessau, Deutschland

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 trees with high life expectancies (Tree-species group as defined within the Federal Forest Inventory (BWI))
ALN	All other deciduous trees with low life expectancies (Tree-species group as defined within the BWI)
ANCAT	Abatement of Nuisances from Civil Air Transport
AR	Activity rate
AWMS	Animal Waste Management System
B_0	Maximal CH_4-production capacity
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	Federal Association of the German Gas and Water Industry (Bundesverband der deutschen Gas- and Wasserwirtschaft)
BHD	Breast-height diameter: tree-trunk diameter at a height of 1.30 m above the ground
BHKW	micro-CHP (CHP = combined heat/power generating system) (Blockheizkraftwerk)
BImSchV	Statutory Ordinance under the Federal Immission Control Act
BML	see BMVEL
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMELV	Federal Ministry of Food, Agriculture and Consumer Protection
BMVEL	see BMELV
BMVG	Federal Ministry of Defence
BMWA	see 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 (BOD) within 5 days
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 (= Fluorchlorkohlenwasserstoffe (FCKW))
CH_4	Methane
C_{org}	Organic carbon stored in the soil
CO	Carbon monoxide
CO_2	Carbon dioxide
CORINAIR	Coordination of Information on the Environment, sub-project: Air
CORINE	Coordinated Information on the Environment
CRF	Common Reporting Format
CSB	Chemical oxygen demand (COD)
D	Germany (Deutschland)
D7	Tree-trunk diameter at a height of 7 m above the ground
DEHSt	German Emissions Trading Agency (Deutsche Emissionshandelsstelle)
DESTATIS	Federal Statistical Office (Statistisches Bundesamt Deutschland)
DFIU	Franco-German Institute for Environmental Research, at the University of Karlsruhe
DG	Landfill gas
DGMK	German Scientific Society for Petroleum, Natural Gas and Coal (Deutsche Wissenschaftliche Gesellschaft für Erdöl, Erdgas und Kohle e.V.)
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	N in wastewater
DOC	Degradable organic carbon
DOC_F	Fraction of DOC dissimilated
DTKW	Steam-turbine power stations
DVGW	German Association of Gas and Water Professionals (Deutsche Vereinigung des Gas- und Wasserfachs e.V.)
EBZ	Line-number in the BEU
EEA	European Environment Agency
EECA	European Electronic Component Manufacturers Association
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz; text 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	Extra light (heating oil)
EM	Emission
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
EMEV	Emissions-relevant energy consumption (Emissionsrelevanter Energieverbrauch)
ESIA	European Semiconductor Industry Association
ETS	Emissions Trading Scheme
EU	European Union
EU-EH	European Emissions Trading Scheme (ETS; Europäischer Emissionshandel)

EUROCONTROL	European Organisation for the Safety of Air Navigation
EUROSTAT	Statistical Office of the European Communities
EW	Population equivalents (Einwohnerzahl)
FA	Combustion systems (Feuerungsanlagen)
FAP	Co-ordinating expert (German: Fachlicher Ansprechpartner), assigned to organize the work in specific NaSE source categories
FAL	Federal Agricultural Research Institute
FAO	United Nations Food and Agriculture Organisation
FCKW	Chlorofluorocarbons (CFCs; Fluorchlorkohlenwasserstoffe)
F gases	Fluorinated hydrocarbons
FHW	District heating stations (Fernheizwerke)
FKW	Perfluorocarbons (PFCs; Fluorkohlenwasserstoffe)
FKZ	Research index (Forschungskennziffer)
FV	Relevant expert (German: Fachverantwortlicher) assigned to cover specific NaSE source categories
FWL	Thermal output from combustion (Feuerungswärmeleistung)
GAS-EM	GASeous EMissions – A calculation programme for emissions from agriculture
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 (German: Wasserstoffhaltige Fluorkohlenwasserstoffe – HFKW)
HCFC	Hydrochlorofluorocarbons (German: Wasserstoffhaltige Fluorchlorkohlenwasserstoffe – HFCKW)
HQG	Key source (Hauptquellgruppe); applied to both emissions sources and sinks.
HS-GIS	High-voltage and 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	Leipzig Institute for Energy (IE Leipzig; Institut für Energie)
IFEU	Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung)
IKW	Industrial power stations (Industriekraftwerke)
IMA	Interministerial Working Group (Interministerielle Arbeitsgruppe)
IPCC	Intergovernmental Panel On Climate Change

K	Fuel input for power generation (direct drive)
k.A.	No entry (keine Angabe)
KP	Kyoto Protocol
KS	Sewage sludge (Klärschlamm)
l	Level (used in the level assessment pursuant to IPCC Good Practice Guidance)
LF	Agriculturally used land (German: 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 (German: Mechanisch-Biologische Abfallbehandlung)
MCF	Methane conversion factor
MS	Medium voltage (Mittelspannung)
MSW	Amount of municipal waste stored
MVA	Waste incineration plant (Müllverbrennungsanlage)
MW	Megawatt
N2O	Nitrous oxide (laughing gas)
NA	Not applicable
NASA	National Aeronautics and Space Administration
NaSE	National System of Emissions Inventories
NBL	New German Länder (neue Bundesländer)
NE	Not estimated
NEAT	Non-energy Emission Accounting Tables
NEC	National emission ceilings for certain air pollutants, pursuant to 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 (Nichtenergetischer Verbrauch)
NFR	Nomenclature for Reporting (new format for reporting to UN ECE)
NFZ	Utility vehicles (Nutzfahrzeuge)
NH3	Ammonia
NIR	National Inventory Report
NMVOC	Non-Methane Volatile Organic Compounds
NO	Not occurring
NO	Nitrogen monoxide
NSCR	Non-selective catalytic reduction
OCF	One-component foam (installation foam)
OX	Oxidation factor
PAH	Polycyclic aromatic hydrocarbons (German: Polycyclische aromatische Kohlenwasserstoffe (PAK))
PAK	see PAH
PARTEMIS	Measurement and prediction of emissions of aerosols and gaseous precursors from gas turbine engines
PCCD/F	Polychlorinated dibenzo-dioxins/- furans
PF	Process furnaces
PFC	Perfluorocarbons

PKW	Automobile (Personenkraftwagen)
PU	Polyurethane
QK	Quality control (QC)
QS	Quality assurance (QA)
QSE	Quality System for Emissions Inventories
REA	Flue-gas desulphurising plant (German: Rauchgasentschwefelungsanlage)
ROE	Oil equivalent (German: Rohöleinheiten)
RSt	Raw steel
RWI	RWI Essen (Rheinisch-Westfälisches Institut für Wirtschaftsforschung)
S	Fuel input for power generation
S	Heavy (German: schwer); used in describing types of heating oil
S&A report	Synthesis and Assessment Report
SA	Heavy (German: schwer) and low in sulphur (German: schwefelarm); used in describing types of heating oil
SF6	Sulphur hexafluoride
SKE	Hard-coal units (Steinkohleneinheiten)
SNAP	Selected Nomenclature for Air Pollution
SO2	Sulphur dioxide
STEAG	STEAG stock corporation: large electricity producer in Germany
t	Trend (used in the level assessment pursuant to IPCC Good Practice Guidance)
TA Luft	Technical instructions on air quality control; First General Administrative Provision on the Federal Immission Control Act
TAN	Total Ammoniacal Nitrogen
THG	Greenhouse gases (Treibhausgase = GHG)
TM	Dry mass (Trockenmasse)
TOC	Total Organic Carbon
TREMOD	Traffic Emission Estimation Model
TS	Dry matter (Trockenstoff)
TÜV	Technischer Überwachungs-Verein (Certifying body for technical and product safety)
TVF	Tonne of utilisable production (Tonne verwertbare Förderung)
UBA	Federal Environment Agency (Umweltbundesamt)
UN ECE	United Nations Economic Commission for Europe
UN FCCC	United Nations Framework Convention on Climate Change
UN	United Nations
UStatG	Environmental Statistics Act (Umweltstatistikgesetz)
VDEW	Electricity Industry Association (Verband der Elektrizitätswirtschaft e.V.)
VDI	Association of German Engineers (Verein Deutscher Ingenieure e.V.)
VDN	Association of network operators (Verband der Netzbetreiber)
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

vTI	Johann Heinrich von Thünen Institute
vTI-AK	Johann Heinrich von Thünen Institute, Institute of Agricultural Climate Research
vTI-WOI	Johann Heinrich von Thünen Institute, Institute of Forest Ecology and Forest Inventory
W	Fuel input for heat generation
WS	WS = Portion of a specific waste water 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}	hecto	h
0.1	10^{-1}	deci	d
0.01	10^{-2}	centi	c
0.001	10^{-3}	milli	m
0.000,001	10^{-6}	micro	µ

Units and abbreviations

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

Standard conversions

Unit	**is equivalent to**
1 tonne (t)	1 megagram (Mg)
1 kilotonne (kt)	1 gigagram (Gg)
1 megatonne (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**	**2007 - contribution to total emissions**	**Trend**
Solid Fuels	l / t	CO_2	22.70 %	25.55 %	rising
Gaseous Fuels	l / t	CO_2	1.38 %	2.34 %	rising
Liquid Fuels	l / t	CO_2	0.64 %	0.41 %	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				
Method of EF determination	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

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)

Method of EF determination

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

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. With the present inventory, Germany is beginning, on a voluntary basis, to fulfill this reporting obligation.

Germany now presents its seventh National Inventory Report (NIR 2009), following its inventories for the years 1990 to 2007. This latest report covers the same period (1990 to 2007), 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).

Chapter 1 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, and it describes the Quality System for Emissions Inventories (QSE).

Chapter 2 provides a general overview of development of emissions of greenhouse gases and their storage in sinks.

Chapters 3 to 9 contain detailed information about the main groups of emissions sources and sinks; this information is designed to enhance the transparency of calculations of German greenhouse-gas emissions and sinks.

The inventories, the National System and the Quality System for Emissions Inventories have all been further improved in keeping with the detailed review that took place in 2008, prior to

[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)

the beginning of the commitment period. As a result of this revision, the figures for achieved emissions reductions differ somewhat from those reported in previous years.

This year's report is considerably improved over the 2008 National Inventory Report: it applies enhanced methods for the areas of transport, solvents and agriculture; includes an updated report on the area of LULUCF; and applies the quality assurance system to the entire emissions reporting process. The last of these improvements has been achieved especially in that a suitable inventory plan has been derived and implemented, and minimum requirements have been defined with regard to quality checking and quality assurance in emissions reporting. Furthermore, progress has been made in institutionalising the national emissions-reporting system.

Details on recalculations, along with information about improvements carried out on the basis of recommendations from the Initial Review under the Kyoto Protocol and for the 2006 Inventory Report, can be found in **Chapter 10.**

More detailed information about specific relevant issues is presented in the literature listed in **Chapter 11**.

The Federal Environment Agency makes all calculations for the greenhouse-gas inventory and carries out all relevant compilation. Emissions and sinks from agriculture, land-use changes and forestry were provided by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) and the Johann Heinrich von Thünen Institute (vTI).

0.1 Background information on greenhouse-gas inventories and climate change

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 influence on climate is now scientific fact.

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

[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]

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.

0.2 Greenhouse-gas emissions and their storage in sinks (with respect to GWP) over time: 1990-2007

By 2007, Germany had already fulfilled a large part of its obligations within the framework of the aforementioned European burden-sharing, amounting to a reduction of 22.4 % 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 (value-added-tax (VAT) increase as of 1.1.2007; mild weather in the 2006/2007 winter season; expansion in use of renewable energies; and changes in methods), emissions in 2007 were considerably lower than those of previous years (cf. Chapter 2.1).

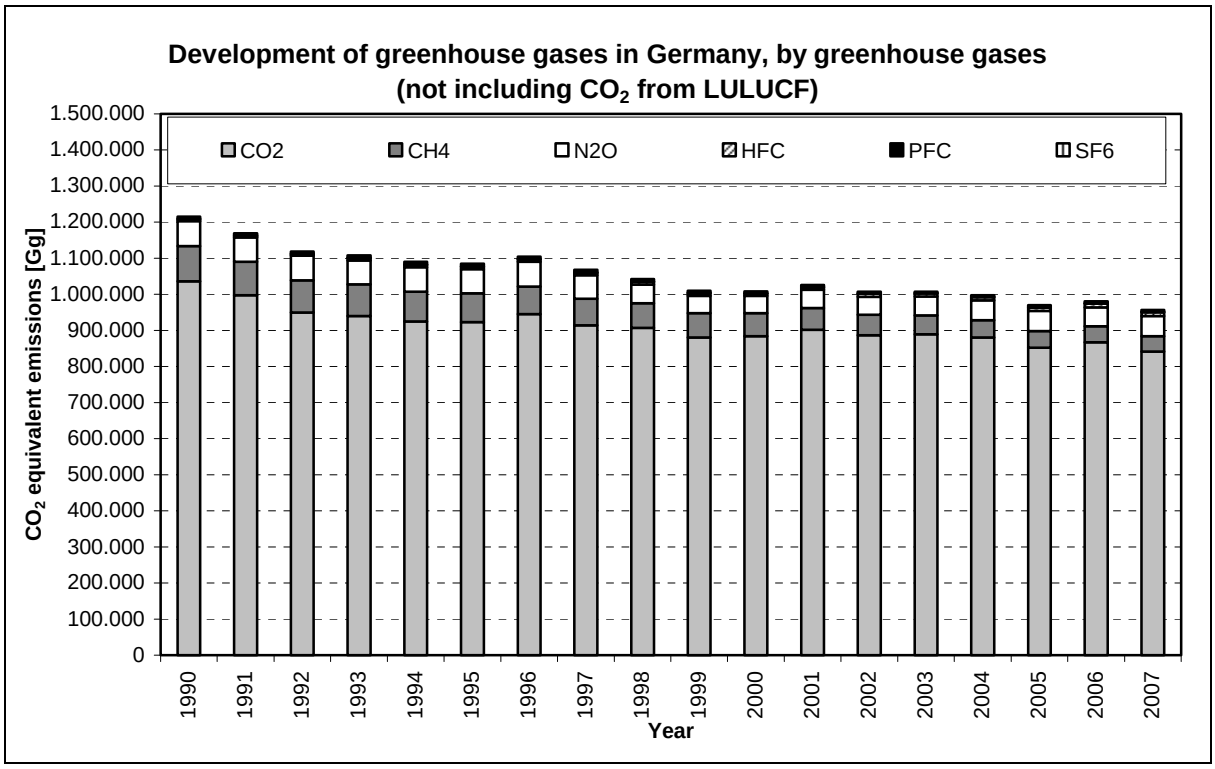


Figure 1: Development of greenhouse gases in Germany since 1990, by greenhouse gases[6]

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

In 2007, carbon-dioxide releases were the most significant greenhouse-gas emissions, accounting for 87.9 % 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

[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.

greenhouse-gas emissions, CO_2 emissions' share of total emissions has increased by nearly 3 percentage points since the base year. Methane (CH_4) emissions from animal husbandry, fuel distribution and landfills account for 4.4 %. Emissions of nitrous oxide (N_2O), caused primarily by agriculture, industrial processes and transport, contribute 5.8 % of greenhouse-gas releases. Fluorocarbons (so-called "F gases") account for about 1.8 % 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

GHG 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
Net CO_2 emissions / storage	**1.007.274**	**968.831**	**919.578**	**909.356**	**893.862**	**891.748**	**913.798**	**882.513**	**875.313**	**848.085**	**851.528**	**879.883**	**864.099**	**869.250**	**855.900**	**829.106**	**850.787**	**824.362**
CO_2 emissions (not including LULUCF)	**1.035.580**	**997.578**	**949.612**	**939.575**	**924.611**	**922.660**	**944.887**	**914.328**	**907.118**	**880.349**	**883.683**	**901.309**	**886.404**	**889.010**	**879.935**	**851.708**	**867.021**	**841.152**
CH_4	97.805	92.470	88.631	88.220	83.153	79.983	77.083	73.306	68.222	67.580	63.834	60.581	57.025	53.000	48.777	46.223	44.103	42.552
N_2O	70.019	67.344	68.561	65.880	67.510	66.877	68.264	65.339	52.047	48.259	48.368	50.422	49.906	51.989	54.658	56.132	52.948	55.878
HFCs	4.369	4.013	4.190	6.160	6.329	6.463	5.843	6.380	6.950	7.192	6.471	7.880	8.784	8.615	9.224	9.978	10.516	11.098
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
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	4.241	4.384	4.559	4.898	5.510	5.567

Total emissions / storage, including LULUCF	**1.186.959**	**1.140.109**	**1.088.695**	**1.077.982**	**1.059.497**	**1.054.041**	**1.073.635**	**1.035.812**	**1.010.708**	**977.670**	**976.065**	**1.004.433**	**984.843**	**988.088**	**973.938**	**947.043**	**964.433**	**939.985**
Total emissions, not including CO_2 from LULUCF	**1.215.265**	**1.168.856**	**1.118.728**	**1.108.201**	**1.090.246**	**1.084.954**	**1.104.723**	**1.067.627**	**1.042.513**	**1.009.934**	**1.008.220**	**1.025.859**	**1.007.147**	**1.007.847**	**997.973**	**969.645**	**980.667**	**956.775**

GHG emissions / sinks, by source and sink categories, in CO_2 equivalents (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	987.938	952.716	904.556	897.349	874.891	870.438	896.434	860.127	851.295	828.799	826.123	846.646	831.260	831.259	818.368	791.801	803.289	773.675
2. Industrial processes	119.820	114.431	114.530	112.667	121.250	121.241	117.146	119.812	105.931	97.511	100.783	99.558	99.927	103.170	107.560	107.776	108.967	116.123
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
4. Agriculture	61.631	55.857	54.612	54.424	53.141	54.433	54.879	54.154	54.437	55.385	55.469	55.419	53.611	53.009	53.171	52.801	52.097	51.479
5. Land use, land-use changes & forestry	-28.250	-28.691	-29.977	-30.163	-30.693	-30.856	-31.032	-31.759	-31.749	-32.207	-32.099	-20.674	-21.553	-19.007	-23.284	-21.849	-15.572	-16.128
CO_2	-28.306	-28.747	-30.033	-30.219	-30.750	-30.912	-31.089	-31.815	-31.805	-32.264	-32.155	-21.426	-22.305	-19.759	-24.036	-22.602	-16.234	-16.790
N_2O	56	56	56	56	56	56	56	56	56	56	56	752	752	752	752	752	662	662
6. Waste	40.424	40.388	39.782	38.595	36.488	34.327	31.833	29.109	26.431	24.139	22.067	20.043	18.227	16.376	14.731	13.113	12.306	11.519

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

GHG emissions / sinks; shares for various GHG, not including CO_2 from LULUCF (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
CO_2 emissions (not including LULUCF)	85.2	85.3	84.9	84.8	84.8	85.0	85.5	85.6	87.0	87.2	87.6	87.9	88.0	88.2	88.2	87.8	88.4	87.9
CH_4	8.0	7.9	7.9	8.0	7.6	7.4	7.0	6.9	6.5	6.7	6.3	5.9	5.7	5.3	4.9	4.8	4.5	4.4
N_2O	5.8	5.8	6.1	5.9	6.2	6.2	6.2	6.1	5.0	4.8	4.8	4.9	5.0	5.2	5.5	5.8	5.4	5.8
HFCs	0.4	0.3	0.4	0.6	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
PFCs	0.2	0.2	0.2	0.2	0.2	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
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
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**

GHG emissions / sinks; shares for emission & sink categores, not including CO_2 from LULUCF (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	81.3	81.5	80.9	81.0	80.2	80.2	81.1	80.6	81.7	82.1	81.9	82.5	82.5	82.5	82.0	81.7	81.9	80.9
2. Industrial processes	9.9	9.8	10.2	10.2	11.1	11.2	10.6	11.2	10.2	9.7	10.0	9.7	9.9	10.2	10.8	11.1	11.1	12.1
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	0.4	0.3	0.3
4. Agriculture	5.1	4.8	4.9	4.9	4.9	5.0	5.0	5.1	5.2	5.5	5.5	5.4	5.3	5.3	5.3	5.4	5.3	5.4
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
6. Waste	3.3	3.5	3.6	3.5	3.3	3.2	2.9	2.7	2.5	2.4	2.2	2.0	1.8	1.6	1.5	1.4	1.3	1.2
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
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

0.3 Overview of emissions estimates and trends for source and sink categories

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 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 22.4 %). Considerations of the various components involved confirm this trend, to varying degrees. For example, the emissions changes since base-year 1990 for the most important greenhouse gases (in terms of quantities) are as follows: -18.8 % for carbon dioxide (CO_2), -56.5 % for methane (CH_4) and -20.2 % for nitrous oxide / laughing gas (N_2O). The corresponding trends for the so-called "F" gases, which contribute about 1.8 % of greenhouse-gas emissions overall, have not been as clearly similar to each other, however. In keeping with the introduction of new technologies, and with use of these substances as substitutes, since base year 1995 SF_6 emissions decreased by 22.9 % and PFC emissions dropped by 69.8 %, while HFC emissions increased by 71.7 %.

These emissions changed considerably with respect to the previous year, 2006 (the decrease amounted to 2.44 %). As to contributors to the overall result, a CO_2-emissions reduction of nearly 3 % (cf. Chapter 2.1), caused by a drop in energy consumption, and a 3.5% reduction in methane emissions, were offset by a + 5.5 % increase in nitrous oxide emissions and + 3.6 % growth in emissions of F gases. The main factors contributing to the methane reductions include significant increases in use of pit gas and continuing decreases in waste-sector emissions.

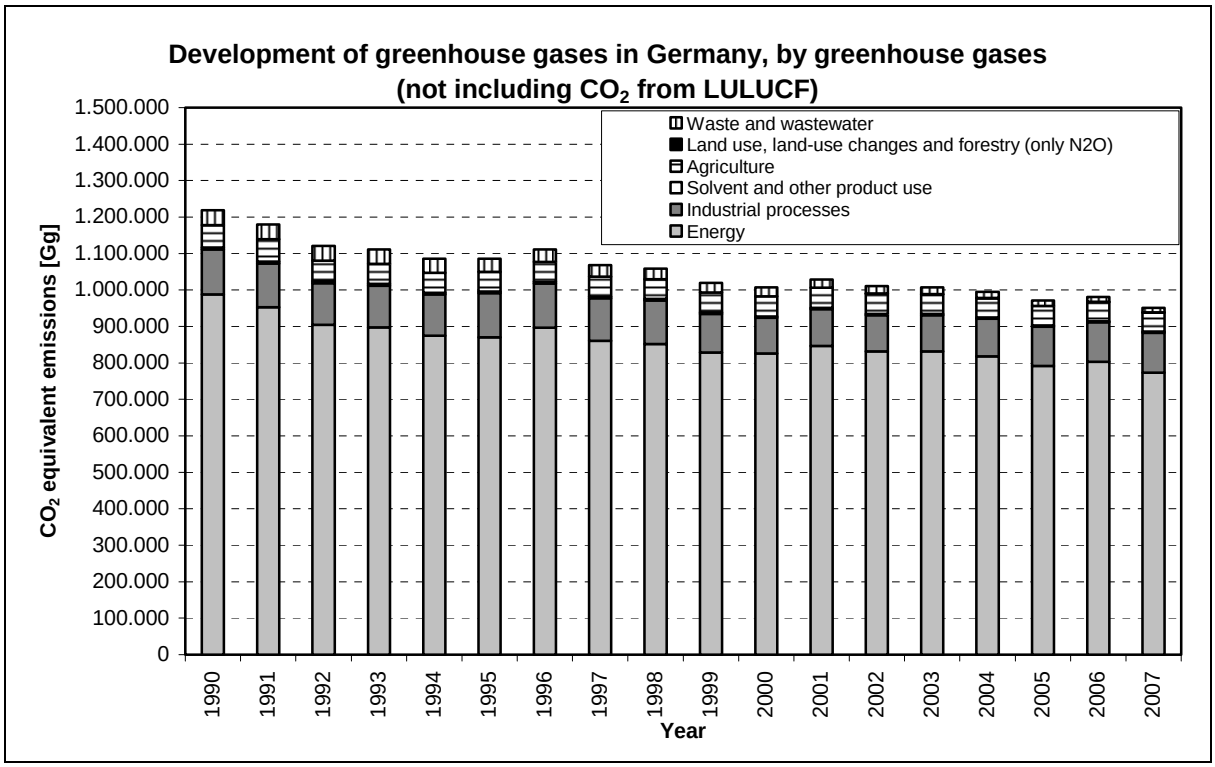


Figure 2: Emissions trends in Germany since 1990, by source categories[7]

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.

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

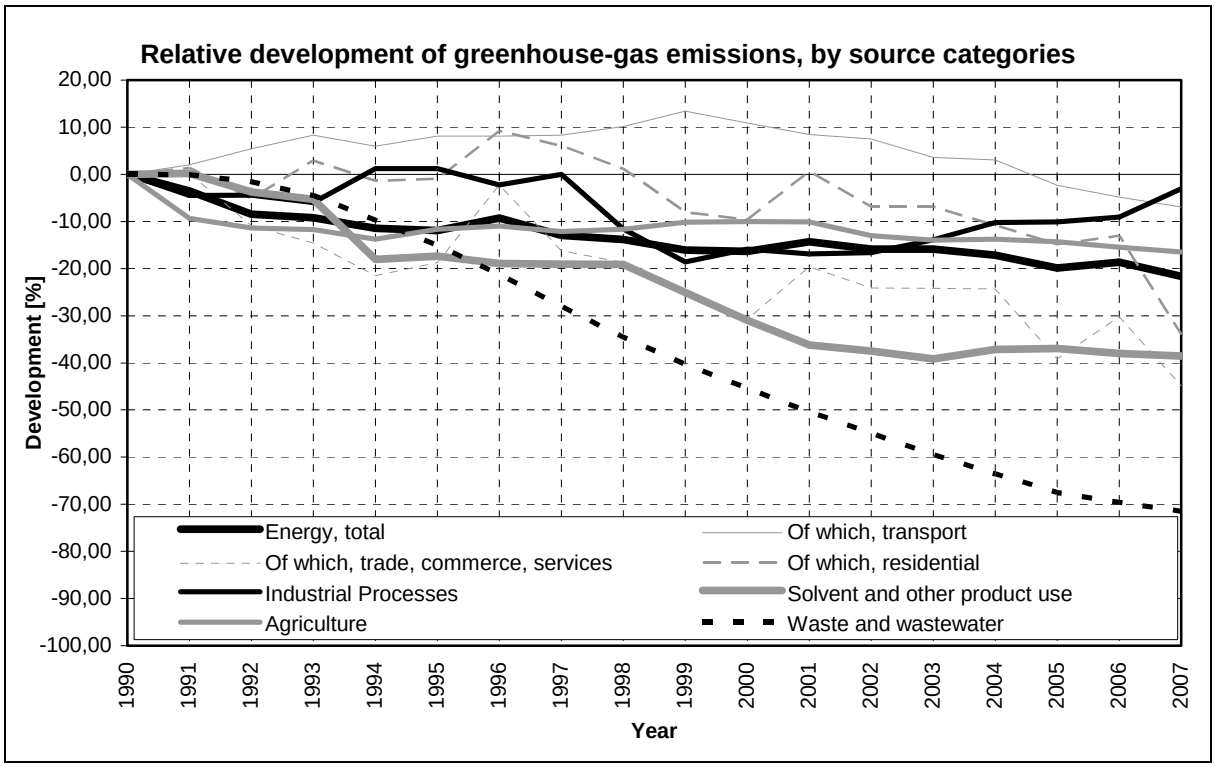


Figure 3: Relative development of greenhouse-gas emissions since 1990, by source categories[8,9]

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

[9] The reference point consists of the emissions of 1990 (=100%), and not those of the base year.

1 INTRODUCTION

1.1 Background information on climate change and on greenhouse-gas inventories

1.1.1 The greenhouse effect

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 solar constant, elements of the earth's orbit, etc.
- Changes in the earth's surface
- Changes in the energy balance in the system of the "earth's surface and atmosphere"
- 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 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.

1.1.2 Climate change

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 for 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.

1.1.3 Reduction obligations and reporting of greenhouse gases

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 on Climate. 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 [10] 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 is reliable. As such, national reporting and the subsequent international review of emissions inventories play a key role.

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

1.2 Institutional specifications and framework conditions for inventory preparation

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 extensive use of the methodological regulations from the *IPCC Guidelines* and the *IPCC Good Practice Guidance,* through ongoing quality management and through continuous inventory improvement.

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 Construction (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. also chapters 1.2.4.5 and 1.2.4.7).

The paper "National System" of 5 June 2007, on basic principles of emissions reporting, is provided in Annex Chapter 17.1.1.

1.2.1 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 twice, at the invitation of the BMU (the 2nd meeting was held on 1 July

2008). At the committee's constitutive meeting, held on 21 December 2007, it was agreed that the committee should meet at least twice per year. With this action, an identified shortcoming, referred to in the Initial Review 2007: Institutional, legal and procedural arrangements (Document FCCC/IRR/2007/DEU of 12 December 2007, Para 11), was eliminated, and further progress toward the institutionalisation of the National System of Emissions Reporting was made.

1.2.2 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 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. From 2003 to 2008, the SNE has given priority to developing new data sources and to improving existing data sources and safeguarding them for the long term. Other important work in this connection has included the introduction of the Quality System of Emissions Inventories (cf. Chap. 1.2.6) and further institutionalisation of the *National System* (cf. Chap. 1.2.4). Furthermore, institutions that need to be integrated within the *National System* have been identified and are now being successively integrated (cf. Chapter 1.2.4.5).

1.2.3 Instruments of the Single National Entity

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

Within 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 in 2005 via in-house directive 11/2005, within the Federal Environment Agency 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*. Establishment of minimum requirements pertaining to data documentation, QC/QA and archiving ensures that additional authorities,

institutions and inventory experts are included in the quality management process. A draft of such minimum requirements, prepared by the Single National Entity, has been accepted by the National Co-ordinating Committee and is currently being successively implemented. In addition, this approach makes its possible for other organisations to build their own internal quality assurance systems on the basis of their existing structures. It thus addresses the reference provided in Paragraph 18 of the 2007 Initial Review. The QSE is described in detail in Chapter 1.2.6.

A searchable Access database – the *Planning and Control Instrument (Planungs- und Steuerungsinstrument* – PlaSte) – serves as the key instrument for monitoring success within the QSE framework. This database is the repository for all tabular documents emerging from the national QC/QA process (QC/QA plan, checklists, lists of responsibilities, etc.). In addition, the PlaSte 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 implementation of quality measures within the framework of inventory preparation is described in Figure 4.

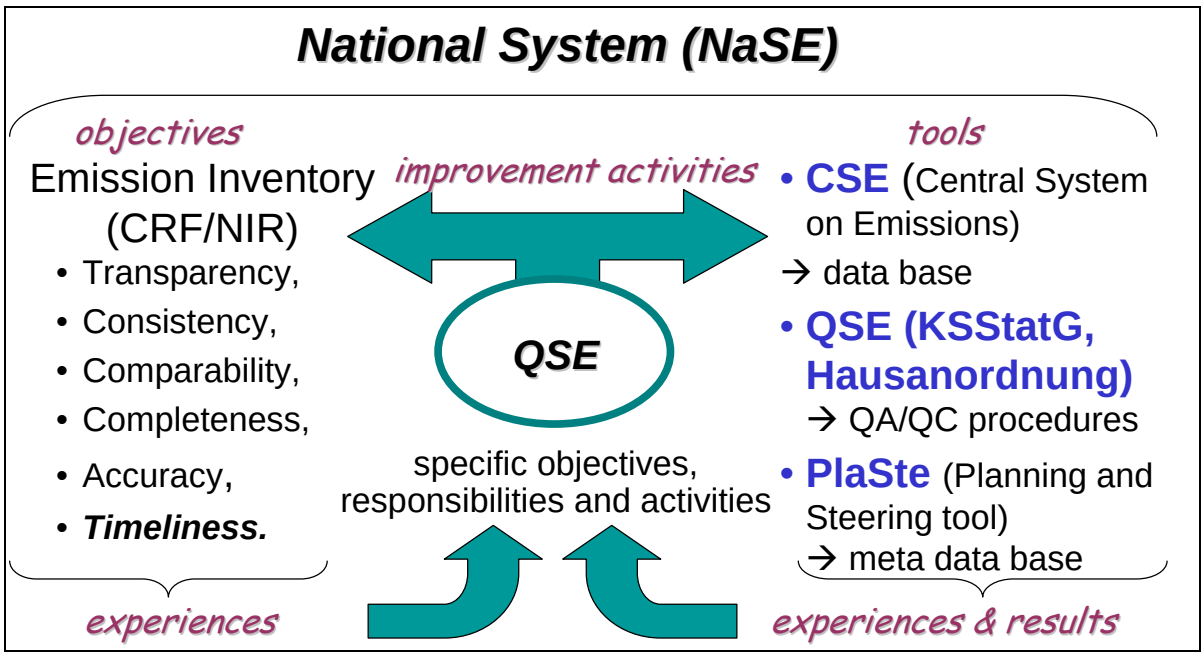


Figure 4: NaSE - Objectives and instruments

1.2.4 Institutional and legal specifications of the National System

Since 2005, decisive progress has been made in institutionalising the National System. This progress has been achieved via establishment of the National Co-ordinating Committee (cf. Chap. 1.2.1), via an in-house directive for the Federal Environment Agency (cf. Chap. 1.2.4.2), via the development of a procedure for using monitoring data from European emissions trading (cf. Chap. 1.2.4.3) and via drafts of pertinent agreements between the *Single National Entity*, other relevant federal institutions and non-governmental organisations (cf. Chap. 1.2.4.5).

1.2.4.1 Emissions inventories working group 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. As a result, in each case in which specifications and definitions have been required, an in-house solution has been prepared first. Then, the solution has been used as a model for transfer to the entire National System.

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 working group has met a total of 11 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 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.

1.2.4.2 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), 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. Via in-house directive (Hausanordnung 11/2005), the Federal Environment Agency (UBA) issued binding provisions on competencies within the Agency, a list of deadlines for the various inventory-preparation steps and the necessary relevant review actions for purposes of quality control / quality assurance.

The directive 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.

1.2.4.3 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. Figure 5 shows the procedure, along with relevant deadlines and workflows, for such data exchange, which must be carried out on an annual basis. Section E 2.3 protects business and operational secrets of installations and installation operators by aggregating data.

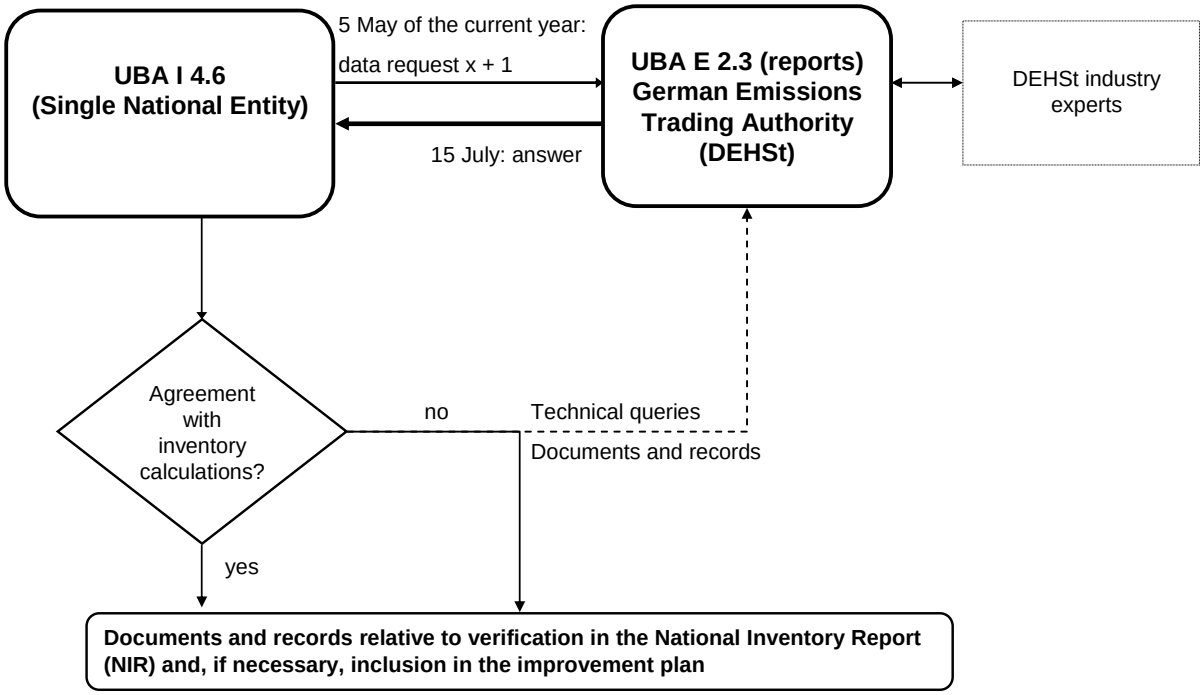


Figure 5: Procedural flow for annual inventory verification using ETS monitoring data

1.2.4.4 Budget items and UBA's environmental research projects

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 harmonisation of individual results, for the overall inventory, as well as 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.

1.2.4.5 Departmental agreements

In the "National System" policy paper of 5 June 2007 on emissions reporting, 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.

The paper "National System" of 5 June 2007, on basic principles of emissions reporting, is provided in Annex Chapter 17.1.1. Pertinent implementation status is provided in Annex Chapter 17.1.2.

The Federal Environment Agency and the Federal Statistical Office are currently preparing an administrative agreement that will establish specifications, on the basis of a legal regulation, for the Federal Statistical Office's data deliveries for emissions reporting.

1.2.4.6 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).

Furthermore, the "National System" policy paper of 5 June 2007 on basic principles for emissions reporting assigns responsibility for the LULUCF area to the BMELV. This responsibility includes reporting on LULUCF for purposes of the UN Framework Convention on Climate Change and the Kyoto Protocol (including reporting pursuant to Art. 3.3).

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). Furthermore, a working group on emissions reporting has been established, 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.

At the National Co-ordinating Committee's second meeting, held on 1 July 2008, the BMELV presented a draft of an integrated monitoring concept for LULUCF (Arts. 3.3. and 3.4 KP) and for a concept for the National System in the area of agriculture and forestry. The following figure provides details relative to the National System in the area of agriculture and LULUCF.

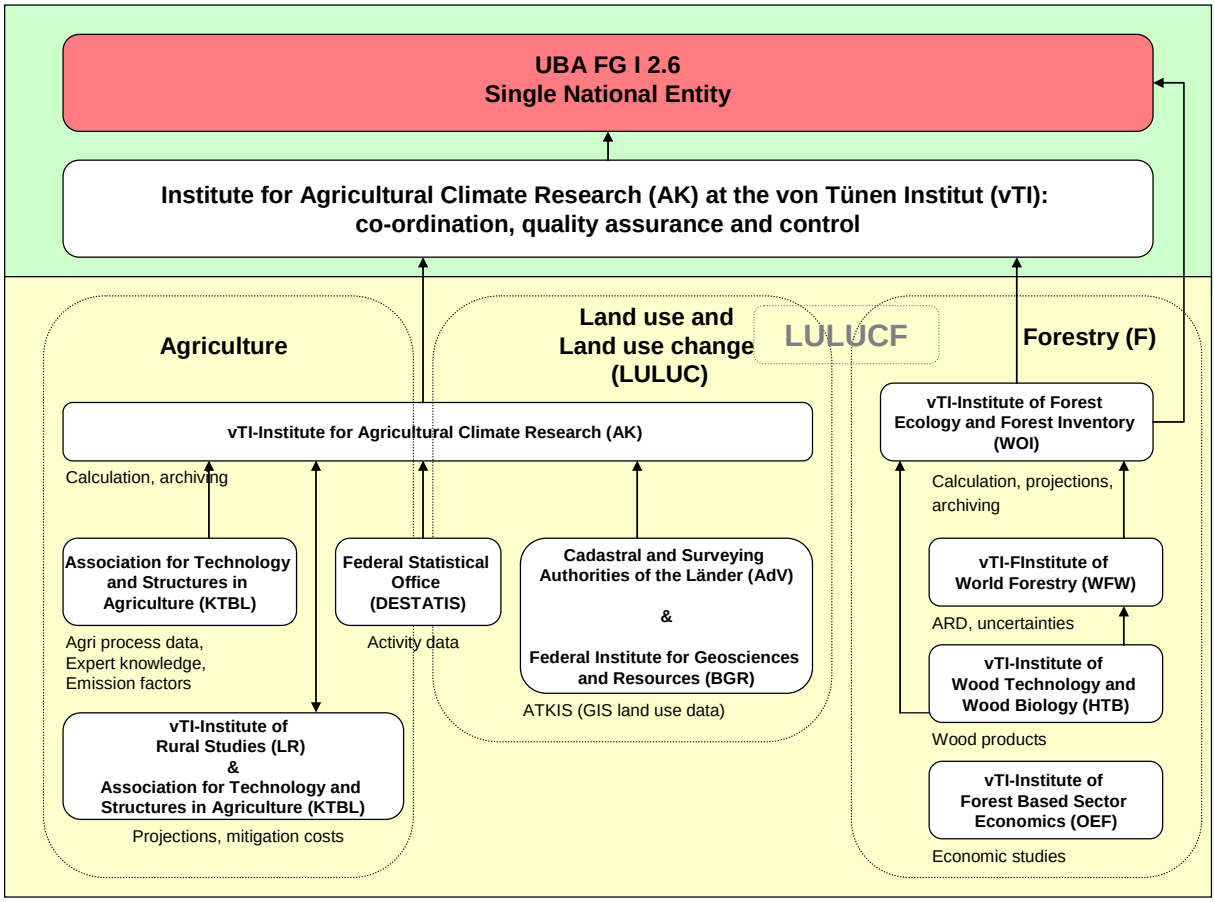


Figure 6: National System in the area of agriculture and LULUCF

1.2.4.7 Sample agreement for co-operation with NGOs

Involvement of associations and other independent organisations has been 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. In future, this agreement will be used to involve stakeholders, under binding terms, within preparation of inventories.

Since the end of 2006, the BMU has been negotiating with EUROCONTROL regarding an agreement on exchange of air-traffic data. Current plans call for a pertinent agreement to be concluded in 2008.

Since mid-2008, the Federal Ministry of Economics and Technology (BMWi) and the Federal Environment Agency have been engaged in discussions with the Association of the German Chemical Industry (VCI) regarding an agreement on data provision for the source categories Chemical industry – Ammonia production (2.B.1), Chemical industry – Nitric acid production (2.B.2) and Chemical industry – Adipic acid production (2.B.3). In addition, the BMWi and the Federal Environment Agency are conducting talks with the ARBIT bitumen industries working group and the VDD industry association for bitumen paper and bitumen roof sheeting, with the aim of obtaining an agreement for the source category Bitumen for roof sheeting (2.A.5). Additional discussions relative to further institutionalisation will follow in 2009. With these

efforts, the Single National Entity is addressing the reference provided in Paragraph 18 of the 2007 Initial Review.

1.2.4.8 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.

A further workshop relative to the National System is planned for spring 2009. That workshop will provide the opportunity for a new review of the inventories by independent third parties, pursuant to Paragraph 15 (b) of the *Guidelines for National Systems*.

1.2.5 Binding schedule in the framework of the National System

Via in-house order (Hausanordnung 11/2005), the Federal Environment Agency (UBA) has issued binding provisions on competencies, a list of deadlines for the various inventory-preparation steps and the necessary relevant checking for purposes of quality control / quality assurance.

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:

05 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	Provision of energy data by the Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen), and of statistical data from the Federal Statistical Office, which 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
01 November	Internal co-ordination within the Federal Environment Agency
as of 15 November	Final quality assurance by the QSE/ZSE/NIR co-ordinator
26 November	Report of the Single National Entity to the Ministry, for commencement of inter-ministerial co-ordination
17 December	Approval via departmental co-ordination (initiated by the BMU)
02 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) 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) to the European Commission (in the framework of the CO_2 Monitoring Mechanism) and to the European Environment Agency
15 April	Report 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

1.2.6 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. Chap. 1.2.4.2). Details regarding assurance of the QSE's binding nature for other NaSE participants are provided in Annex 17.1.1.

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

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

From those provisions, the Federal Environment Agency derived its own "General minimum requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting" (cf. Chap. 17.2.1). 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 Chap. 17.1.1).

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, 17.2.1.11.

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

Within the QSE framework, a concept for a start-up organisation was developed that defines binding responsibilities, for the Federal Environment Agency, for implementation of the necessary QC and QA measures. The defined roles and responsibilities have the purpose of facilitating effective information exchange and directive-conformal execution of QC and QA (cf. Table 3).

Table 3: QSE – Roles and responsibilities

Role	Tasks	Responsible
Specialised representative 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 affected heads (FGL)
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 coordinator (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 coordinator (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 coordinator (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

1.2.6.3 Organisation for establishing the Quality System for Emissions Inventories

Procedures for QC/QA measures in the QSE are oriented to the emissions-reporting process described in Chapter 1.3. At the same time, quality management is directly linked with the various steps in the inventory process. Suitable QC measures, assigned to the various process players, have been allocated to each step of the inventory-preparation process (cf. Figure 7).

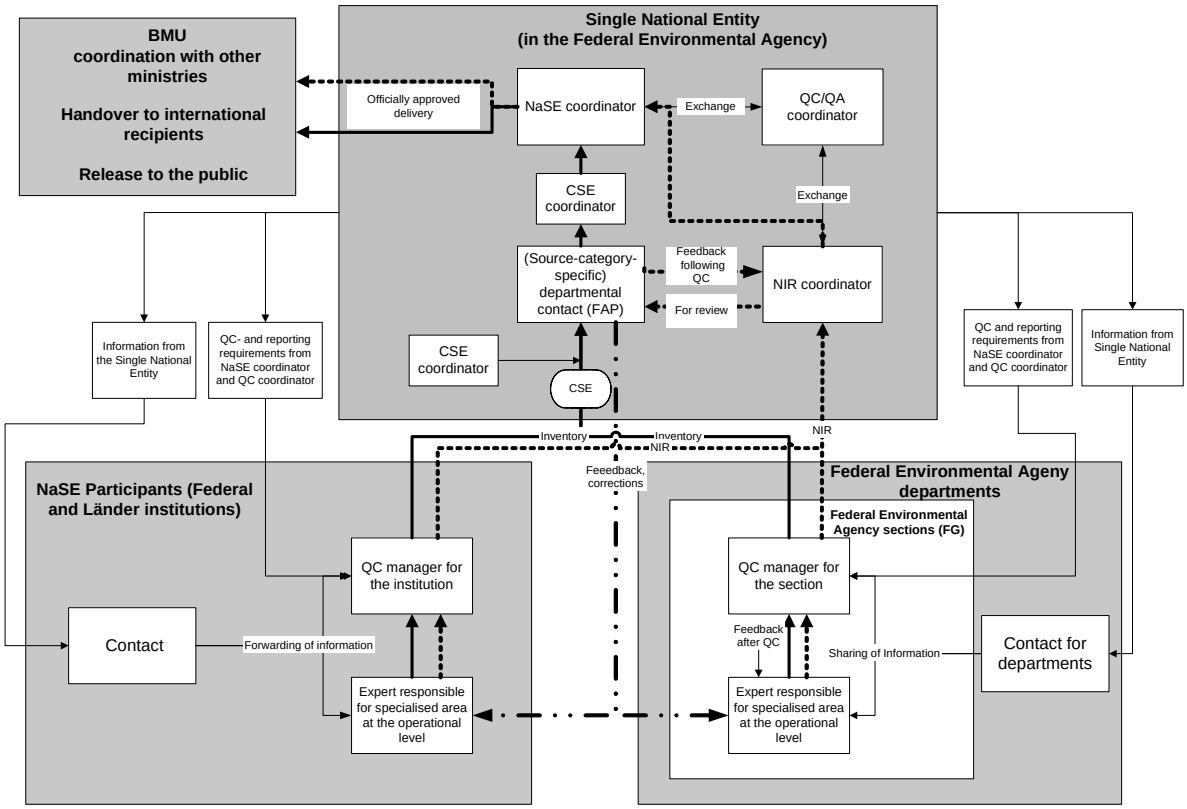


Figure 7: QSE – Roles, responsibilities and workflow

The required QC reviews for Tier 1 pursuant to Paragraph 14 (g) of the *Guidelines for National Systems* were carried out for the first time for the 2006 report. They were sent to the involved experts, in the form of QC checklists and attached data requests, and then were completed throughout the course of support work.

1.2.6.4 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 17.2.1) are largely being fulfilled in conjunction with production of the pertinent inventory contributions. For the QSE, a documentation concept was developed that represents all such measures and related actions in an integrated form tailoured to the specific parties and tasks concerned. The various components of such documentation are shown in Figure 8.

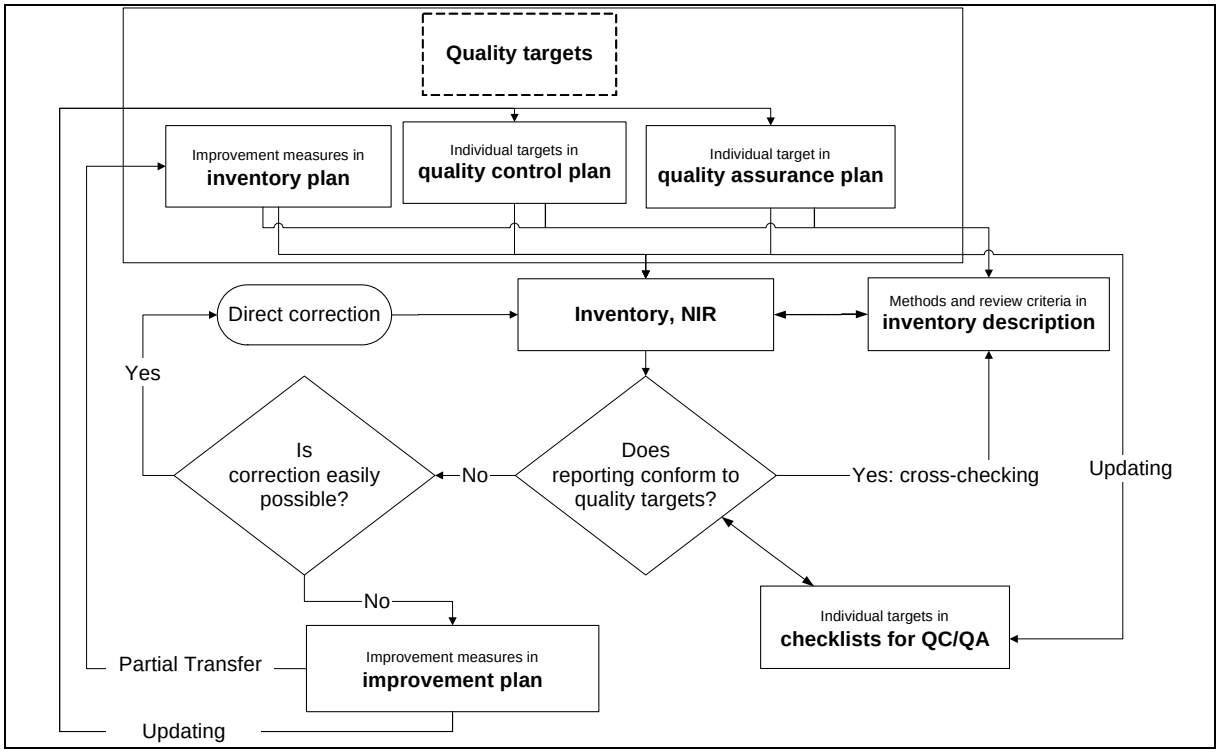


Figure 8: NaSE & QSE – Control and documentation

A general description of the **Quality targets** is provided in the QSE handbook; the description is derived from the *IPCC Good Practice Guidance*[11]. 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

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

out by NaSE participants[12] along with inventory preparation. They are designed to provide information about the quality of the data and methods on which the inventory is based. As mentioned above, 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. As of the 2007 report, these checklists are being maintained electronically, and thus they can be evaluated with the help of a database. Also as of the 2007 report, in a first step, Tier 1 QC checks have been expanded to include category-specific QC checks in accordance with Tier 2, for key categories. For the 2008 report, 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 and practical usefulness 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.

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.

The obligation to prepare defined documentation was introduced in the Federal Environment Agency via an internal directive (cf. Chapter 1.2.6.5). It provides the key basis for archiving inventory information pursuant to the provisions of Paragraph 16 (a) of the *Guidelines for National Systems.*

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:

[12] 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)

- 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.

At the same time, the central archive will include a suitable reference system for relevant data that have not been archived in it; that system will indicate "who has non-centrally archived what data where", and in what form such data were aggregated for the inventories.

1.2.6.5 The QSE handbook

The international requirements for quality assurance and quality control measures in emissions reporting for the National System of Emissions Inventories (NaSE) in Germany have been specified 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". This 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. 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 UBA 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 categories,
- the NIR,
- the guide for calculations of uncertainties and determination of key categories pursuant to Tier 2,
- a form for proposals relative to ongoing improvement of the QSE, and
- a guide to using the QSE checklists.

1.2.6.6 Support provided by expert-review groups

In addition to the Federal Environment Agency's own quality control and assurance measures, inventory review by expert-review groups provides important impetus for inventory improvement. It is thus in the Single National Entity's own interest to fulfil the provisions of

Paragraphs 16 (b) and (c) regarding provision of archived inventory information for the review process and for responding to questions of expert-review groups. This relationship has been given priority in the design of the QSE. For this reason, 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.

1.2.6.7 Use of EU ETS monitoring data for improvement of GHG-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.

In work for the 2006 report, technical discussions on implementation of emissions trading identified significant gaps in the inventory. Some of these have been closed with the help of data from emissions trading or via research projects. These efforts have improved the database for determining "allocated quantities" under the Kyoto Protocol (time series for the period 1990 to 2004). In 2006, in the framework of a data-comparison research project carried out by the German Emissions Trading Authority's section E 2.3[13], the emissions inventories' data were compared with the data in the German Emissions Trading Authority's installations database. This work led to the development of allocation rules 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 (cf. Chapter 1.2.4.3).

1.2.7 Changes in national emissions-trading registries

Such information has been included with the submission as a separate document, "*UNFCCC Standard Independent Assessment Report - Submitted by Germany - Reporting under Article 3(1)g and h of Decision No 280/2004/EC"*.

1.3 Short description of inventory preparation

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 thus intensively studied and analysed.

It can be divided into the following main processes:

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

[13] FKZ 205 41 521

These main processes are broken down into sub-processes (cf. Figure 9). The process of inventory preparation is co-ordinated closely with preparation of the National Inventory Report 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. For this reason, suitable QC/QA measures have been assigned to each sub-process. Quality review, thus, does not consider only the final quality of inventory data; it also considers review results in the context of their position in the overall process chain. This, in turn, makes it easy to carry out periodical internal evaluations of the inventory-preparation process pursuant to paragraph 15 (d) of the *Guidelines for National Systems*.

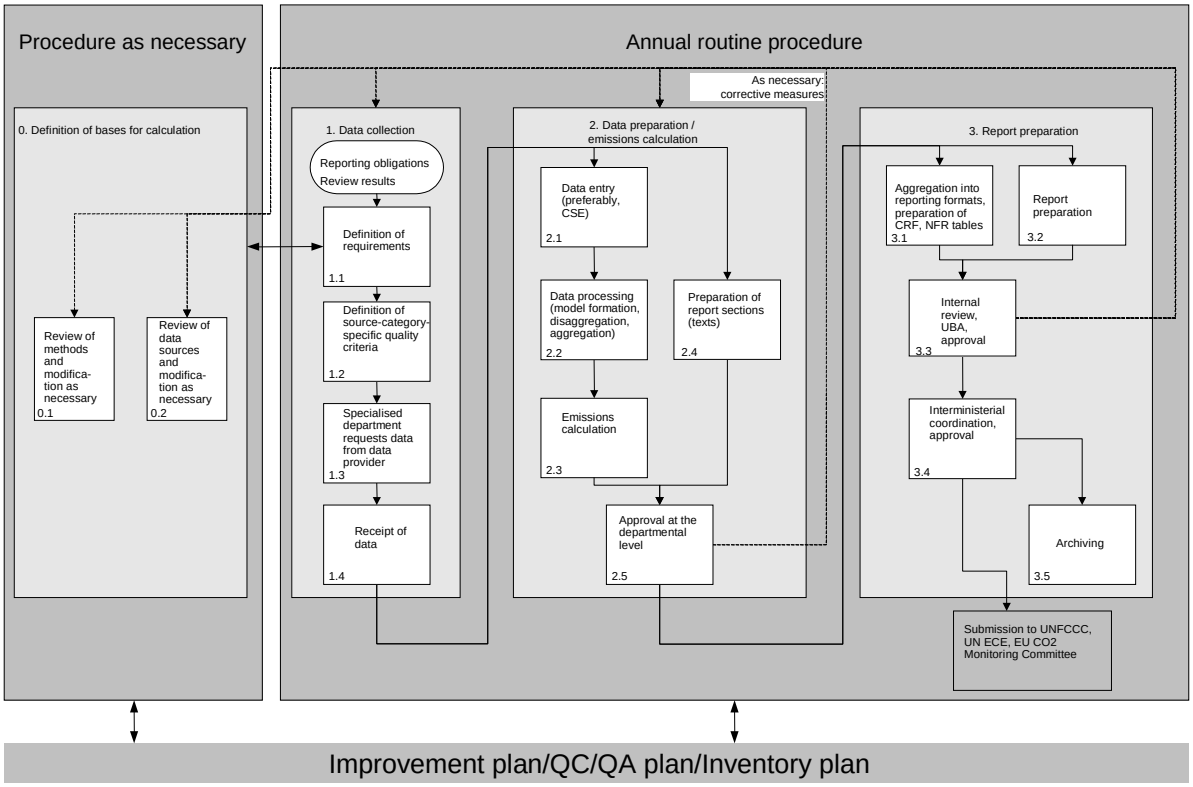


Figure 9: Overview of the emissions-reporting process

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

1.3.1 Preliminary processes

In order to be able to concentrate the many and detailed activities and capacities required for inventory preparation on the principal source categories of the inventory, the IPCC has introduced the definition of a "key source". This refers to those source categories which play an especially prominent role in the national inventory because their emissions 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.

Key sources are considered additionally by means of preliminary processes that are carried out, in each case, between two emissions-reporting cycles, in addition to the sub-processes outlined in Figure 9.

The following sub-processes are considered preliminary processes:

- Determination of key sources (pursuant to Tier 1, in keeping with Chap. 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 determination of key sources via Monte Carlo simulation (pursuant to Tier 2, in keeping with Chap. 6.4 of the *IPCC Good Practice Guidance*).

1.3.1.1 Determination of key sources (pursuant to Tier 1)

The Single National Entity determines 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, selection of key sources is used to identify source categories to which priority must be given in inventory improvement.

The *IPCC Good Practice Guidance* (2000) specifies the methods to be applied in determining key sources. These methods make it possible, via inventory analysis 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), to identify the relevant key sources.

The key sources were defined by applying two Tier 1 procedures, Level (for the base year and for 2007) and Trend (for 2007, as compared to the base year), to German greenhouse-gas emissions. In keeping with IPCC provisions, analyses take account of both emissions from sources and storage of greenhouse gases in sinks.

1.3.1.2 Calculation and aggregation of uncertainties relative to emissions

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

In calculation and aggregation of uncertainties, uncertainties for activity 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. Plans call for carrying out Tier 2 uncertainties determination every three years. In the years in between, uncertainties will be determined in accordance with Tier 1.

In the current NIR, Germany reports uncertainties that have been calculated pursuant to the Tier 1 method. In determination of uncertainties in accordance with Tier 1, the uncertainties were estimated, wherever possible, by data-providing experts of the relevant Federal Environment Agency sections and by external institutions.

Aggregated uncertainties serve as a basis for expanded determination of key categories.

1.3.1.3 Expanded determination of key sources

Expanded determination of key sources, using detailed uncertainties analysis with Monte Carlo simulation (in keeping with the IPCC's relevant Tier 2 method), is being carried out for the German greenhouse-gas inventory at three-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-category analysis nearly completely.

1.3.2 Definition of bases for calculation

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

Another factor that is critical to the success of the overall process is **selection and review of 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.

1.3.3 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-category identification, are all communicated to the relevant experts via informational events held by the Federal Environment Agency's *working group on emissions inventories*, and via the Federal Environment Agency's intranet site for emissions reporting. 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.

1.3.4 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 oriented tightly to the data) 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 (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.

1.3.5 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 Table 4, which are based on effects of greenhouse gases out to a 100-year time horizon.

Table 4: Global Warming Potential (GWP) of greenhouse gases

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

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

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 departmental 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**.

1.4 Brief general description of methodologies and data sources used

1.4.1 Data sources

1.4.1.1 Energy

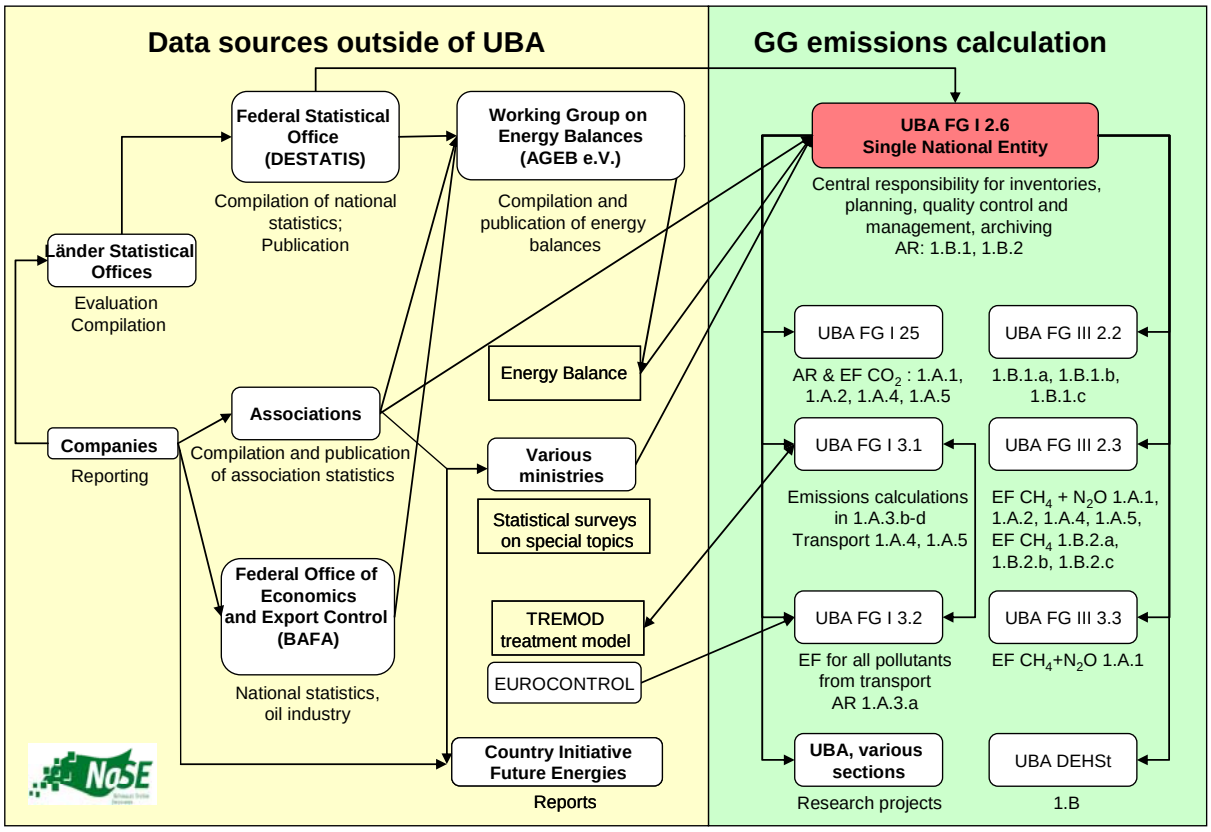


Figure 10: Responsibilities and data flows for calculation of greenhouse-gas emissions in the energy sector

In all likelihood, the most important data sources for determination of activity 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. As a result, publication of energy balances is subject to some delay.

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.

At short intervals (one to two years), the Association of Industrial Energy and Power Producers (*Verband der Industriellen Energie- und Kraftwirtschaft (VIK) e.V.*) publishes Energy-Sector Statistics (*Statistik der Energiewirtschaft* (hereinafter referred to as: VIK Statistics / VIK-Statistik; VIK, n.y.). The VIK Statistics include data on power generation, types of installations and fuel consumption. Their data is broken down extensively, in accordance with both source categories and types of facilities. The VIK Statistics are normally published within a little over a year after the relevant data has been collected.

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. Some of these data are also included in the VIK Statistics. To support further data differentiation, and clarification of details, the Federal Statistical Office (Destatis) 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") – the so-called "Silver Book" – 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 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 "Petroleum 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 the road-transport sector, transport emissions (1.A.3) are calculated primarily with the *TREMOD* model ("*Transport Emission Estimation Model*"; IFEU, 2005[14]. For calculation with TREMOD, extensive basic data from generally accessible statistics and special surveys were 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).

In the area of air transports, the current report is the first to make use of data of *EUROCONTROL,* the *European air traffic control authority*. 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. Use of the split factors determined by *EUROCONTROL* necessitates extensive recalculations with respect to previous inventories.

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

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. Procedures for processing it include federal and Land (state) ministries, including their authorities (such as supreme state mining authorities), and they make use of reports and expert opinions of the "Landesinitiative Zukunftsenergien" 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 (Destatis), 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 gas statistics of the Federal association of the German gas and water industry (Bundesverband der deutschen Gas- und Wasserwirtschaft - BGW) and the German Emissions Trading Authority (DEHSt). Work at present is drawing especially on expert opinions of the Association of the petroleum and natural-gas industry (Wirtschaftverband Erdöl und Erdgasgewinnung e.V. - WEG).

14 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.

1.4.1.2 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 (Destatis), 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).

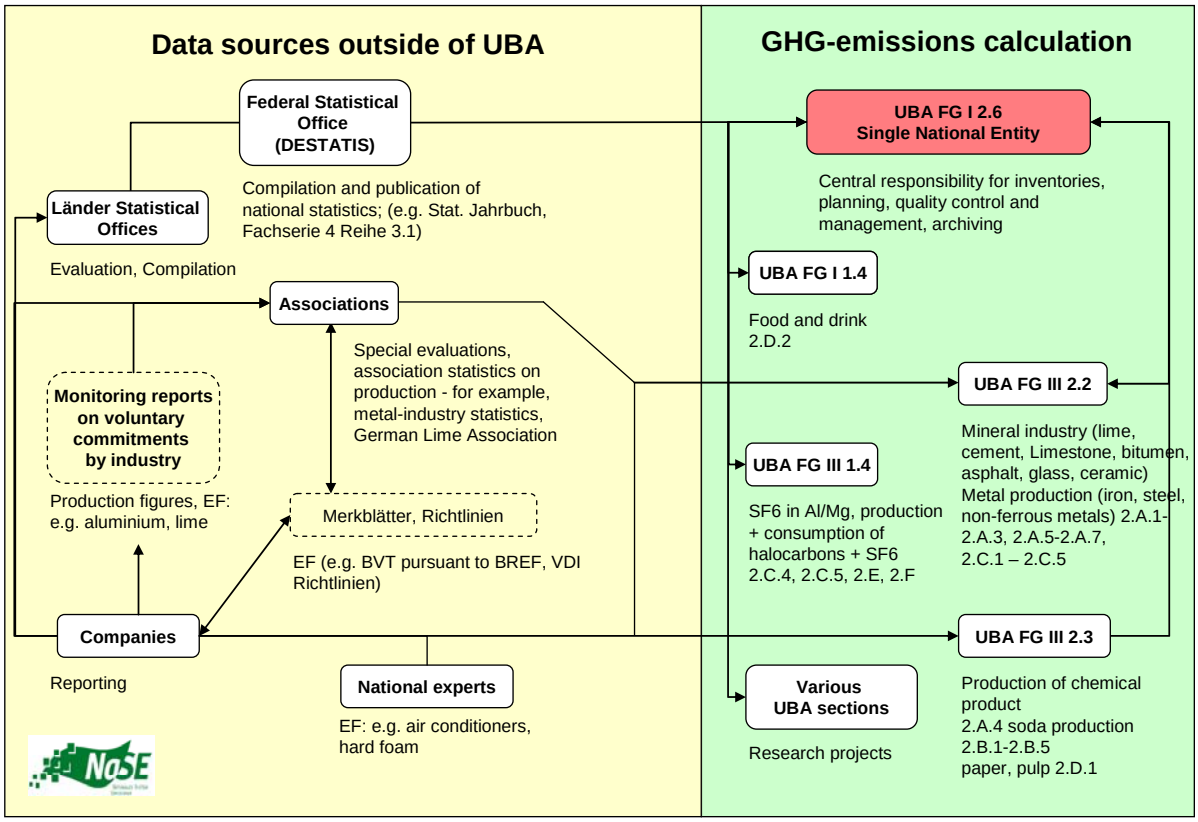


Figure 11: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of industrial processes

A range of different sources are used to determine emission factors for the mineral industry. The emission factor used for calculation of emissions from cement-clinker production (2.A.1) is based on a calculation of the German Cement Works Association (VDZ) carried out by aggregating plant-specific data. CO_2 emissions from lime production (2.A.2) 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-compositon 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 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 and via research projects. To date, activity data for 2.B.1 Ammonia production and 2.B.2 Nitric acid production have been collected by the Federal Statistical Office. The emission factors for 2.B.1 and 2.B.2 have been determined by Federal Environment Agency experts. Since ammonia production is a key category for CO_2 and nitric acid production is a key category for N_2O, data for these areas will be collected on a plant-by-plant basis in future. 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. 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, laughing gas, organic substances, caprolactam, soot and others. The activity data have been obtained via research projects, data from the Federal Statistical Office and data from the Association of the German Petroleum Industry. The relevant emission factors have been determined via experts' assessments and via research projects.

The activity data for the metal industry (2.C) were provided by 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 halogenated hydrocarbons and SF_6 (2.E), use is made of *manufacturers' data* and *surveys of manufacturers*, due to a lack of reliable statistical data. 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.

1.4.1.3 Solvent and other product use

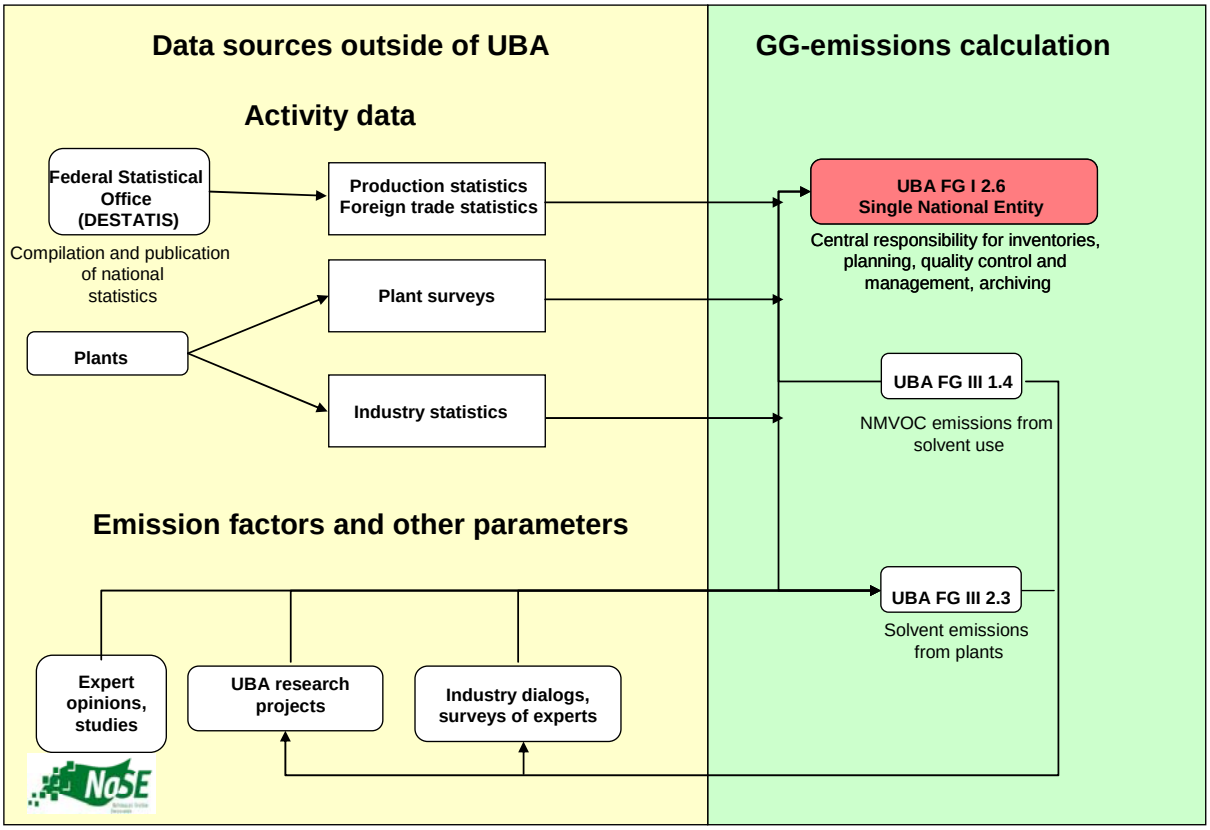


Figure 12: Responsibilities and data flows for calculation of greenhouse-gas emissions from use of solvents and other products

The Federal Environment Agency's Section (FG) III 1.4 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, Federal Environment Agency's Section III 1.4 is supported by the agency's Section III 2.3, 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 is drawn mainly from published statistics of the Federal Statistical Office (Destatis), 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.

1.4.1.4 Agriculture

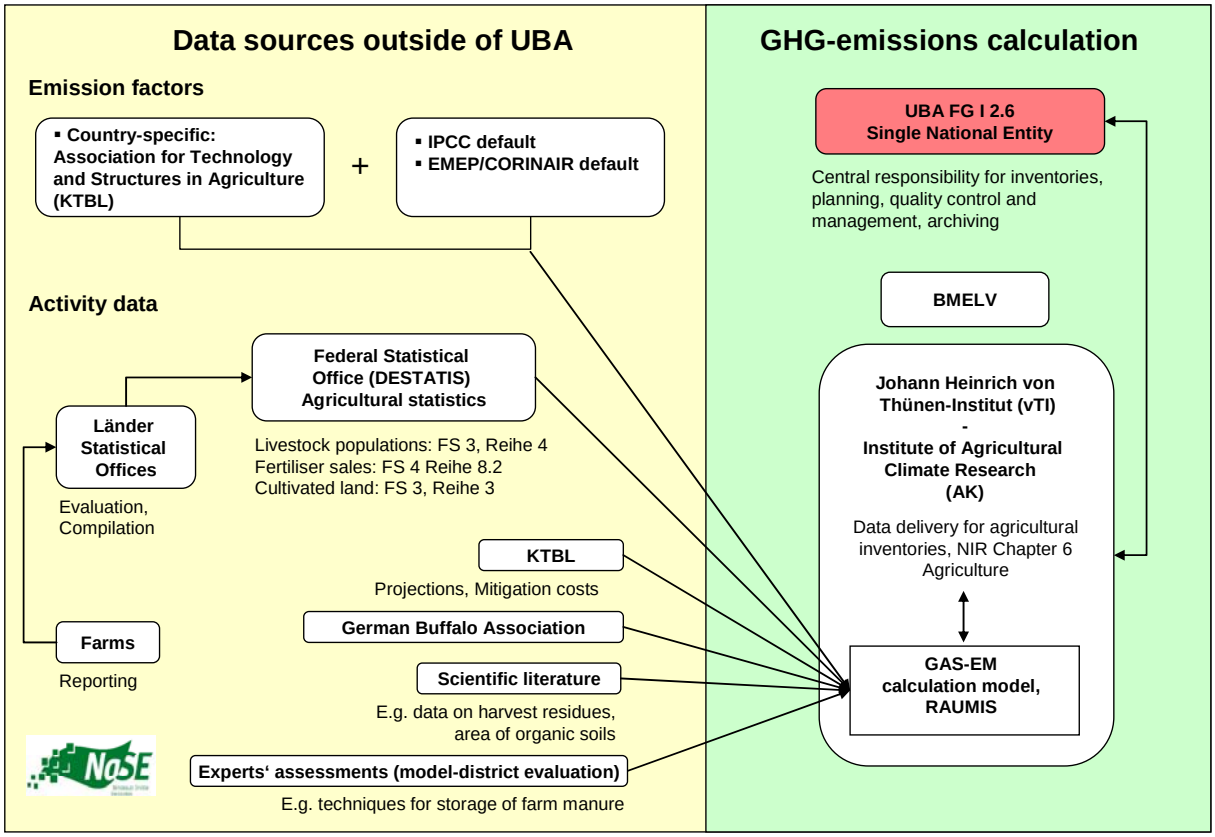


Figure 13: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of agriculture

Emissions calculations for source category 4 (Agriculture) are carried out by the von Thünen Institute (vTI). For calculation of agricultural emissions in Germany, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) initated a suitable joint project, in the framework of which the former Federal Agricultural Research Institute (FAL) developed a modular model for relevant spread-sheet calculation (GASeous Emissions, GAS-EM) (Dämmgen et al, 2002). 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; 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, harvest 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 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.

1.4.1.5 Land-use changes and forestry

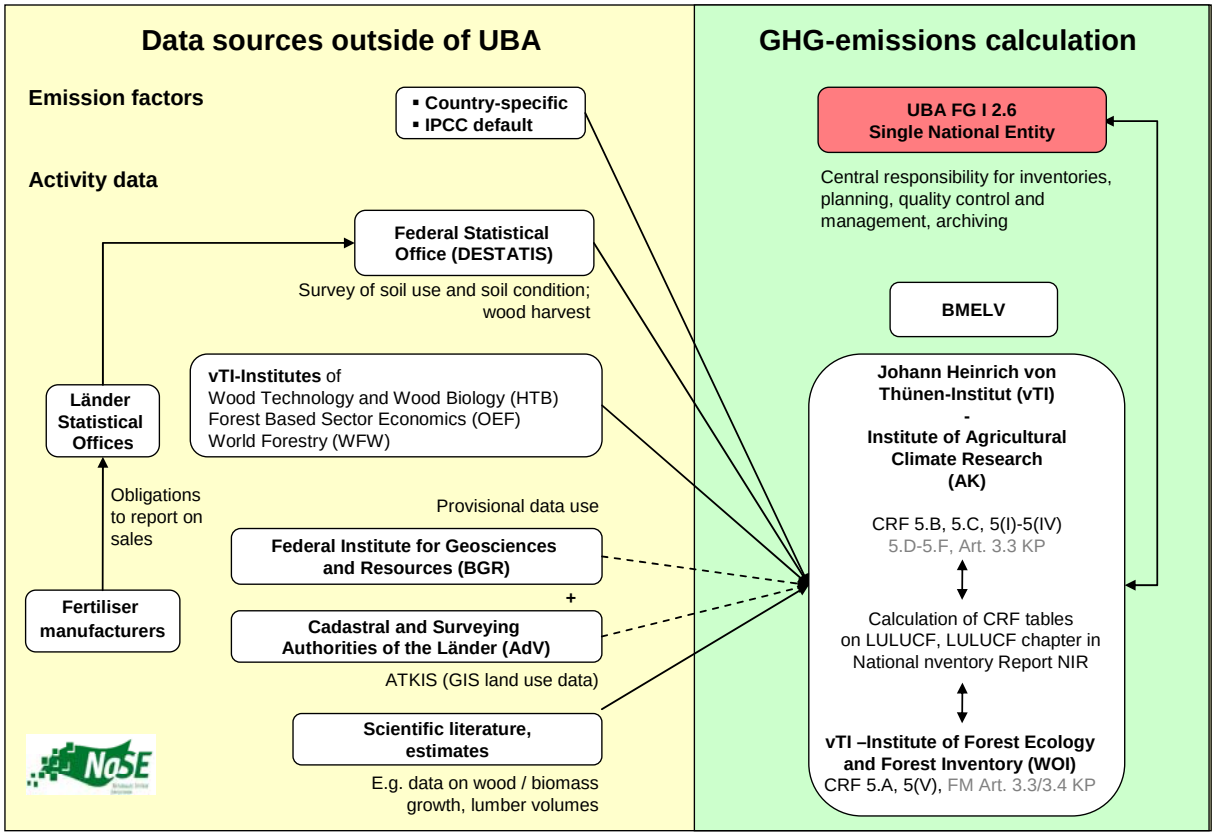


Figure 14: Responsibilities and data flows for calculation of greenhouse-gas emissions from the area of land-use changes and forestry[15]

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. All data for subsequent years, including 2007, were updated via extrapolation by the Federal Research Centre for Forestry and Forest Products (BFH; as of 2008, a part of the vTI). 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 2003 to 2012 period. It is expected to provide finalised, high-quality emissions

[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").

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.

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. A nation-wide study on data collection for the 2008 commencement of the 2008-2012 commitment period is expected to enhance conclusions regarding trends during that commitment period. 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.

No reliable estimates are yet available of emissions from other pools (dead wood, plant debris, soils). Such estimates are expected to become available upon completion of work for the second nation-wide survey of the condition of forest soils (BZE2), of work for the Federal Forest Inventory 3 and of certain studies. The aforementioned agreement will also provide the basis for building the necessary capacities and resources for pertinent preliminary methodological work. The relevant inventory sections will also be prepared by 2013.

As to determination of usage changes on agricultural areas, no activity data are yet available that fully meet quality requirements in this category. The activity data on CO_2 emissions and CO_2 storage in the soil need to be supported by data on agricultural areas, as well as by quantitative and qualitative information (differentiated by types of usage and cultivation) for identification of land-use changes and by data for determination of carbon stocks in soils and in biomass. The relevant data used in these areas, which data were taken from the area survey and from the main survey on soil use (Bodennutzungshaupterhebung; managed by the Federal Statistical Office), are available only aggregated by area; for this reason, the data can be used only in combination with additional data sources (e.g. remote sensing: CORINE Landcover) and with mathematical models developed especially for this case (and based on legal requirements and on empirical data). Soil carbon stocks are estimated with the help of soil maps provided by the Federal Institute for Geosciences and Natural Resources (BGR), while use-related changes in these stocks are estimated using emission factors derived from the scientific literature via multiple regression.

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. 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.

As of this report, LULUCF-oriented area surveys will be carried out completely, annually and without any double-counting, using a digital landscape model (B-DLM/ATKIS) of the Federal Republic of Germany in which all relevant areas are precisely defined and georeferenced. Projects will be carried out, as of 2008, for improving activity data and, especially, for determining country-specific emisssion factors for carbon and nitrogen – and CO_2, CH_4 and N_2O. These projects will lead to high-quality estimates of emissions and removals for the land-use categories farmland, grassland, wetlands, settlements and other land uses. 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.

1.4.1.6 Waste and wastewater

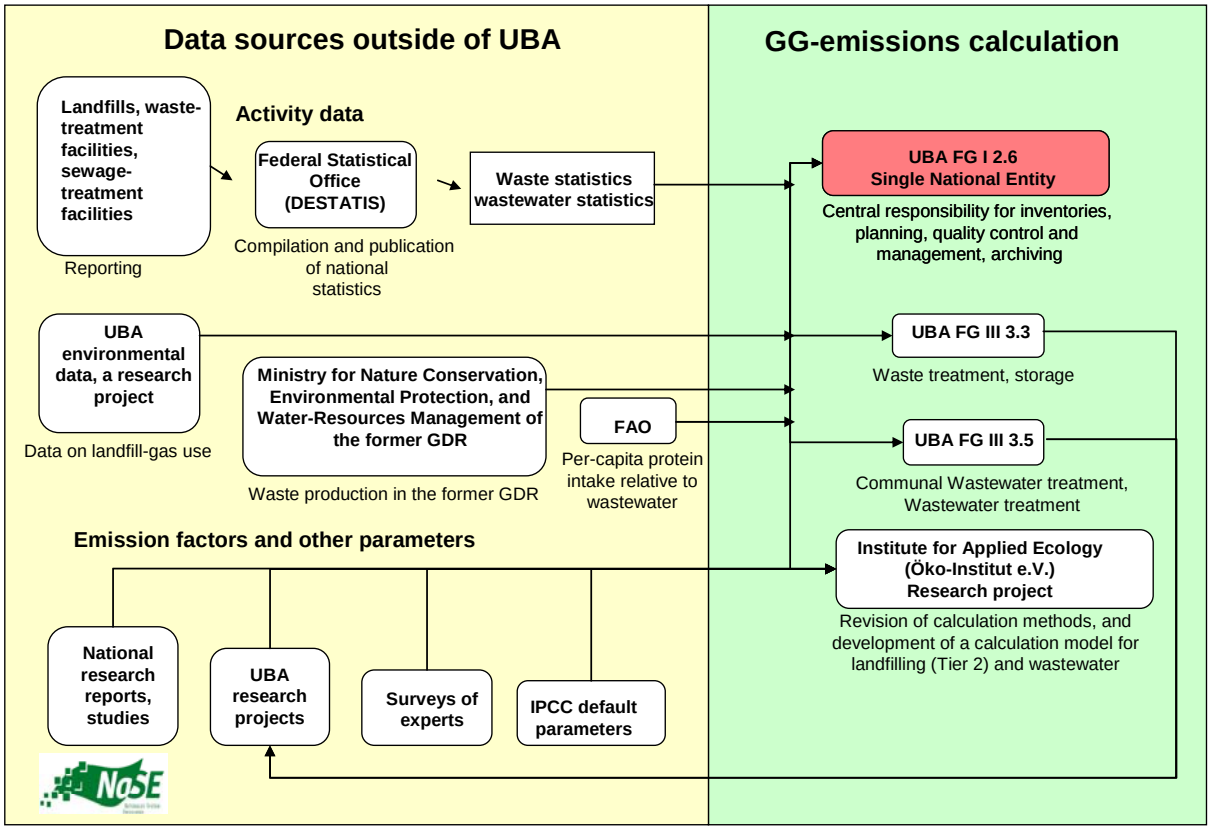


Figure 15: Data flows for calculation of greenhouse-gas emissions from the area of waste

Section FG III 3.3 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 is drawn mainly from published data of the Federal Statistical Office (Destatis), 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.

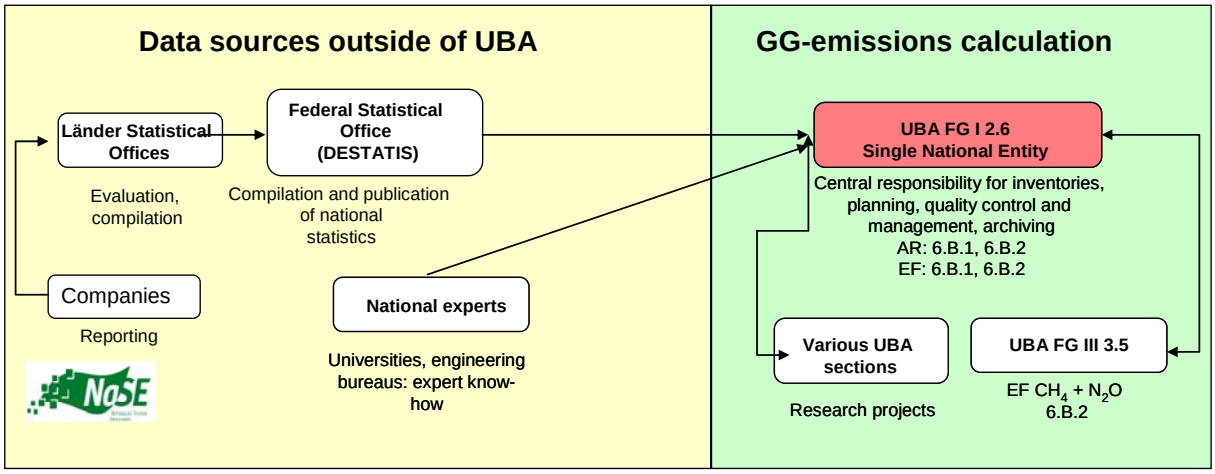


Figure 16: Data flows for calculation of greenhouse-gas emissions from the area of wastewater

No specialised section has yet been identified that would be responsible for selecting the methods, parameters and data for calculating emissions from industrial wastewater handling sector (wastewater and sewage sludge) (6.B.1).

Section FG III 3.5 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 (Destatis), 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 have been taken from FAO data.

The emission factors and other parameters that enter into calculation of emissions from wastewater treatment were taken from national studies and research reports conducted/prepared in research projects commissioned directly by the Federal Environment Agency. IPCC default parameters were 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).

1.4.2 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-category analysis" (cf. Chap. 1.5 in this regard).

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.

With the exception of CO_2 emissions, road-traffic greenhouse-gas emissions were calculated with the help of the TREMOD model, which is based on a bottom-up Tier 2/3 approach. In compliance with the information from the Energy Balance for the Federal Republic of Germany, CO_2 emissions are calculated on the basis of a top-down Tier 1 approach.

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 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 shown 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 ascertained or created during the course of the year.

1.5 Brief description of key sources

The key sources were defined by applying two Tier 1 procedures, Level (for the base year and for 2007) and Trend (for 2007, 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. In each case, the analysis is first carried out solely for emissions and, then, in a second step, for storage of greenhouse gases in sinks. All specified key sources resulted from work in 2007 – they resulted either from level analysis for 2007 or from trend assessment.

For 2007, this approach identified 39 source categories, out of a total of 116 source and sink categories studied, as key sources. Only 29 of these were identified, by both trend and level analysis, as key sources. In addition, 6 source categories were identified as key sources solely by trend analysis, and 4 source categories were so identified solely by level analysis. This is shown in Table 5. Combination of all results of the analyses shows that a total of 94.7% of greenhouse-gas emissions (not including LULUCF) in 2007 were released by the key sources. The identified key sources include different shares of the various greenhouse gases, with respect to the relevant total emissions of the gases (not including LULUCF): CO_2: 96.8 %; CH_4: 81.2 %; N_2O: 73.3 %; HFCs: 100 %; PFCs: 36.8 % and SF_6: 42.3 %.

Table 5: Number of source categories and key sources

Source categories		116	
			Key sources
by Level	Level & Trend	Trend	
4	29	6	**39**

Table 6 provides an overview of the results of analysis of key sources. Annex 1 (Chapter 12) of this report presents detailed explanations of the key-source analysis carried out.

Table 6: Key source categories for Germany pursuant to the Tier 1 method

IPCC Source Categories	CRF	Activity	Emissions of	LEVEL Base year	LEVEL Base year (-sinks)	LEVEL 2007	LEVEL 2007 (-sinks)	TREND 2007	TREND 2007 (-sinks)	Emission baseyear	Emission 2007
1A1a Public electricity and Heat production	1A1a	all fuels	CO2	●	●	●	●	●	●	335781.5	345672.7
1A1b. Petroleum Refining	1A1b	all fuels	CO2	●	●	●	●	●	●	20005.9	22003.8
1A1c. Manufacture of Solid Fuels and Other Energy Industries	1A1c	all fuels	CO2	●	●	●	●	●	●	59066.1	17851.6
1A2a. Manufacturing Industries and Construction Iron and Steel	1A2a	all fuels	CO2	●	●	●	●	●	●	12577.9	5863.1
1A2f. Manufacturing Industries and Construction Other	1A2f	all fuels	CO2	●	●	●	●	●	●	138312.0	80446.8
1A3b. Transport Road Transportation	1A3b	all fuels	CO2	●	●	●	●	●	●	150358.3	144114.2
1A3c. Transport Railways	1A3c	all fuels	CO2					●	●	2879.3	1278.0
1A3d. Transport Navigation	1A3d	Diesel Oil	CO2					●	●	2049.8	531.1
1A3e. Transport Other Transportation	1A3e	all fuels	CO2	●	●					4302.3	3632.3
1A4a. Other Sectors Commercial/Institutional	1A4a	all fuels	CO2	●	●	●	●	●	●	63949.6	35850.3
1A4b. Other Sectors Residential	1A4b	all fuels	CO2	●	●	●	●	●	●	129474.0	85949.8
1A4c. Other Sectors Agriculture/Forestry/Fisheries	1A4c	all fuels	CO2	●	●	●	●	●	●	10917.1	5727.8
1A5 Other Include Military fuel use under this category	1A5	all fuels	CO2	●	●			●	●	11797.8	1285.1
1B1a. Fugitive Emissions from Fuels Coal Mining and Handling	1B1a	Solid Fuels	CH4	●	●		●	●	●	18415.2	3982.3
1B1c. Fugitive Emissions from Fuels Other (Abandoned Mines)	1B1c	Solid Fuels	CH4					●	●	1806.8	73.8
1.B.2.b. (all) Fugitive Emissions from Fuels, Natural Gas	1B2b	Natural Gas	CH4	●	●	●	●		●	6781.5	6581.2
2A1. Mineral Products Cement Production	2A1		CO2	●	●	●	●	●	●	15145.8	14306.0
2A2. Mineral Products Lime Production	2A2		CO2	●	●	●	●			6135.0	5670.9
2B1. Chemical Industry	2B1	Ammonia production	CO2	●	●	●	●	●	●	4596.4	5200.5
2B2 Chemical Industry	2B2	Nitric Acid Production	N2O	●	●	●	●	●	●	4673.4	9555.2
2B3 Chemical Industry	2B3	Adipic Acid Production	N2O	●	●	●	●	●	●	18804.6	5623.5
2B5 Chemical Industry	2B5	Other	CO2	●	●	●	●	●	●	6869.8	10338.1
2C1. Metal Production Iron and Steel Production	2C1	Steel (integrated production)	CO2	●	●	●	●	●	●	48326.0	46243.6
2C3. Aluminium Production	2C3		PFC´s					●	●	1551.7	193.3

IPCC Source Categories	CRF	Activity	Emissions of	LEVEL Base year	LEVEL Base year (-sinks)	LEVEL 2007	LEVEL 2007 (-sinks)	TREND 2007	TREND 2007 (-sinks)	Emission baseyear	Emission 2007
2C4. SF6 Used in Aluminium and Magnesium Foundries	2C4		SF6					●	●	197.1	2355.4
2E. Production of Halocarbons and SF6	2E	production of HCFC-22	HFC´s		●			●	●	4218.5	198.7
2E. Production of Halocarbons and SF6	2E		PFC´s			●	●	●	●	2244.6	10892.1
2F. Industrial Processes	2F	Consumption of Halocarbons and SF6	PFC´s	●	●			●	●	6413.8	2894.8
4A.1. Enteric Fermentation	4A1a	Dairy Cattle	CH4	●	●	●	●			9603.9	7904.4
4A.1. Enteric Fermentation	4A1b	Non-Dairy Cattle	CH4	●	●	●	●	●		10755.3	7676.8
4D1. Agricultural Soils	4D1	Direct Soil Emissions	N2O	●	●	●	●	●	●	22889.3	20087.5
4D3. Agricultural Soils	4D3	Indirect Emissions	N2O	●	●	●	●			6693.4	5676.3
5.A Forest Land	5A		CO2	●		●		●		74399.5	79398.6
5.B Cropland	5B		CO2	●	●	●	●	●	●	28174.0	32613.9
5.C Grassland	5C		CO2	●	●	●	●	●	●	13057.0	14102.6
5.D Wetlands	5D		CO2						●	2230.2	2823.1
5.E Settlements	5E		CO2			●	●	●	●	1965.6	11881.4
6 A1 Managed Waste Disposal on Land	6 A1		CH4	●	●	●	●	●	●	35910.0	8211.0
6B Wastewater Handling	6B2	Domestic and Commercial Wastewater	CH4					●	●	2226.2	107.8

1.6 Information about the quality assurance and control plan and the inventory plan

This chapter cannot be updated until the evaluations have been completed; in all likelihood, this process will be completed in time for the NIR 2009 final submission.

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 monitoring such QC/QA measures.

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 1.2.6. 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.

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, 2005, unpublished). The most important specifications made by the handbook are consist of quality reviews carried out during inventory preparation. These include:

- 98 individual objectives and 46 optional objectives
- 45 Federal Environment Agency employees, working in various functional roles
- Four graduated review procedures that build on each other, carried out 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 reviews are linked with general quality targets (cf. Chap. 17.2.1.10.3) and individual process steps (cf. Chap. 1.3), so that final evaluation can take account of such targets and steps. As a whole, the reviews cover the entire inventory-preparation process.

Evaluation of the checklists identifies source categories that need to be reviewed – and, possibly, revised – with regard to fulfillment of specific inventory requirements. Such source categories are collected within the improvement plan and supplemented with relevant additional information. Some are added to the binding inventory plan. The inventory plan undergoes internal and interdepartmental approval processes and then is published in aggregated form.

The first inventory plan was published together with the 2007 report. It consisted solely of content identified with the help of QC checklists. Evaluation of the checklists was limited to the key category groups for emissions reporting.

For the 2008 inventory plan, the QC/QA checklists of all source-category groups have been evaluated. They are supplemented with evaluations of the Initial Review 2006, the Synthesis & Assessment Report 2006 and the results of the EU Consistency Report 2007. On the basis of all these evaluations, a detailed (internal) improvement plan for 2008 has been prepared. The most important measures from this plan, in turn, have been added to the inventory plan 2008. The detailed 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 1.2.6.2) and by the Federal German ministries involved in emissions reporting (cf. Chapter 1.2.4.5). 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 7. The inventory plan is regularly updated, within an ongoing process.

In implementation of measures from the inventory plan 2007, some 60 % of the pertinent measures were completed as part of preparation of the Initial Review and of the 2008 emissions report.

Table 7: Inventory plan 2009

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.	1.A.3.a, 1.C.1.a, 2.B.1-2, 2.E.3, 2.F.6, 2.F.8, 3.A-D, 4, 5
Check whether it was possible to take pointers from inventory reviews into account.	Alle, 1, 2, 4, 4.A, 4.B, 4.D, 5, 5.A, 5.B, 5.C
Check whether there are any gaps in the available data for time series as of 1990.	1.A.3.b-c, 6.B.2
Check whether the AR are plausible and complete (have no gaps and are completely documented).	1.B.1, 4, 5
Check whether the EF are plausible and complete (have no gaps and are completely documented).	1.A.1b, 4.B(b), 5.C.2
Check whether the source category is completely covered by the relevant data source and whether the defined data sets for EF and AR are consistently delimited.	1.A.2.d, 1.A.3.c+e, 2.D.1, 2.F.1
Check whether uncertainties have been determined and are complete.	1.A.1, 1.A.2, 1.A.3, 1.A.4.cii, 1.A.5.b, 1.B.1, 1.C.1, 2.A.5, 2.C.2, 2.D.1, 2.F.1, 4.A, 4.D, 5, 6.B.2
Check whether any recalculations are required. If they are they must be documented in a logical manner.	1.A.2.d, 2.D.1
Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	1.A.1, 1.A.2.f, 1.A.3.b-e, 1.A.4.c.ii, 1.B, 2.B.2, 2.C.1+4, 2E-F, 4.A, 4.D, 5.A.2, 5.B.1, 5.C.1, 6.B.2
Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.	1.A, 1.A.1, 1.A.2.a+f, 1.A.3, 1.A.4, 1.A.4cii, 1.A.5, 1.C.1, 2.A.5-6, 2.C.1-2, 4.A., 4.D, 6.B.2
Check whether data has been entered into the CSE correctly, including whether all numbers, units and conversion factors have been correctly entered and properly integrated.	1.A.3.b-c+e, 1.A.4.c.ii, 1.A.5.b, 1.B.1, 1.C1, 2.A.5-6, 2.D.1, 2.F.1, 4.A, 4.D, 6.B.2
Check whether the NIR source category has been completely and logically described in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	1.A.1, 1.A.2, 1.A.2.d+f, 1.A.3.a-c+e, 1.A.4.c.ii, 1.A.5.b, 1.B.2, 2.C.2-3, 2.F.6, 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+c+e, 1.A.4, 1.A.5.b, 1.B.1, 1.C.1, 2.A.5-6, 2.C.2, 2.F.6, 5, 6.A.1, 6.B.2, 6.D
Check whether the data source (s) used will be available throughout the long term.	1.A, 2.A.2, 2.A.7, 2.B.4, 2.C.1-2, 2.C.4, 2.E, 2.F.1-5, 2.F.8, 4.A, 4.D, 5
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.A.1-3, 1.A.4.c, 1.B.2, 1.C.1, 2.A.5-6, 4, 5
Various types of required action.	2.C.4-5, 2.E
Check whether pertinent responsibilities need to be updated.	1.A.2.f, 1.B, 2.A.1-2+5-7

1.7 General estimation of uncertainties

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 Chap. 6 of the GPG. Since then, this 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 the uncertainties figures are still incomplete, pertinent figures are added from other sources, in the framework of a Tier 1 calculation.

1.7.1 Procedure for determining uncertainties pursuant to Tier 1, Chap. 6 of the GPG

In the Tier 1 method, in keeping with Chap. 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 ortherwise 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|). These adjustments in combination of uncertainties for sinks, made by taking the sinks' absolute values into account, are responsible for part of the reduction of the inventory's total uncertainty (about 2 %).

1.7.2 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 activity rates for oil and natural gas (CRF 1.B.2) include slight uncertainties, resulting from 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 provide relevant consolidated information. In addition, uncertainties can increase via the frequently great complexity of processes in which non-combustion-related activities generate emissions, via an inadequate understanding of certain emissions-generating processes and via a lack of knowledge about the relevant contributions of individual activities.
- 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. The uncertainties for the relevant emission factors are larger, due to the industry's 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 large. This applies especially to waste landfilling, since the diversity of the waste types involved 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 for 2007 is +/-9.7 % (level). Figures for nitrous oxide emissions account for a major share – slightly over 50 % – of that uncertainty. Within that share, the agricultural sector's contribution predominates: Agricultural soils (4.D)

account for some 35% of it. CO_2 sinks within the LULUCF sector also contribute significantly to the total uncertainty: Forests (5.A) account for about 25%. CO_2 emissions from LULUCF: Cropland (5.B) account for nearly 10%. CO_2 emissions from the sector Fuel combustion (1.A) also contribute an important share – about 9% – to the total uncertainty. Within that sector, solid fuel combustion within the sub-sectors Public electricity and heat production (1.A.1.a) and commercial/institutional/residential (1.A.4.a/b) predominates. Additional noteworthy individual contributions are provided by the LULUCF source categories Grassland (5.C), at 4.4% (CO_2), and Settlements (5.E), at 3.7% (CO_2); by Fugitive emissions from fuels (1.B); at nearly 3 % (CH_4); and by the category Chemical industry (2.B), at 2.1% (N_2O). The inventory's trend uncertainty amounts to 13%. In this area as well, nitrous oxide emissions from agricultural soils (4.D) and CO_2 sinks (5.A) provide the major contributions.

The large uncertainties for N_2O, for both experts' assessments and the values from the IPCC Guidelines, have a large impact on the maximum uncertainty figure for the inventory as a whole. As a result, in the next report rounds, it will continue to be necessary to improve the data for this pollutant in the sectors agriculture, LULUCF and industrial processes.

Detailed information about the applicable uncertainties is provided in Annex 7 (cf. Chapter 18).

1.8 General checking of completeness

Completeness details for the individual source categories are presented in CRF Tables 9(a) and 9(b). 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.

In the area of agriculture, while survey data from a past research project on management systems in animal husbandry are available, an effort is being made to carry out periodic, representative data surveys, in the interest of the inventory's continuing completeness and consistency.

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.

In the framework of the R&D project 201 42 258, other countries' inventory data under the category "other sources" was analysed (ÖKO-INSTITUT, 2004a) in support of systematic review of completeness of national emissions data. This study was designed to show which of the source categories other countries report on are also emissions-relevant in Germany – in order to expand German inventories accordingly, if necessary. The results of this analysis show that systematic review for completeness needs to be expanded, especially in the area of industrial processes.

In 2006, the methodological aspects of using data from European emissions trading (EU-ETS) for national climate-protection reporting were studied in the framework of a research project of the German emissions trading agency (deutsche Emissionshandelsstelle – dEHSt), carried out in co-operation with the Single National Entity (FKZ 205 41 521). The central results of such work included development of rules for allocating data from verified emissions reports to the structure of the CSE inventory database. In the first time that such rules were applied during inventory preparation, the rules were applied in connection with the ETS data for 2006. Data from monitoring of emissions trading cannot be used directly for inventory preparation. They can be used for verification of individual source categories and for identification of data gaps or methodological errors, however. No data gaps were identified for the 2009 inventory. Verifications and corrections for the various individual source categories are presented in the relevant specific chapters.

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.

2 TRENDS IN GREENHOUSE GAS EMISSIONS

Table 8 below shows the total emissions, as determined for this inventory, of direct and indirect greenhouse gases and of the acid precursor SO_2. The reference figure 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 9 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 22.4 % compared to the aforementioned reference figure. Total emissions decreased sharply with respect to the previous year, 2006 (the decrease amounted to 2.44 %). As to contributors to the overall result, a CO_2-emissions reduction of nearly 3 %, caused by a drop in energy consumption, and a 3.5% reduction in methane emissions, were offset by a + 5.5 % increase in nitrous oxide emissions and + 3.6 % growth in emissions of F gases. The main factors contributing to the methane reductions include significant increases in use of pit gas and continuing decreases in waste-sector emissions.

Table 10 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.

[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 8: Emissions of direct and indirect greenhouse gases and SO_2 in Germany since 1990

Emission change (Gg)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Net CO_2 emissions / storage	1,007,274	968,831	919,578	909,356	893,862	891,748	913,798	882,513	875,313	848,085	851,528	879,883	864,099	869,250	855,900	829,106	850,787	824,362
CO_2 emissions (not including LULUCF)	1,035,580	997,578	949,612	939,575	924,611	922,660	944,887	914,328	907,118	880,349	883,683	901,309	886,404	889,010	879,935	851,708	867,021	841,152
CH_4	97,805	92,470	88,631	88,220	83,153	79,983	77,083	73,306	68,222	67,580	63,834	60,581	57,025	53,000	48,777	46,223	44,103	42,552
N_2O	70,019	67,344	68,561	65,880	67,510	66,877	68,264	65,339	52,047	48,259	48,368	50,422	49,906	51,989	54,658	56,132	52,948	55,878
HFCs (CO_2 equivalent)	4,369	4,013	4,190	6,160	6,329	6,463	5,843	6,380	6,950	7,192	6,471	7,880	8,784	8,615	9,224	9,978	10,516	11,098
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
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	4,241	4,384	4,559	4,898	5,510	5,567
CO	12,182	9,954	8,609	7,797	6,848	6,687	6,279	6,140	5,732	5,361	5,080	4,823	4,533	4,319	4,100	3,812	3,793	3,763
NMVOC	3,759	3,197	2,924	2,685	2,206	2,091	1,999	1,958	1,915	1,760	1,593	1,499	1,423	1,351	1,355	1,334	1,298	1,280
NO_X	2,863	2,636	2,474	2,362	2,217	2,122	2,036	1,954	1,903	1,872	1,803	1,720	1,624	1,551	1,487	1,403	1,364	1,294
SO_2	5,311	3,921	3,197	2,853	2,386	1,712	1,444	1,200	958	783	626	624	579	556	530	510	514	494

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

Change in emissions with respect to the base year, i.e. 1990 (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Net CO_2 emissions / storage	0.0	-3.8	-8.7	-9.7	-11.3	-11.5	-9.3	-12.4	-13.1	-15.8	-15.5	-12.6	-14.2	-13.7	-15.0	-17.7	-15.5	-18.2
CO_2 emissions (not including LULUCF)	0.0	-3.7	-8.3	-9.3	-10.7	-10.9	-8.8	-11.7	-12.4	-15.0	-14.7	-13.0	-14.4	-14.2	-15.0	-17.8	-16.3	-18.8
CH_4	0.0	-5.5	-9.4	-9.8	-15.0	-18.2	-21.2	-25.0	-30.2	-30.9	-34.7	-38.1	-41.7	-45.8	-50.1	-52.7	-54.9	-56.5
N_2O	0.0	-3.8	-2.1	-5.9	-3.6	-4.5	-2.5	-6.7	-25.7	-31.1	-30.9	-28.0	-28.7	-25.7	-21.9	-19.8	-24.4	-20.2
HFCs (CO_2 equivalent)						0.0	-9.6	-1.3	+7.5	+11.3	+0.1	+21.9	+35.9	+33.3	+42.7	+54.4	+62.7	+71.7
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
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
Changes in total GHG emissions and storage																		
Total emissions with respect to EU burden-sharing[18]	-1.4	-5.2	-9.2	-10.1	-11.5	-12.0	-10.4	-13.4	-15.4	-18.1	-18.2	-16.8	-18.3	-18.2	-19.0	-21.3	-20.4	-22.4
CO	0.0	-18.3	-29.3	-36.0	-43.8	-45.1	-48.5	-49.6	-53.0	-56.0	-58.3	-60.4	-62.8	-64.5	-66.3	-68.7	-68.9	-69.1
NMVOC	0.0	-15.0	-22.2	-28.6	-41.3	-44.4	-46.8	-47.9	-49.1	-53.2	-57.6	-60.1	-62.1	-64.1	-63.9	-64.5	-65.5	-66.0
NO_X	0.0	-7.9	-13.6	-17.5	-22.6	-25.9	-28.9	-31.8	-33.5	-34.6	-37.0	-39.9	-43.3	-45.8	-48.1	-51.0	-52.4	-54.8
SO_2	0.0	-26.2	-39.8	-46.3	-55.1	-67.8	-72.8	-77.4	-82.0	-85.3	-88.2	-88.3	-89.1	-89.5	-90.0	-90.4	-90.3	-90.7

[18] Defined base-year emissions of 1,232,430 Gg CO_2 equivalent; cf. Chapter 0.2

Table 10: Changes in emissions of direct and indirect greenhouse gases and SO_2 in Germany, in each case since the relevant previous year

Emissions change with respect to the previous year (%)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Net CO_2 emissions / storage	0.0	-3.8	-5.1	-1.1	-1.7	-0.2	+2.5	-3.4	-0.8	-3.1	+0.4	+3.3	-1.8	+0.6	-1.5	-3.1	+2.6	-3.1
CO_2 emissions (not including LULUCF)	0.0	-3.7	-4.8	-1.1	-1.6	-0.2	+2.4	-3.2	-0.8	-3.0	+0.4	+2.0	-1.7	+0.3	-1.0	-3.2	+1.8	-3.0
CH_4	0.0	-5.5	-4.2	-0.5	-5.7	-3.8	-3.6	-4.9	-6.9	-0.9	-5.5	-5.1	-5.9	-7.1	-8.0	-5.2	-4.6	-3.5
N_2O	0.0	-3.8	+1.8	-3.9	+2.5	-0.9	+2.1	-4.3	-20.3	-7.3	+0.2	+4.2	-1.0	+4.2	+5.1	+2.7	-5.7	+5.5
HFCs (CO_2 equivalent)	0.0	-8.1	+4.4	+47.0	+2.8	+2.1	-9.6	+9.2	+8.9	+3.5	-10.0	+21.8	+11.5	-1.9	+7.1	+8.2	+5.4	+5.5
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
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
Changes in total GHG emissions and storage																		
Total emissions / storage, including LULUCF	0.0	-3.9	-4.5	-1.0	-1.7	-0.5	+1.9	-3.5	-2.4	-3.3	-0.2	+2.9	-2.0	+0.3	-1.4	-2.8	+1.8	-2.5
Total emissions, not including CO_2 from LULUCF	0.0	-3.8	-4.3	-0.9	-1.6	-0.5	+1.8	-3.4	-2.4	-3.1	-0.2	+1.7	-1.8	+0.1	-1.0	-2.8	+1.1	-2.4
CO	0.0	-18.3	-13.5	-9.4	-12.2	-2.4	-6.1	-2.2	-6.7	-6.5	-5.2	-5.1	-6.0	-4.7	-5.1	-7.0	-0.5	-0.8
NMVOC	0.0	-15.0	-8.5	-8.2	-17.8	-5.2	-4.4	-2.1	-2.2	-8.1	-9.5	-5.9	-5.0	-5.1	+0.3	-1.6	-2.7	-1.4
NO_X	0.0	-7.9	-6.1	-4.5	-6.1	-4.3	-4.1	-4.0	-2.6	-1.6	-3.7	-4.6	-5.6	-4.5	-4.1	-5.6	-2.8	-5.1
SO_2	0.0	-26.2	-18.5	-10.8	-16.4	-28.2	-15.7	-16.9	-20.2	-18.2	-20.0	-0.4	-7.2	-3.9	-4.7	-3.8	+0.8	-4.0

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

By 2007, the above-described obligation to reduce greenhouse-gas emissions, in the framework of EU burden-sharing, had already been fulfilled, via a reduction of 22.4 %. 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 directly acting greenhouse gases that predominate by amount were considerably reduced; CO_2 emissions decreased by 18.8 % and CH_4 emissions were reduced by 56.5 %. In the main, the reasons for these reductions are found in five areas, as described in the following section.

The climatological winter of 2006/2007 was unusually mild. As a result, heating-energy consumption was considerably reduced during that period. In addition, December 2007 was, on average, somewhat milder than the corresponding temperatures during the international climatological reference period, 1961-90 (MÜLLER-WESTEMEIER et.al., 2008: p. 35). The value-added-tax (VAT) increase, from 16% to 19%, that was introduced as of 1 January 2007 had a similarly significant impact. It prompted consumers to make planned fuel purchases early, still within 2006. On the other hand, both of these factors must be seen as one-time effects that will not occur in subsequent years.

Changes in methods used for the areas of agriculture and air transports are another significant factor. In the area of agriculture, this year's inventory makes the first change to complete use of the IPCC 2006 Guidelines. In another first, in the air-transports sector, this year's report now uses an improved split factor for differentiation between national and international air transports. Both of these changes have led to methods-related emissions reductions. On the other hand, indirectly acting CO_2 emissions from solvents production are being reported for the first time, and this has tended to increase trends.

Finally, expansion of use of renewable energies, the sole both lasting and influenceable factor among those in question, has contributed significantly to fulfillment of Germany's emissions-reduction obligations.

Along with these primary factors, a broad range of measures also contributed to the reductions, in areas such as expansion in use of renewable energies, fuel conversions, enhanced economic effectiveness, changes in livestock-keeping methods and decreases in livestock populations. The causes for such measures' effects are discussed in detail in the discussion below of trends for the various individual greenhouse gases.

Release of carbon dioxide from stationary and mobile combustion processes is far and away the principal cause of emissions, accounting for 87.9 % 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 nearly 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 4.4 % in 2006. Emissions of nitrous oxide, caused primarily by agriculture, industrial processes and transport, account for 5.8 % of greenhouse gas releases. The other relevant gases, the so-called "Kyoto" or "F" gases, together accounted for about 1.8 % 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

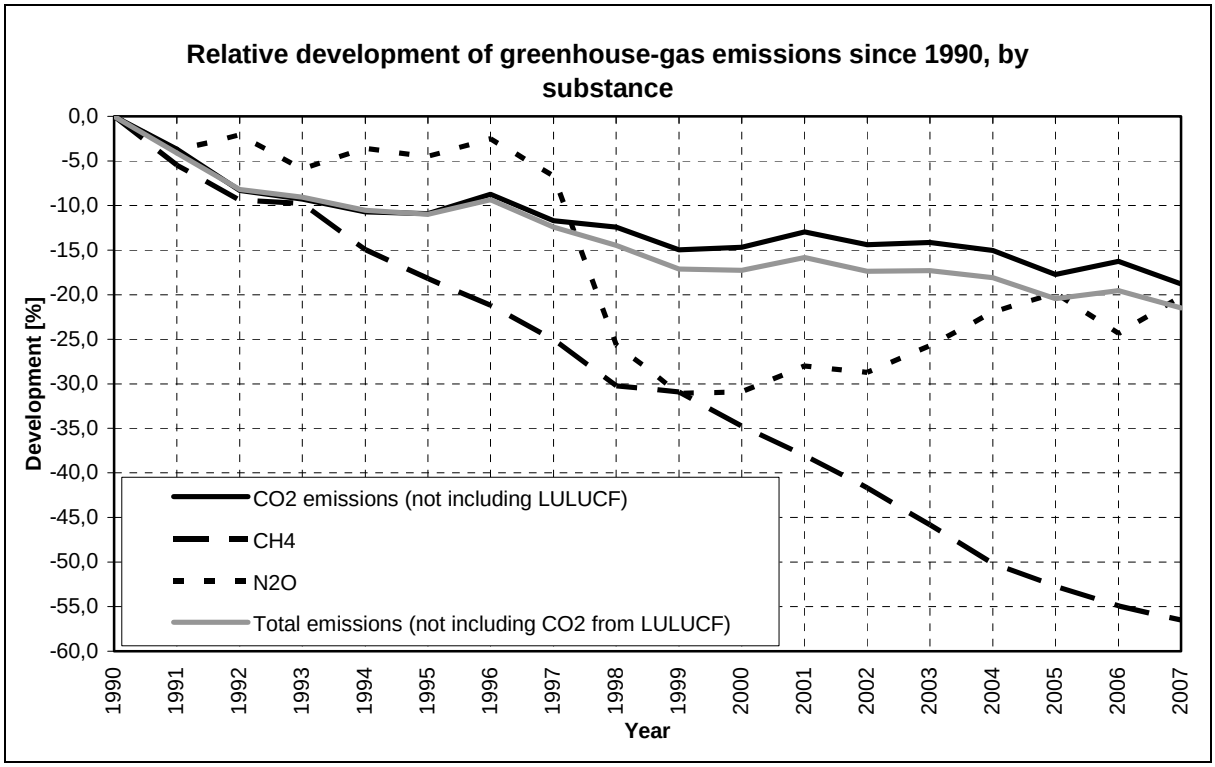


Figure 17: Relative development of greenhouse gases in comparison to their levels in 1990

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, to the year covered by the present report.

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 solid fuels have decreased by 35.6% with respect to their 1990 levels, and those from liquid fuels have dropped by 39.4 %, emissions from combustion of gaseous fuels have increased by 44.9 %.

When these emissions trends are viewed at the source-category level, many different effects emerge. While in the sectors manufacturing, other combustion systems and military, and production of solid fuels, a highly pronounced emissions reduction totalling 194 million t CO_2 occurred, in the public electricity and heat production sector CO_2 emissions have been growing again slightly since 1999.

In the mid-1990s, the statistical reporting procedure was changed for a number of facilities, with the effect that fuel inputs that previously were allocated to the source categories

"Manufacture of solid fuels and other energy industries" (1.A.1.c) and "Manufacturing industries and construction: other" (1.A.2.f) were now reported under the source category "Public electricity and heat production" (1.A.1.a). As a result, CO_2 emissions were shifted from the industrial sector to the public sector. By comparison to the relevant increase in electricity consumption, the CO_2-emissions increase, amounting to 9.9 million t, was relatively moderate. The primary reasons for this 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.

In the refineries sector, emissions also increased slightly over the corresponding 1990 levels, by about 2 million t CO_2, as a result of capacity increases.

Similar trends have occurred in the transport sector. In that sector, CO_2 emissions increased from 165 million t in 1990 to nearly 187 million t in 1999. Since then, they have fallen considerably below their outset level, to 153 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 1990-2007 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 2007, the balance between petrol-related (44.5 %) and diesel-related emissions (55 %) reversed.

In 2007, total emissions decreased from their previous year's level, as a result, especially, of the factors described in Chapter 2.1.

2.2.2 Nitrous oxide (N_2O)

N_2O emissions decreased by over 20 % in the period under consideration. The main sources were use of nitrogen-containing fertilisers in agriculture, the chemical industry, stationary and mobile combustion processes and animal husbandry in agriculture. 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 over 51 %, in relation to the corresponding level in 1990. Emissions trends since 1999 have been influenced strongly by economic trends in the chemical industry.

2.2.3 Methane (CH_4)

Methane emissions are caused mainly by animal husbandry in agriculture, waste landfilling and distribution of liquid and gaseous fuels; the role of energy-related and process-related emissions is almost negligible. These emissions have been decreased by 56.5 % 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 pit gas from coal mining, for energy recovery, has increased. Emissions in this area have decreased by nearly 78 % 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 by 3.5 %. This trend is due to further increases in use of pit gas for energy recovery, as well as to further decreases in landfill emissions.

2.2.4 F gases

Figure 18 shows emissions trends for so-called "F" gases for the period 1995-2007. 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 PU 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.

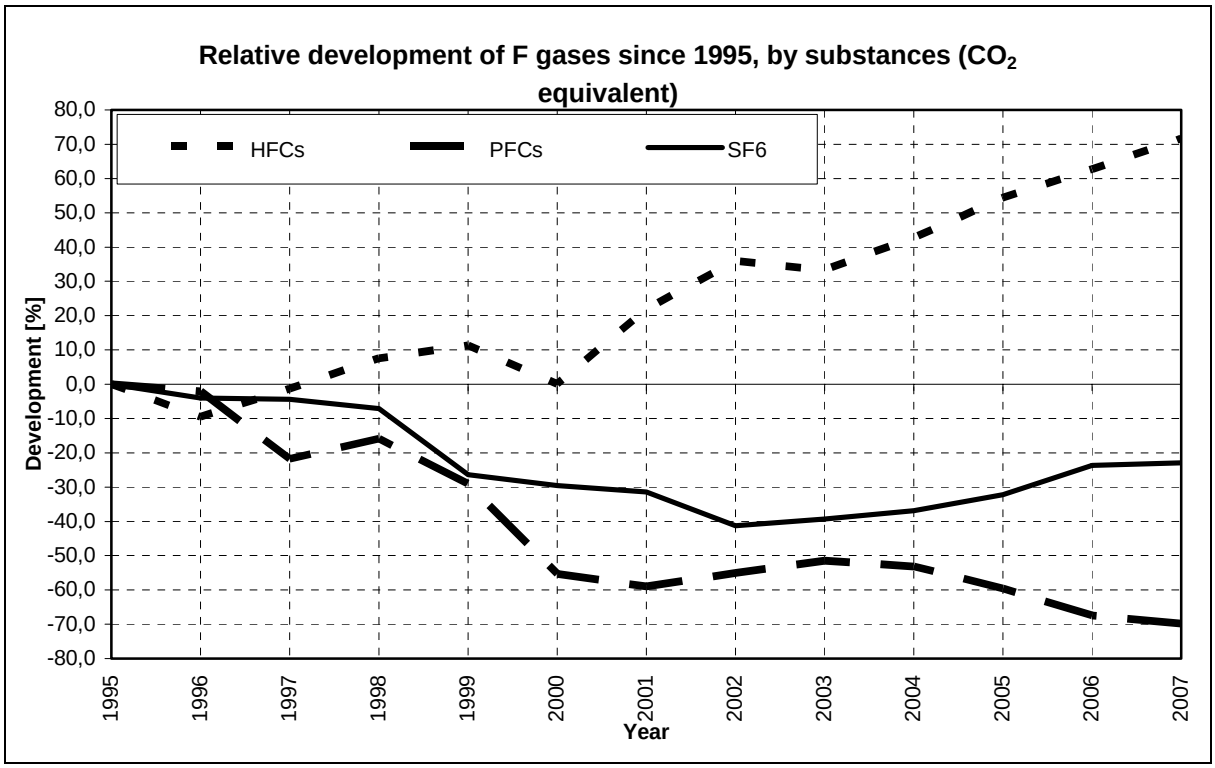


Figure 18: Relative development of F gases in comparison to relevant 1995 levels

2.3 Description and interpretation of emission trends, by source categories

In the category of energy-sector emissions, which have been decreasing, combustion-related emissions are shaped primarily by CO_2 emissions from stationary and mobile combustion systems (cf. also the results of the key-category 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 play a negligible role, 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 over 21 % 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 pit 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. 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 grow as production increases 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. And yet that trend as well is being increasingly offset by production increases.

Since 1990, emissions for the totality of all industrial processes and pollutants, in GHG equivalents, have been reduced by about 3 %. On the other hand, those emissions increased by over 6.5 % by comparison to the previous year.

Emissions in the area of solvent and product use are not particularly high, in absolute values. 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.

The decrease in agricultural emissions since 1990, amounting to over 16.5 %, 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 that has occurred in the areas of land-use changes and forestry is primarily the result of increases in CO_2 emissions from cropland and settlement areas.

The most significant emissions reduction, at 71.5 %, occurred in the area of waste emissions. In this area, intensified recycling of recyclable materials ("yellow sack" for recyclable materials, Ordinance on Packaging, etc.), and the prohibition, 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 77 %. Emissions from wastewater treatment, which also belong to this source category, are considerably lower, in terms of amounts, than landfill emissions. Nonetheless, they decreased by over 45 %.

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	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1. Energy	0.0	-3.6	-8.4	-9.2	-11.4	-11.9	-9.3	-12.9	-13.8	-16.1	-16.4	-14.3	-15.9	-15.9	-17.2	-19.9	-18.7	-21.7
2.Industrial processes	0.0	-4.5	-4.4	-6.0	1.2	1.2	-2.2	0.0	-11.6	-18.6	-15.9	-16.9	-16.6	-13.9	-10.2	-10.1	-9.1	-3.1
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
4. Agriculture	0.0	-9.4	-11.4	-11.7	-13.8	-11.7	-11.0	-12.1	-11.7	-10.1	-10.0	-10.1	-13.0	-14.0	-13.7	-14.3	-15.5	-16.5
5. Land use, land-use changes & forestry	0.0	1.6	6.1	6.8	8.6	9.2	9.8	12.4	12.4	14.0	13.6	-26.8	-23.7	-32.7	-17.6	-22.7	-44.9	-42.9
CO_2 (net sink)	0.0	1.6	6.1	6.8	8.6	9.2	9.8	12.4	12.4	14.0	13.6	-24.3	-21.2	-30.2	-15.1	-20.2	-42.6	-40.7
N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.231.2	1.231.2	1.231.2	1.231.2	1.231.2	1.072.1	1.072.1
6. Waste	0.0	-0.1	-1.6	-4.5	-9.7	-15.1	-21.3	-28.0	-34.6	-40.3	-45.4	-50.4	-54.9	-59.5	-63.6	-67.6	-69.6	-71.5
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

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
1. Energy	0.0	-3.6	-5.1	-0.8	-2.5	-0.5	3.0	-4.1	-1.0	-2.6	-0.3	2.5	-1.8	0.0	-1.6	-3.2	1.5	-3.7
2. Industrial processes	0.0	-4.5	0.1	-1.6	7.6	0.0	-3.4	2.3	-11.6	-7.9	3.4	-1.2	0.4	3.2	4.3	0.2	1.1	6.6
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
4. Agriculture	0.0	-9.4	-2.2	-0.3	-2.4	2.4	0.8	-1.3	0.5	1.7	0.2	-0.1	-3.3	-1.1	0.3	-0.7	-1.3	-1.2
5. Land use, land-use changes & forestry	0.0	1.6	4.5	0.6	1.8	0.5	0.6	2.3	0.0	1.4	-0.3	-35.6	4.2	-11.8	22.5	-6.2	-28.7	3.6
CO_2 (net sink)	0.0	1.6	4.5	0.6	1.8	0.5	0.6	2.3	0.0	1.4	-0.3	-33.4	4.1	-11.4	21.6	-6.0	-28.2	3.4
N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.231.2	0.0	0.0	0.0	0.0	-12.0	0.0
6. Waste	0.0	-0.1	-1.5	-3.0	-5.5	-5.9	-7.3	-8.6	-9.2	-8.7	-8.6	-9.2	-9.1	-10.2	-10.0	-11.0	-6.2	-6.4
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

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 9. Over this period, a number of significant successes have been achieved in reducing these pollutants. For example, emissions of SO_2 have been reduced by almost 91 %, those of CO by 69 %, those of NMVOCs by 66 % and those of NO_X by nearly 55 %.

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 emission trends for the various individual air pollutants involved, are provided by the Web site of the Federal Environment Agency.

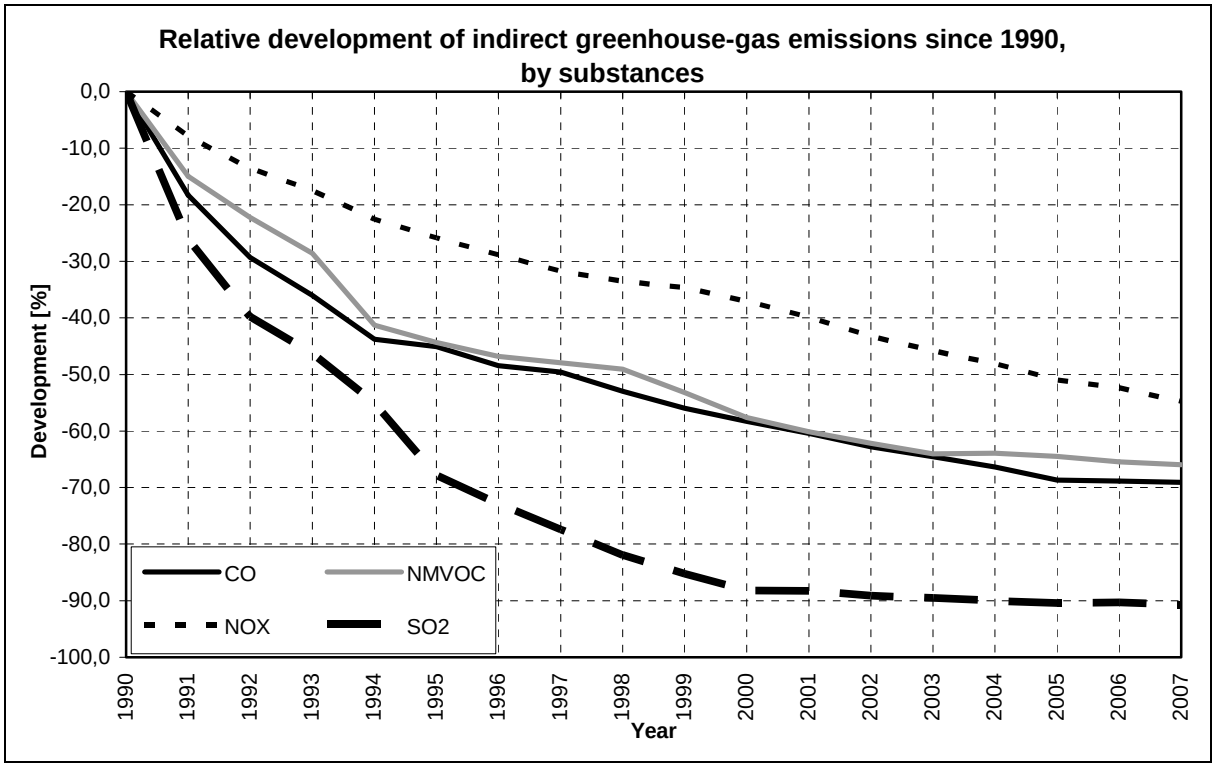


Figure 19: Emissions trends for indirect greenhouse gases and SO_2

3 ENERGY (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 Emission Sources" ("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.

3.1 Combustion of fuels (1.A)

The activity rates for stationary combustion are calculated in the "Balance of Emission Sources" (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 13.1.

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 and 204 41 132), documented in detail. Currently, efforts are underway to integrate the model, which is Excel-based, within the CSE database. 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 14.

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

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

1. **Public thermal power stations** (line 11) are plants that feed produced electricity into the public grid. This also includes industrial plants which operate their power stations together with electricity utility companies as joint power stations. The fuel input for electricity generation is reported here. This line of the Energy Balance also includes the fuel input in public thermal power stations attributable to electricity production.
2. **Industrial thermal power stations** (line 12) comprise the following operator groups:
   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 plants 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).

3. **Thermal 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 plants also supply industrial customers with process heat.
4. **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 heat networks in which the basic load is met by thermal power stations.

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

5. 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)

6. **Final energy consumption by industry** (line 60 of the Energy Balance) indicates the fuel used for heat generation which is required for both production purposes and room 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.
7. The data on **final energy consumption by households** (line 66 of the Energy Balance) lists fuel inputs for heat generation and includes the application areas of heating, water heating and cooking.

8. The data on **final energy consumption by trade, commerce, services and other consumers** (line 67 of the Energy Balance) comprises fuel inputs used for hot water production, room heating and process heat generation in this sector.

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 which

- Are used in facilities with differing requirements under immission protection legislation (e.g. large furnaces, medium-sized furnaces, small furnaces, waste incineration plants)
- Operate according to different technical principles (e.g. steam turbine power stations, gas turbine power stations, motor power stations)
- Exhibit regional peculiarities (e.g. different individual mining regions have different qualities of crude lignite)
- Are allocated to different source categories in national and international emissions reporting
- Are listed in various Energy Balance lines according to 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 these differing requirements, the Energy Balance data in the model *Balance of Emission Sources* (BEU) are disaggregated, using additional statistics as well as the Federal Environment Agency's own calculations. The following Figure 20 provides an overview of the relevant structure:

Balance of Emission Sources (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), • Households and commerce, trade, services and other consumers 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 20: Characteristics of the Federal Environment Agency's structure of the Balance of Emission Sources, 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 led to 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, thereby facilitating the preparation of consistent time series.

Figure 20 and the following tables (Table 12 through Table 17) 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 first column is the relevant table's sequential number in the *Balance of Emission Sources*. 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 Sources* table is used. 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 "file name" in the eighth column is a unique reference to the database of the *Central System of Emissions (CSE)*.

Table 12: Structure of the Balance of Emission Sources – public services

No.	Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]	File name
Public supply							
1	Electricity generation in large combustion systems of public power stations	11	13. BImSchV	DTKW	Public supply	S	OEKW13
2	Electricity generation in large combustion systems of public crude-lignite-fired power stations	11	13. BImSchV	DTKW	Public supply	S	OEBKW13
2a	Electricity generation in large combustion systems of public hard-lignite-fired power stations	11	13. BImSchV	DTKW	Public supply	S	OEHBKW13
3	Electricity generation in waste incineration systems of public power stations	11	17. BImSchV	DTKW	Public supply	S	OEKW17
4	Electricity generation in gas turbines (TA Luft) of public power stations	11	TA Luft	GTKW	Public supply	S	OEKWGTTA
4a	Electricity generation in gas and steam turbine systems of public power stations	11	TA Luft	GuD	Public supply	S	OEKWGUDT
4b	Electricity generation in large combustion systems of gas turbines of public power stations	11	13. BImSchV	GTKW	Public supply	S	OEKWGT13
4c	Electricity generation in large combustion systems of gas and steam turbine systems of public power stations	11	13. BImSchV	GuD	Public supply	S	OEKWGUD13
5	Electricity generation in gas machines of public power stations	11	TA Luft	GMKW	Public supply	S	OEKWGM
6	Electricity generation in diesel motors of public power stations	11	TA Luft	DMKW	Public supply	S	OEKWDM
22	Heat generation in large combustion systems of public power stations	15	13. BImSchV	DTKW	Public supply	W	HEKW13
22a	Heat generation in large combustion systems of public crude-lignite-fired power stations	15	13.BImSchV	DTKW	Public supply	W	HEBKW13
23	Heat generation in waste-incineration systems of public power stations	15	17. BImSchV	DTKW	Public supply	W	HEKW17
25	Heat generation in gas turbines (TA Luft) of public power stations	15	TA Luft	GTKW	Public supply	W	HEKWGTTA
25a	Heat generation in gas and steam turbine systems (TA Luft) of public power stations	15	TA Luft	GuD	Public supply	W	HEKWGuDTA
25b	Heat generation in large combustion systems of gas turbines of public power stations	15	13. BImSchV	GTKW	Public supply	W	HEKWGT13
25c	Heat generation in large combustion systems of gas and steam turbine systems of public power stations	15	13. BImSchV	GuD	Public supply	W	HEKWGUD13
26	Heat generation in gas machines of public power stations	15	TA Luft	GMKW	Public supply	W	HEKWGM
28	Heat generation in large combustion systems of public district heating stations	16	13. BImSchV	FHW	Public supply	W	FEHW13
29	Heat generation in waste-incineration systems of public district heating stations	16	17. BImSchV	FHW	Public supply	W	FEHW17
30	Heat generation in TA Luft systems of public district heating stations	16	TA Luft	FHW	Public supply	W	FEHWTA

1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMKW = gas motor power stations, DMKW = diesel motor power stations, FHW = district heat 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 Emission Sources – coal mining

No.	Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]	File name
Coal mining							
7a	Electricity generation in large combustion systems of power stations of the hard-coal-mining sector	12	13. BImSchV	DTKW	Coal mining	S	STKBKW 13
7b	Electricity generation in TA-Luft systems of power stations of the hard-coal-mining sector	12	TA-Luft	DTKW	Coal mining	S	STKBKWTA
8a	Electricity generation in large combustion systems of mine-pit power stations (newly established category)	12	13. BIMSchV	DTKW	Other coal mining	S	GRKW13
8b	Electricity generation in waste-incineration systems of mine-pit power stations (newly established category)	12	17. BIMSchV	DTKW	Other coal mining	S	GRKW17
33a	Heat generation in large combustion systems of mine-pit power stations	40	13. BImSchV	DTKW	Other coal mining	W	UEGK13
33b	Heat generation in large combustion systems of power stations of the hard-coal-mining sector	40	13. BImSchV	DTKW	Coal mining	W	UESTKB13
33c	Heat generation in TA Luft systems of power stations of the hard-coal-mining sector	40	TA-Luft	DTKW	Coal mining	w	UESTKBTA
41	Direct drive via diesel motors of mine and mine-pit power stations	40	TA Luft	DMKW	Coal mining	K	UEKZDM
43	Production of hard-coal coke	40	TA Luft	PF	Coal mining	W	UEPFKO

1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMKW = gas motor power stations, DMKW = diesel motor power stations, FHW = district heat 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 Emission Sources – other industrial power stations

No.	Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]	File name
Other industrial power stations							
12	Electricity generation in large combustion systems of DB power stations	12	13. BImSchV	DTKW	Deutsche Bahn AG (German Railways)	S	DBKW13
14	Electricity generation in large combustion systems of other industrial power stations	12	13. BImSchV	DTKW	Other mining and manufacturing (not including VAW)	S	UIKW13
14b	Electricity generation in large combustion systems of power stations of the pulp and paper industry	12	13. BImSchV	DTKW	Pulp and paper industry	S	ZPKW13
15	Electricity generation in waste incineration systems of other industrial power stations	12	17. BImSchV	DTKW	Other mining and manufacturing	S	UIKW17
16	Heat generation in TA Luft systems of other industrial power stations	12	TA Luft	DTKW	Other mining and manufacturing	S	UIKWTA
18	Electricity generation in gas turbines (TA Luft) of other industrial power stations	12	TA Luft	GTKW	Other mining and manufacturing	S	UIKWGT
18a	Electricity generation in large combustion systems of gas turbines of other industrial power stations	12	13. BImSchV	GTKW	Other mining and manufacturing	S	UIKWGT13
18b	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
18c	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
19	Electricity generation in gas machines of other industrial power stations	12	TA Luft	GMKW	Other mining and manufacturing	S	UIKWGM
21	Electricity generation in diesel motors of other industrial power stations	12	TA Luft	DMKW	Other mining and manufacturing	S	UIKWDM
47	Heat generation in large combustion systems of industrial power stations of the manufacturing sector and other mining	60	13. BImSchV	DTKW	Other mining and manufacturing	W	INKW13
48	Heat generation in waste-incineration systems of the manufacturing sector and other mining	60	17. BImSchV	DTKW	Other mining and manufacturing	W	INKW17
50	Heat generation in TA Luft systems of industrial power stations of the manufacturing sector and other mining	60	TA Luft	DTKW	Other mining and manufacturing	W	INKWTA
51	Heat generation in gas turbines of industrial power stations of the manufacturing sector and other mining	60	TA Luft	GTKW	Other mining and manufacturing	W	INKWGT
51 a	Heat generation in large combustion systems of industrial power stations of the manufacturing sector and other mining	60	13. BImSchV	GTKW	Other mining and manufacturing	W	INKWGT13
51b	Heat generation in TA Luft systems of gas and steam turbine systems of industrial power stations of the manufacturing sector and other mining	60	TA Luft	GuDKW	Other mining and manufacturing	W	INKWGUDTA
51c	Heat generation in large combustion systems of gas and steam turbine systems of industrial power stations of the manufacturing sector and other mining	60	13. BImSchV	GuDKW	Other mining and manufacturing	W	INKWGUD13

No.	Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]	File name
52	Heat generation in gas machines of industrial power stations of the manufacturing sector and other mining	60	TA Luft	GMKW	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, GMKW = gas motor power stations, DMKW = 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 15: Structure of the Balance of Emission Sources – refineries, other energy producers, iron and steel industry

No.	Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]	File name
Refineries							
13	Electricity generation in large combustion systems of refinery power stations	12	13. BImSchV	DTKW	Petroleum processing	S	UIKR13
13a	Electricity generation in TA Luft systems of refinery power stations	12	TA-Luft	DTKW	Petroleum processing	S	UIKRTA
17	Electricity generation in gas turbines (TA Luft) of refinery power stations	12	TA Luft	GTKW	Petroleum processing	S	UIKRGTTA
17a	Electricity generation in large combustion systems of gas turbine systems of refinery power stations	12	13. BImSchV	GTKW	Petroleum processing	S	UIKRGT13
34	Heat production in large combustion systems of refinery power stations	40	13. BImSchV	DTKW	Petroleum processing	W	UEKR13
34a	Heat generation in TA Luft systems of refinery power stations	40	TA-Luft	DTKW	Petroleum processing	W	UEKRTA
39	Heat generation in gas turbines (TA Luft) of refinery power stations	40	TA Luft	GTKW	Petroleum processing	W	UEKRGTTA
39a	Heat generation in large combustion systems of gas turbine systems of refinery power stations	40	13. BImSchV	GTKW	Petroleum processing	W	UEKRGT13
42	Heat generation in diesel motors of refinery power stations	40	TA Luft	DMKW	Petroleum processing	W	UEKRDM
44	Refinery bottom-heating systems (large combustion systems)	40	13. BImSchV	PF	Petroleum processing	W	UEPFRG
44a	Refinery bottom-heating systems (TA Luft installations)	40	TA Luft	PF	Petroleum processing	W	UEPFRT
Other energy producers of the transformation sector							
31	Heat generation in large combustion systems (industrial boilers) of the other transformation sector	40	13. BImSchV	FA	Other energy producers	W	UEUM13
36	Heat generation in TA Luft systems (industrial boilers) of the other transformation sector	40	TA Luft	FA	Other energy producers	W	UEUMTA
Iron and steel industry							
54	Manufacturing of pig iron (process combustion)	60	TA Luft	Blast furnaces	Iron and steel industry	W	INPFHO
55	Sinter production (process combustion)	60	TA Luft	Sintering plants	Iron and steel industry	W	INPFSI

1) DTKW = steam turbine power stations, GTKW = gas turbine power stations, GT = gas turbines, GuD = gas and steam turbine power stations, GMKW = gas motor power stations, DMKW = 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 16: Structure of the Balance of Emission Sources – other tables

No.	Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]	File name
Other tables in the BEU structure							
36a	Gas turbines (TA Luft) in natural-gas-compressor stations	40	TA Luft	GT	Gas industry	K	GVKOMPTA
36b	Large combustion systems of gas turbines in natural-gas-compressor stations	40	13. BImSchV	GT	Gas industry	K	GVKOMP13
46	Heat generation in large combustion systems (industrial boilers) of the manufacturing sector and other mining	60	13. BImSchV	Steam / hot-water boilers	Other mining and manufacturing	W	INDU13
49	Heat generation in TA Luft systems (industrial boilers) of other mining and manufacturing (process heat)	60	TA Luft	Steam / hot-water boilers	Other mining and manufacturing	W	INDUTAP
57	Manufacturing of rolled steel (process combustion)	60	TA Luft	Production of rolled steel	Steel production	W	INPFWA
58	Production of iron, steel and malleable cast iron (process combustion)	60	TA Luft	Foundries	Foundry industry	W	INPFGU
59	Production of non-ferrous heavy metals (process combustion)	60	TA Luft	Foundries for non-ferrous metals	Non-ferrous-metal production	W	INPFNE
60	Lime production (process combustion)	60	TA Luft	Lime-burning furnaces	Lime production	W	INPFKA
61	Production of cement clinkers (process combustion)	60	TA Luft	Cement furnaces	Cement production	W	INPFZK
62	Glass production (process combustion)	60	TA Luft	Glass smelting furnaces	Glass production	W	INPFGL
63	Sugar manufacturing (process combustion)	60	TA Luft	Sugar refineries	Sugar production	W	INPFZU
64	Ceramics production (process combustion)	60	TA Luft	Kilns	Brick production	W	INPFZI
64a	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
66	Other process combustion	60	TA Luft	Process combustion	Other mining and manufacturing	W	INUEPF

1) GT = gas turbines

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

Table 17: Structure of the Balance of Emission Sources – deleted structural elements

No.	Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]	File name
6a	Power generation from biogenic fuels	11	TA Luft / 1. BImSchV		Public supply	S	OEKWBIO
27	Heat generation in diesel motors of public power stations	15	TA Luft	DMKW	Public supply	W	HEKWDM
7	Electricity generation in large combustion systems of STEAG	12	13. BImSchV	DTKW	Coal mining / STEAG	S	STEA13
8	Electricity generation in large combustion systems of other mine-pit power stations	12	13. BImSchV	DTKW	Other coal mining	S	ZGSK13
9	Electricity generation in gas turbines of mine and mine-pit power stations	12	TA Luft	GTKW	Coal mining	S	ZGKWGT
10	Electricity generation in gas machines of mine and mine-pit power stations	12	TA Luft	GMKW	Coal mining	S	ZGKWGM
11	Electricity generation in diesel motors of mine and mine-pit power stations	12	TA Luft	DMKW	Coal mining	S	ZGKWDM
32	Heat generation in large combustion systems of STEAG	40	13. BImSchV	DTKW	Coal mining / STEAG	W	UEST13
33	Heat generation in large combustion systems other mine-pit power stations	40	13. BImSchV	DTKW	Other coal mining	W	UEZK13
38	Heat generation in gas turbines of mine and mine-pit power sta.	40	TA Luft	GTKW	Coal mining	W	UEKZGT
40	Heat generation in gas machines of mine and mine-pit power stations	40	TA Luft	GMKW	Coal mining	W	UEKZGT
43a	Production of hard-coal coke (17. BImSchV)	40	17. BImSchV	PF	Coal mining	W	UEPFKO17
14a	Electricity generation in large combustion systems of Vereinigte Aluminium Werke (VAW), Bonn	12	13. BImSchV	DTKW	Vereinigte Aluminium Werke (VAW)	S	VAW13
24	Heat generation in TA Luft systems of other industrial power stations (only production for feeding into public grid)	15	TA Luft	DTKW	Other mining and manufacturing	W	HEKWTA
35	Heat generation in large combustion systems of other industrial power stations of the transformation sector	40	13. BImSchV	DTKW	Other energy producers	W	UEKI13
37	Heat generation in TA Luft systems of industrial power stations of the transformation sector	40	TA Luft	DTKW	Other energy producers	W	UEKITA
20	Electricity generation in diesel motors of refinery power stations	12	TA Luft	DMKW	Petroleum processing	S	UIKRDM
49a	Heat generation in TA Luft systems (industrial boilers) of other mining and manufacturing (heating systems)	60	TA Luft	Steam / hot-water boilers	Other mining and manufacturing	W	INDUTAH
53	Heat generation in diesel engines of industrial power stations of the manufacturing sector and other mining	60	TA Luft	DMKW	Other mining and manufacturing	W	INKWDM
53a	Heat generation in small combustion systems (industrial boilers) of the other mining and manufacturing sector (process heat)	60	1. BImSchV	Steam / hot-water boilers	Other mining and manufacturing	W	INDU01P
53b	Heat generation in small combustion systems (industrial boilers) of the other mining and manufacturing sector (heating systems)	60	1. BImSchV	Steam / hot-water boilers	Other mining and manufacturing	W	INDU01H
56	Production of Siemens-Martin steel (process combustion)	60	TA Luft	Siemens-Martin furnaces	Steel production	W	INPFSM
65	Calcium carbide production (process combustion)	60	TA Luft	Kilns	Calcium carbide production	W	INPFCA

Table 18: Structure of the Balance of Emission Sources – structural elements already integrated within the CSE and no longer executed within the BEU

No.	Process, fuel	EB line	Allocation under emissions laws	Type of facility[1)]	Economic sector	SWK[2)]	File name
67	Heat generation in TA Luft systems in agricultural and horticultural operations	67	TA Luft	Steam / hot-water boilers	Agriculture	W	LAWITA
68	Heat generation in small combustion systems in agricultural and horticultural operations	67	1. BImSchV	Steam / hot-water production systems	Agriculture	W	LAWI01
69	Heat generation in TA Luft systems of other small consumers	67	TA Luft	Hot-water boilers	Small consumers	W	UEKVTA
70	Heat generation in small combustion systems of other small consumers	67	1. BImSchV	Hot-water boilers	Small consumers	W	UEKV01
71	Heat generation in TA Luft systems of military agencies	67	TA Luft	Hot-water boilers	Military agencies	W	MILITA
72	Heat generation in small combustion systems of military agencies	67	1. BImSchV	Hot-water boilers	Military agencies	W	MILI01
73	Heat generation in small combustion systems of households	66	1. BImSchV	Heat producing systems	Residential	W	HAUS01

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

3.1.1.1 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**	**2007 - contribution to total emissions**	**Trend**
All Fuels	l / t	CO_2	26.61 %	33.89 %	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				
Method of EF determination	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" (1.A.1.a) is a key source, in terms of emissions level and trend, for CO_2 emissions.

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.

Some 98 GW of net bottleneck capacity were in place in the public electricity generating sector in 2007. Of this amount, about 66 GW were operated with fossil fuels or with transformation products of fossil fuels. As a group, all fossil-driven plants generated some 345 TWh of electrical work. This corresponds to about 66 % of all public electricity generation (about 523 TWh). About 281 TWh of electricity were generated solely with lignite and hard coal (DESTATIS 2006a).

In 2006, thermal power stations contributed net electricity production of 54 TWh, and net heat production of 101 TWh, to the public energy supply. District-heat production is supplemented by non-coupled heat production by thermal power stations and heating stations (usually in peak-load operation), amounting to net heat production of about 35 TWh. (Federal Statistical Office 2007, FS 4, Reihe (series) 6.5, Statistik (statistics) No. 066 and No. 064).

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

Activity rates

The calculation method has been selected on the basis of current key-category 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 Emission Sources" 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 may be applied to the relevant activity rates.

The activity rates for 1990 for the new German Länder had already been revised and substantiated for the 2006 report. For the 2007 report, the activity rates of the new German Länder, for the 1991-1994 period, were adjusted and substantiated, for the first time, on the basis of findings from the aforementioned research project (FKZ 205 41 115 / Sub-project A "Revision and substantiation 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 plants of public power stations, and of heat production in waste-incineration plants of public district-heating stations, the Energy Balance values diverge considerably from those in the waste statistics of the Federal Statistical Office (DESTATIS, FS19 Reihe 1). Presumably, the waste statistics' assumptions pertaining to fuel inputs from waste (here: household waste / municipal waste) are more realistic than those used in the Energy Balance. For this reason, the differences between the Energy Balance values and those in Fachserie 19 (DESTATIS, FS19 Reihe 1) are compensated for via determination of so-called "non-Energy-Balance values". This increases the activity rates for household waste / municipal waste for the entire time series as of 1990. As of the NIR 2006, the fossil and biogenic waste fractions in household waste / municipal waste are listed separately, on a 1:1 basis.

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 is provided by the report on the research project "Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010" ("Determination and evaluation of emission factors for combustion systems in Germany for the years 1995, 2000 and 2010"; RENTZ et al, 2002). The values for the intermediate years 1996 - 1999 and 2001 - 2007 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 3.1.2, 3.1.3, 3.1.4.6 and 3.1.5.5, where the factors include power stations, gas turbines or boilers for production 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 14.1.2) discusses the procedure used in the research project.

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).

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 systems, as determined in the research project, are summarised in Table 19. These factors were used as a basis for calculating the source-category-specific emission factors for the CSE.

Table 19: 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 20, 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 20: Technological emission factors for nitrous oxide from systems < 50 MW furnace thermal output

Fuel		Technology	Output	Federal *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 in large combustion systems is provided by Annex 3 in Chapter 14.1.2.4.

3.1.1.3 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 numbers themselves are based on a personal communication from an expert.

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 14.1.2.1.

Other aspects relative to time-series consistency of activity rates are explained in Chapter 13.5 and Chapter 13.6.

The uncertainty of the determined emission factors has been evaluated in the framework of the DFIU research project described in Chapter 3.1.1.2 and in Annex 3, Chapter 14.1.2.1.

By drawing on the results of a research project that has now been completed, we were able to considerably increase the accuracy of the activity rate for limestone input in flue-gas desulphurising systems (cf. Chapter 14.1.2.4 in the Annex).

3.1.1.3.1 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, in Chapter 14.1.2.2.

3.1.1.3.2 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: Kapitel 6, S. 6.14); in the process, uniform distribution of uncertainties is assumed – in keeping with the calculation method selected).

3.1.1.3.3 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 3.1.1.2). The individual CH_4 emission factors, as determined in the research project (RENTZ et al, 2002), are listed in Annex 14.1.2.3. Previously, the factors listed there, for hard coal fired in combustion systems < 50 MW (mean value for D: 3.35 kg/TJ), and for light heating oil and natural gas fired in gas turbines, were used in the CSE for the years as of 1995. Review and adoption of the project's remaining proposals are still pending. For these fuels, the existing emission factors in the CSE are used without change (solid fuels: 1.5 kg/TJ; liquid fuels: 3.5 kg/TJ; and gaseous fuels: 0.3 kg/TJ).

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

3.1.1.3.4 Time-series consistency of emission factors

In the framework of the aforementioned research project (RENTZ et al 2002), the emission factors for N_2O were determined for 1995 (reference year) and then 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 2007. The N_2O emission factors were forecast to decrease slightly only in the area of use of gas turbines (natural gas, light heating oil). This is a result of the higher mean gas-turbine-intake temperatures required in modern gas turbines in order to increase efficiency. These changes have no significant effect, however, on levels of total N_2O emissions in the CRF area under consideration.

The time series for N_2O between 1995 and 2007 were reviewed in this light and assessed as consistent overall. The time series of CH_4 emission factors for 1995 to 2007 were also reviewed and assessed as internally consistent.

We can now report that we have completed source-specific review of N_2O emission factors, with regard to consistency with the values as of 1995, for the period from 1990 to 1994. With this progress, we have carried out the improvements requested in the 2007 In-Country Review.

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

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 been carried out completely.

Since the inventories, in general, are based on the Energy Balances for Germany prepared by the Working Group on Energy Balances (AGEB, 2003) – whose quality-assurance system is currently not known to us – quality assurance, quality control and verification are carried out by reviewing the Energy Balance for completeness and plausibility and by making personal enquiries as necessary in individual cases. The results of the research project (FKZ 203 41 253 /03) for substantiating the Energy Balance sources are now available to the Federal Environment Agency. These results have led to shifting of fuel-input quantities within the Energy Balance, as well as to addition of energy inputs not listed in the Energy Balance. In source category 1.A.1.a, such changes have applied solely to inputs of household waste /

municipal waste (fossil and biogenic), as described in Chapter 3.1.1.2 "Methodological issues (1.A.1.a)".

The Federal Environment Agency has not yet received any information regarding the quality assurance system applied to official statistics used for breaking energy inputs down by specific technologies and fuels. For this reason, quality assurance, quality control and verification are carried out here as well by reviewing the Energy Balance for completeness and plausibility and by making personal enquiries as necessary in individual cases.

General measures for assuring the quality of emission factors for combustion systems, as used in the framework of a research project (RENTZ et al, 2002), are outlined in the methods description in Annex 3, Chapter 14.1.2.1 (after Figure 36). Their results were reported in the NIR 2005.

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

In keeping with the availability of new energy balances and updated evaluation tables, recalculations have been carried out for the years 2003 to 2006. In addition, improvements in the calculation method for determining CO_2 emissions from flue-gas desulphurisation have also led to recalculations, affecting the entire time series (1990-2006).

The 2006 values for fuel inputs of household waste / municipal waste were updated, since Fachserie 19 (Fachserie = technical publication series), with the figures for 2006, did not become available in time for the NIR 2008. For this reason, the relevant data were estimated for the previous NIR. For the current greenhouse-gas inventory, the values for the year 2007 were again estimated. The 2007 values will be updated when FS 19 2008 (for the year 2007; FS = Fachserie) appears.

We have recalculated the N_2O emissions loads for the years 1990 through 1994 in keeping with the emission-factor adjustments described in Chapter 3.1.1.3.4.

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

In a major research project, we plan to update the database, as described in Chapter 3.1.1.2, for emission factors (apart from those for CO_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.

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

3.1.2.1 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**	**2007 - contribution to total emissions**	**Trend**
All Fuels	l / t	CO_2	1.59 %	2.16 %	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				
Method of EF determination	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 119 Mt in 2007. In that period, 109 Mt of crude oil, along with 13.5 Mt of intermediate products, were input for processing. Production of petroleum products totalled 120 Mt, of which about 62 Mt consisted of fuels, about 29 Mt consisted of heating oils, about 8 Mt consisted of naphtha and about 21 Mt consisted of other products. (MWV, 2008).

The refineries operate power stations with electrical output of about 0.9 GW. In 2006, these power stations generated 5 TWh of electrical work and yielded process heat for production purposes. (DESTATIS 2006b).

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”.

3.1.2.2 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 (Destatis), 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.

A calculation using the Federal Statistical Office's statistics produces a fuel-specific relationship between the fuel inputs for heat production in refinery power stations and the fuel inputs for electricity production in refinery power stations. This 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 3.1.1.2 and in Chapter 14.1.2.1 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 also used for refinery power stations.

3.1.2.3 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).

3.1.2.3.1 Result for N_2O

The values for the relative uncertainty are on the order of about 0.6. The pertinent comments made in Chapter 3.1.1.3.2 also apply, mutatis mutandis.

3.1.2.3.2 Result for CH_4

The results of Chapter 3.1.1.3.3 apply, mutatis mutandis.

3.1.2.3.3 Time-series consistency of emission factors

The results of Chapter 3.1.1.3.4 apply, mutatis mutandis.

3.1.2.4 Source-specific quality assurance / control and verification (1.A.1.b)

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 been carried out completely.

Since the inventories, in general, are based on the Energy Balances for Germany prepared by the Working Group on Energy Balances (AGEB, 2006) – whose quality-assurance system is currently not known to us – quality assurance, quality control and verification are carried out by reviewing the Energy Balance for completeness and plausibility and by making

personal enquiries as necessary in individual cases. The research project "Updating of emissions-calculation methods 2003 – Sub-project 03 – substantiation of energy figures in the Energy Balance " (FKZ 203 41 253 / 03) substantiated the sources for the Energy Balance, thereby contributing decisively to quality assurance and control.

The Federal Environment Agency has not yet received any information regarding the quality assurance system applied to official statistics and association statistics used for sectoral allocation, or other breakdowns, of energy inputs. For this reason, quality assurance, quality control and verification are carried out here as well by reviewing the Energy Balance for completeness and plausibility and by making personal enquiries as necessary in individual cases.

With regard to emission factors, the results of Chapter 3.1.1.3 apply, mutatis mutandis.

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

In keeping with the availability of new energy balances and updated evaluation tables, recalculations have been carried out for the years 2003 to 2006.

The results of Chapter 3.1.1.5 apply, mutatis mutandis.

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

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

The planned **emission-factor** updates described in Chapter 3.1.1.6 (updates of EF apart from those for CO_2) will also cover power stations and bottom-heating systems in petroleum refineries.

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

3.1.3.1 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**	**2007 - contribution to total emissions**	**Trend**
All Fuels	l / t	CO_2	4.68 %	1.75 %	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				
Method of EF determination	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, for 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 2006, the German hard-coal mining sector extracted 20.7 Mt of usable hard coal (24.7 Mt in 2005) (STATISTIK DER KOHLEWIRTSCHAFT 2007: for the year 2006, Übersicht (Overview) 1, and www.kohlenstatistik.de). Coke production in 2006 amounted to 8.3 Mt (STATISTIK DER

KOHLENWIRTSCHAFT 2007, for the year 2006, p. 51, Zahlenübersicht (numbers overview) 45, "Koksproduktion" (coke production) line). Production of hard coal briquettes and other coal products combined amounted to less than 1 Mt.

In 2006, 180.4 Mt of crude lignite was produced in Germany (www.kohlenstatistik.de). Combined production of lignite briquettes and other lignite products amounted to about 5.3 Mt (www.kohlenstatistik.de). From these plants, steam is drawn off for drying crude lignite for production of lignite products.

In 2007, German production of petroleum totalled nearly 3.4 Mt (MWV, 2008), while production of natural gas totalled about 18,850 Mm^3 (H_u = 31,736 kJ/m^3) (BAFA, 2008). The fuel input needed for operation of the plants is included in the Balance of Emission Sources (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 (pit power stations); electricity and heat production in gas turbines, gas engines and diesel engines of all pit (*Zeche* + *Grube*) 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 pit (*Zeche* + *Grube*) power stations. The structural elements "STEAG power stations" and "other pit power stations" have been eliminated, since the statistics show them simply as power stations of the hard-coal mining sector. 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).

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

The calculation method has been selected on the basis of the latest key-category 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 (DESTATIS, 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 pit and briquette plants of the hard-coal mining sector".

The listed fuel input for electricity production in pit 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 2006) 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.

To calculate the total energy consumption for production of hard-coal coke, the Federal Environment Agency uses the transformation output, in 1000t (Energy Balance (AGEB, 2006), in natural units, line 23, and Statistik der Kohlenwirtschaft 2006 for the years with no Energy Balance), and the specific energy consumption for hard-coal production (FICHTNER 1982). Top-gas input in Energy Balance line 33, "Energy consumption in coking plants", is allocated completely to production of hard-coal coke. The difference between that result and the calculated total energy consumption is then the figure for coke-oven / city gas.

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 pits' 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 14.1.1.

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 3.1.1.2 and in Chapter 14.1.2.1 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.

3.1.3.3 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 3.1.1.3.1.

3.1.3.3.1 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 was 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 3.1.1.3.2 also apply, mutatis mutandis.

3.1.3.3.2 Result for CH_4

The results of Chapter 3.1.1.3.3 apply, mutatis mutandis.

3.1.3.3.3 Time-series consistency of emission factors

The results of Chapter 3.1.1.3.4 apply, mutatis mutandis.

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

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 been carried out completely.

Since the inventories, in general, are based on the Energy Balances for Germany prepared by the Working Group on Energy Balances (AGEB, 2008) – whose quality-assurance system is currently not known to us – quality assurance, quality control and verification are carried out by reviewing the Energy Balance for completeness and plausibility and by making personal enquiries as necessary in individual cases. The research project "Updating of emissions-calculation methods 2003 – Sub-project 03 – substantiation of energy figures in the Energy Balance " (FKZ 203 41 253 / 03) substantiated the sources for the Energy Balance, thereby contributing decisively to quality assurance and control.

The Federal Environment Agency has not yet received any information regarding the quality assurance system applied to official statistics and association statistics used for sectoral allocation, or other breakdowns, of energy inputs. For this reason, quality assurance, quality control and verification are carried out here as well by reviewing the Energy Balance for completeness and plausibility and by making personal enquiries as necessary in individual cases.

The results of Chapter 3.1.1.4 apply, mutatis mutandis.

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

In keeping with the availability of new energy balances and updated evaluation tables, recalculations have been carried out for the years 2003 to 2006. In addition, the figures for inputs of coal dust / fluidised-bed coal as of the year 2000 have been corrected.

The results of Chapter 3.1.1.5 apply, mutatis mutandis.

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

The planned **emission-factor** updates described in Chapter 3.1.1.6 (updates of EF apart from those for CO_2) will also cover power stations and other combustion systems in the mining sector.

3.1.4 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 heat/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); DESTATIS, 2006c).

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.

Since relevant individual data is lacking, gases cannot be listed separately by sectors. For this reason, total gas inputs in 1.A.2 are combined under 1.A.2.f Other.

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 Sources* (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 method is described in the final report for the research project (FKZ 204 41 132) and in Annex 13.6 of the NIR 2007.

3.1.4.1 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**	**2007 - contribution to total emissions**	**Trend**
All Fuels	l / t	CO_2	1.00 %	0.57 %	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	N									
Method of EF determination	T2									

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

3.1.4.1.1 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 had been 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.

3.1.4.1.2 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 Emission Sources (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 Sources (BEU).

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 pertinent share for process-related emissions is calculated with the same method that is used for emissions trading (reported and substantiated under 2.C.1).

3.1.4.1.3 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.

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

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 been carried out.

The data cannot be verified, since the data sources used for this source category are the only ones available (i.e. no alternatives are available).

3.1.4.1.5 Source-specific recalculations (1.A.2.a)

In keeping with the availability of new energy balances and updated evaluation tables, recalculations have been carried out for the years 2003 to 2006. In addition, the figures for lignite-quantity inputs as of the year 1996 have been corrected.

3.1.4.1.6 Planned improvements (source-specific) (1.A.2.a)

No improvements are planned at present.

3.1.4.2 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**	**2007 - 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	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination										

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

3.1.4.2.1 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.

3.1.4.2.2 Methodological issues (1.A.2.b)

The pertinent fuel inputs are contained in the Balance of Emission Sources (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; DESTATIS, 2006b) (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 (DESTATIS, 2006c).

Descriptions of calculation algorithms for activity rates in the Balance of Emission Sources (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 14.1.1).

3.1.4.2.3 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.

3.1.4.2.4 Source-specific quality assurance / control and verification (1.A.2.b)

Because staff responsibilities for this area remain to be clarified, it has not yet been possible to carry out general quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents.

The data cannot be verified, since the data sources used for this source category are the only ones available (i.e. no alternatives are available).

3.1.4.2.5 Source-specific recalculations (1.A.2.b)

In keeping with the availability of new energy balances and updated evaluation tables, recalculations of the fuel-input figures for the years 2005 and 2006 have been carried out.

3.1.4.2.6 Planned improvements (source-specific) (1.A.2.b)

No improvements are planned at present.

3.1.4.3 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**	**2007 - 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 4.2.4).

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-category analysis.

3.1.4.4 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**	**2007 - 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	NE	NO	NO	NO	NE	NE	NE	NE	NE
EF uncertainties in %	-50 / +90									
Distribution of uncertainties	N									
Method of EF determination	T2									

The source category “Pulp, paper and print” is not a key source.

3.1.4.4.1 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.

3.1.4.4.2 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 was 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 21: 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

3.1.4.4.3 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 findings, 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.

3.1.4.4.4 Source-specific quality assurance / control and verification (1.A.2.d)

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

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.

3.1.4.4.5 Source-specific recalculations (1.A.2.d)

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

3.1.4.4.6 Planned improvements (source-specific) (1.A.2.d)

No improvements are planned at present.

3.1.4.5 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**	**2007 - 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	NO	NO	NO	CS	CS	CS	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination										

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

3.1.4.5.1 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.

3.1.4.5.2 Methodological issues (1.A.2.e)

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

As a result of this revision, it was determined that the statistics publications Statistiken 060 (DESTATIS, 2006b) and 067 (DESTATIS, 2006c) 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).

3.1.4.5.3 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.

3.1.4.5.4 Source-specific quality assurance / control and verification (1.A.2.e)

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.

The data cannot be verified, since the data sources used for this source category are the only ones available (i.e. no alternatives are available).

3.1.4.5.5 Source-specific recalculations (1.A.2.e)

In keeping with the availability of new energy balances and updated evaluation tables, recalculations of the fuel-input figures for the years 2005 and 2006 have been carried out.

3.1.4.5.6 Planned improvements (source-specific) (1.A.2.e)

No improvements are planned at present.

3.1.4.6 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**	**2007 - contribution to total emissions**	**Trend**
All Fuels	l / t	CO_2	10,96 %	7,89 %	falling

The source category Other (1.A.2.f), the sum of all other sub- source categories, is a key source, in terms of emissions level and trend, for 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-category 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.

3.1.4.7 Manufacturing industries and construction – Cement production (1.A.2.f, Cement) (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									
Method of EF determination	T2									

Outside of the framework of binding key-source analysis, this sub- source category must be considered particularly important.

3.1.4.7.1 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.

3.1.4.7.2 Methodological issues (1.A.2.f, Cement)

Descriptions of calculation algorithms for activity rates in the Balance of Emission Sources (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 (DESTATIS, 2006c).

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 (DESTATIS, 2006c) 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 22: 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 [%]
Recycled tyres	97,319	27
Recycled 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

3.1.4.7.3 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 secondary fuels were determined using the Monte Carlo method (UBA 2005b, FKZ 204 42 203/02). In the procedure, figures for C content, water content and net calorific value were taken into account. Such figures are based on varying estimates, as well as on small numbers of measurements and analysis results, and thus show wide spreads. The CO_2 emission factors for secondary fuels, along with the relevant uncertainties, apply throughout the entire relevant time series, because no findings on trends are available. The time series are thus consistent.

Uncertainties were determined for all fuels in 2004 and for the aforementioned secondary 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 14.1.2.1.

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

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

been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely.

In the "Base year" research project ("Basisjahr"; UBA 2005c, FKZ 205 41 115), the existing 1990 data for the new German Länder was checked, using production indexes, and improved.

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.

The data cannot be verified, since the data sources used for this source category are the only ones available (i.e. no alternatives are available).

3.1.4.7.5 Source-specific recalculations (1.A.2.f Cement)

Changes in the calculation algorithm led to recalculation of the figures for liquid fuels, for the entire time series as of 1995. In keeping with the availability of new energy balances and updated evaluation tables, recalculations of all fuel-input figures for the years 2005 and 2006 have been carried out.

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

No improvements are planned at present.

3.1.4.8 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										
Method of EF determination	CS					CS				

3.1.4.8.1 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 production is not listed separately, but is included under 1.A.2.f Other.

3.1.4.8.2 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 (DESTATIS, 2006c).

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).

3.1.4.8.3 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.

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

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely.

3.1.4.8.5 Source-specific recalculations (1.A.2.f, Ceramics)

In keeping with the availability of new energy balances and updated evaluation tables, recalculations of all fuel-input figures for the years 2005 and 2006 have been carried out.

3.1.4.8.6 Planned improvements (source-specific) (1.A.2.f, Ceramics)

No improvements are planned at present.

3.1.4.9 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										
Method of EF determination	CS					CS				

3.1.4.9.1 Source-category description (1.A.2.f, Glass production)

This sub- source category includes process combustion for the areas of flat-glass production; concave-glass production; production of glass fibre; finishing and processing of flat glass; and production and finishing of other glass and technical glass products.

Some plants within this category also generate power for their own use; this generation is not listed separately, but is included under 1.A.2.f Other.

3.1.4.9.2 Methodological issues (1.A.2.f, Glass production)

Descriptions of calculation algorithms for activity rates in the Balance of Emission Sources (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 (DESTATIS, 2006c).

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).

3.1.4.9.3 Uncertainties and time-series consistency (1.A.2.f, Glass production)

Since 1995, when official statistics were converted to the economic-sector classification system (Klassifikation der Wirtschaftszweige; DESTATIS, 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.

3.1.4.9.4 Source-specific quality assurance / control and verification (1.A.2.f, Glass production)

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely.

In the research project "Base year and updating" (UBA 2005c, FKZ 205 41 115), the available data for 1990 for the new German Länder was revised and improved using production indexes.

The data cannot be verified, since the data sources used for this source category are the only ones available (i.e. no alternatives are available).

3.1.4.9.5 Source-specific recalculations (1.A.2.f, Glass production)

Recently published energy balances of the Working Group on Energy Balances (AGEB) indicate that use of coke-oven / city gas was discontinued in the glass industry as of 2003. Recalculations for the period as of 2003 were carried out in line with this finding.

3.1.4.9.6 Planned improvements (source-specific) (1.A.2.f, Glass production)

No improvements are planned at present.

3.1.4.10 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										
Method of EF determination	CS									

3.1.4.10.1 Source-category description (1.A.2.f, Lime production)

With regard to conventional fuels, the process-combustion figures refer to production of lime.

The reported figures for inputs of substitute fuels refer to all process combustion in German lime works.

3.1.4.10.2 Methodological issues (1.A.2.f, Lime production)

Descriptions of calculation algorithms for activity rates in the Balance of Emissions Sources (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 (DESTATIS, 2006c), 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 (DESTATIS, 2006b) is used.

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 23: 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 [%]
Recycled oil	78,689	0
Animal meals and fats	74,867	100
Commercial waste - other	68,129	52.33

3.1.4.10.3 Uncertainties and time-series consistency (1.A.2.f, Lime production)

Since 1995, when official statistics were converted to the economic-sector classification system (Klassifikation der Wirtschaftszweige; DESTATIS, 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 were 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 14.1.2.1.

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

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely.

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.

The data cannot be verified, since the data sources used for this source category are the only ones available (i.e. no alternatives are available).

3.1.4.10.5 Source-specific recalculations (1.A.2.f, Lime production)

Changes in the calculation algorithm led to recalculations of the figures for liquid fuels, for the entire time series as of 1995. In keeping with the availability of new energy balances and updated evaluation tables, recalculations of all fuel-input figures for the years 2005 and 2006 have been carried out.

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

Now that data revision has been completed within the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132)), no source-specific improvements are planned at present.

3.1.4.11 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										
Method of EF determination	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.

3.1.4.11.1 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 is 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 does not permit such allocation. Since no delivery data is 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.

3.1.4.11.2 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, pit 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 3.1.1.2 and in Chapter 14.1.2.1 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.

3.1.4.11.3 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 3.1.1.3.1.

Result for N_2O: The results of Chapter 3.1.1.3.2 apply, mutatis mutandis.

Result for CH_4: The results of Chapter 3.1.1.3.3 apply, mutatis mutandis.

The results obtained in Chapter 3.1.1.3.4 in determination of time-series consistency apply mutatis mutandis.

3.1.4.11.4 Source-specific quality assurance / control and verification (1.A.2.f Other)

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely.

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 3.1.1.4, in the general procedure for source-specific quality assurance / control and verification, apply mutatis mutandis.

3.1.4.11.5 Source-specific recalculations (1.A.2.f Other)

Activity rates

As a result of the review, it became necessary to reassess the N_2O-emission factors methodically, for the years 1990 to 1994. This work led to changes in these emission factors. Revision of the relevant calculation algorithms led to recalculation of the activity rates as of 1995. In addition, the activity rates were brought into line with the energy balances and evaluation tables published as of 2003.

Emission factors:

The results of Chapter 3.1.1.5 apply, mutatis mutandis.

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

Activity rates:

No improvements are planned at present.

Emission factors:

The planned emission-factor updates described in Chapter 3.1.1.6 (updates of EF apart from those for CO_2) will also cover power stations and other combustion systems in the sector "Manufacturing – other energy production".

3.1.5 Transport (1.A.3)

3.1.5.1 Transport – Civil aviation (1.A.3.a)

3.1.5.1.1 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**	**2007 - 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 %										
Distribution of uncertainties										
Method of EF determination	T1	T1	--	--	--	T1				

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

Ar 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 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) and sulphur dioxide (SO_2).

3.1.5.1.2 Methodological issues (1.A.3.a)

In its emissions reporting, Germany is 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 2006, p 3.61). Both methods calculate emissions on the basis of individual aircraft movements, without cross-checking fuel consumption against national energy balances.

For the years 1990 to 2002, emissions continue to be calculated in accordance with the Tier 1 method, as given by equation 2.7 of the IPCC GPG p. 2.57 (IPCC, 2000):

Emissions = fuel consumption * emission factor

For these years, no data are available that break down movements of aircraft operating in Germany into different flight phases.

CO_2 and SO_2 emissions figures do not depend on what Tier method is used; they depend solely on quantities and characteristics of consumed fuel. Emissions of NMVOC, CH_4, CO, NO_x and N_2O, on the other hand, depend on engines, flight elevations, flight phases, etc., and thus they are described more precisely by higher-Tier methods. With the exception of pertinent NO_x data, Eurocontrol does not provide such data. They thus must continue to be calculated in accordance with Tier 1, for the entire time series.

In previous inventories, inputs of petrol (aviation gasoline) were allocated to consumed fuel and were not reported separately. In recalculation of air-transport emissions, those inputs were calculated separately, with adjusted emission factors and net calorific values. 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 rate:

Aviation turbine fuel / kerosine

For purposes of emissions reporting, to date reliable data, calculated with ANCAT 3, are available on fuel consumption, and CO_2 and NO_x emissions, for national and international flights as of the year 2003.

The consumption data are not used directly; they are cross-checked against figures for aircraft fuel sold in Germany, as given in the national Energy Balance (until 1995) and by the Federal Office of Economics and Export Control (BAFA; as of 1996) (Working Group on Energy Balances (AGEB), 2008; BAFA, 2008). This procedure is necessary because the

aircraft movements recorded by Eurocontrol do not completely correspond to the aircraft movements that must be reported for inventory preparation. It is also required in order to establish consistency with national statistics.

For the present purposes, kerosine-consumption figures from the Energy Balance and from BAFA statistics have to be broken down by national and international flights. To date, this breakdown has been carried out using a constant value of 20 %, in keeping with a pertinent study of the TÜV Technical Inspection Association from 1989 (UBA 2001). 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 2006 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 years as of 2003, 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 high level of uncertainty and thus are not directly adopted for the inventory.

Since the pertinent data for 2007 did not become available on time, a national percentage – 8.3 % was extrapolated from the data for the three years immediately before that year.

Table 24 shows a sample of the development of national air transports' share of total fuel consumption.

Table 24: Development of the national share of fuel consumption since 1990

Year	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
National share [%]	20.0	15.0	11.2	10.6	10.0	9.5	8.6	8.3	8.4	8.3

Avgas

The 2009 report provides a first separate report on emissions from use of aviation gasoline (avgas).

For the period until 1995, the pertinent activity data come from the Energy Balances of the Federal Republic of Germany (AGEB, 2008). For the period as of 1996, data of the Federal Office of Economics and Export Control (BAFA) are used (BAFA, 2008).

Emission factors:

Aviation turbine fuel / jet kerosine

The emission factor for **carbon dioxide** was derived on the basis of the carbon content of kerosine. In the process, a pertinent emission factor of 3.150 g/kg (73.256 kg/kJ) was assumed.

Emissions of **sulphur dioxide** depend exclusively on the sulphur content of the fuel in question. On the other hand, the sulphur content is subject to regional fluctuations. For reasons of consistency, this content is determined by the Federal Environment Agency transport section that provides all fuel-relevant indexes (these were last provided in September 2004). Pursuant to measurements carried out in 1998, the sulphur concentration in fuel is about 210 ppm, i.e. 0.021 mass-percent (DÖPELHEUER, 2002) or 210 mg/kg. According to Shell AG (Germany) and the Association of the German Petroleum Industry

(deutscher Mineralölwirtschaftsverband; MWV), the sulphur content of kerosine is on the order of that of low-sulphur diesel fuel – no precise, generally valid relevant data was provided, however. Since the strong reduction of the sulphur content in refinery fuel streams will also have positive influences on kerosine, a kerosine sulphur content of 210 mg/kg can be assumed. Assuming complete combustion, this results in an emission factor of 0.4 g/kg; this is the value that will be used in future. For the reader's information, it should be added that a small part of emitted sulphur dioxide is further oxidised into SO_3 which, in turn, reacts with water to form sulphuric acid. The values listed in the IPCC guidelines, 1.0 g/kg for cruising flight and 2.4 g/kg for the LTO cycle, are not considered up-to-date.

Until 1999, emission factors for other pollutants were determined on the basis of the research project *"Determination of exhaust emissions from air traffic over the Federal Republic of Germany" ("Ermittlung der Abgasemissionen aus dem Flugverkehr über der Bundesrepublik Deutschland"*, Federal Environment Agency, 1989) via backward calculation from emissions.

For kerosine, a conversion factor of 43,000 kJ/kg is used to convert emission factors to energy equivalents, taking account of the pertinent net calorific values.

Avgas

The emission factors used to calculate emissions from avgas were determined as part of a research project of the environmental research institute Öko-Institut Berlin. To some extent, they are the same as those used for kerosine (CH_4, N_2O, NO_x, SO_2). In part, they originate from the IPCC Guidelines of 1996 (NMVOC, CO) and 2006 (CO2), however.

A conversion factor of 44,300 kJ/kg is used to convert the emission factors into energy equivalents.

The emission factors used for kerosine and avgas are shown in Table 25.

Table 25: Emission factors used

	CO_2	CH_4	N_2O	NH_3	NO_X	CO	NMVOC	SO_2	TSP*
	[kg/TJ] Kerosine								
1990	73,265	1.00	1.50	4.00	323.06	361.47	59.62	25.03	12.00
1991	73,265	1.00	1.50	4.00	333.35	365.39	59.00	24.00	12.00
1992	73,265	1.00	1.50	4.00	341.88	369.01	59.00	24.00	12.00
1993	73,265	1.00	1.50	4.00	350.00	372.50	59.00	24.00	12.00
1994	73,265	1.00	1.50	4.00	358.00	376.00	59.00	24.00	12.00
1995	73,265	1.00	1.50	4.00	366.00	379.50	59.00	9.30	12.00
1996	73,265	1.00	1.50	4.00	374.00	383.00	59.00	9.30	12.00
1997	73,265	1.00	1.50	4.00	382.00	386.50	59.00	9.30	12.00
1998	73,265	1.00	1.50	4.00	390.00	390.00	59.00	9.30	12.00
1999	73,265	1.00	1.50	4.00	390.00	390.00	59.00	9.30	12.00
2000 - 2007	73,265	0.93	3.49	4.00	325.58	213.95	37.44	9.30	12.00
	Avgas								
1990 - 2007	69,300	0.93	3.49	-	325.58	15,000.00	300.00	9.30	27.04**

* EF (TSP) = EF (PM_{10}) = EF ($PM_{2.5}$)

** The value is calculated from the lead content in AvGas 100 LL (0.56 g/L) (cf. dust emissions from leaded petrol in road transports)

Source: CRF; Öko-Institut (2007)

3.1.5.1.3 Uncertainties and time-series consistency (1.A.3.a)

Division of the Energy Balance into national and international shares is subject to uncertainties. A study carried out by the Öko-Institut (Öko-Institut, 2007) confirmed the figure of 20 % as the national share of total kerosine 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.

As of 2003, data from Eurocontrol are used that were prepared with the ANCAT 3 model. Eurocontrol, the European Organisation for the Safety of Air Navigation, cross-checked those results, for individual flights, with actual fuel-consumption figures and concluded that the pertinent error is about 10 to 12 %[19]. The main sources of the error include the small number of aircraft classes involved, a failure to consider different aircraft-engine types within each given aircraft class and differences between assumed and actual flight routes. The error inherent in assumptions pertaining to flight routes amounts to about 6 %, according to Eurocontrol. As soon as data pursuant to AEM 3 become available (cf. the methods aspects above), those data will be used. Their error is expected to be only about 3 to 5 %.

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

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 been carried out completely.

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.

The IPCC's proposed emission factors were taken into account in the considerations below. On the other hand, it must be noted that the proposed values were generated with an average fleet that does not reflect the German air-transport sector. This means that current findings have shown that the values cannot be used in the proposed manner. The results of the verification will serve as the basis for future, planned improvements.

Already for the NIR 2003, the emission factors used for determination of air-transport emissions had to be revised and adjusted in keeping with new information that had become available and with technological progress in aircraft engines. Since – as explained above – combustion differs as flight altitude varies, generation of emission factors is sometimes problematic. For higher flight altitudes, correlation with the emission factors determined for the LTO cycle (landing/take-off cycle, i.e. flight movements to 3,000 feet, i.e. to about 915 m) is necessary. For example, formation of nitrogen oxides depends strongly on external conditions and on conditions in combustion chambers. Both types of conditions change with altitude.

Profound changes have occurred in connection with emissions of **NITROGEN OXIDES**, since efforts to make aircraft engines more fuel-efficient have led to increases in average emission factors. On the other hand, in the past the effects of cruising flight were overestimated, for example, and this is reflected in the value in Table 3. Determining the emission factor for

[19] In general, Eurocontrol does not maintain data on kerosine consumption of individual flights. Some airlines have provided actual fuel-consumption data, for limited numbers of flights and on a voluntary basis, to Eurocontrol for purposes of reviewing the modelled results.

nitrous oxide 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 primary 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, the combustion-chamber intake 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) (RAND, 2003).

At present, reliable values are available only from the ICAO database (ICAO, 2002). These values refer only to the LTO cycle, however. The cycle is used to determine 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 flight phases of specified duration and with specified thrust, as listed below (cf. Table 26).

Table 26: Reference-phase duration for engines, pursuant to ICAO

	Taxiing	Rolling for take-off	Climbing	Approach and landing	Total
Thrust	7 %	100 %	85 %	30 %	-
Duration	26:00	0:42	2:12	4:00	32:54

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 Association (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 "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 about 13.5 g/kg and engines using technologies that provide "low" specific nitrogen-oxide emissions have about 11 g/kg (refers to values in the ICAO database, i.e. applies only to the LTO cycle) (RAND, 2003). Emission factors for NO_X, HC and CO, based on various different sources, are highly relevant in this context (IPCC, 1999). On the other hand, such factors are based on the base year 1992 and on forecasts for 2015.

The table below shows figures for the years 1992 and 2015 as provided by three different research institutions. All values successively provided by the DLR, NASA (National Aeronautics and Space Administration) and ANCAT (Abatement of Nuisances from Civil Air Transport) refer to entire average flights, i.e. both the LTO range and cruising flight (cf. Table 27).

Table 27: NO_X emission factors for 1992 and 2015, from NASA, ANCAT and DLR, without military air transports (all flight phases)

Source:	1992	2015
NASA	12.6	13.7
ANCAT	14.0	12.4
DLR	14.2	12.6

Source: IPCC 1999

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-chambre 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, and thus the zenith for the emission factor EF (NO_X) will have been passed by then.

On the basis of relevant figures for 1995, an average worldwide EF (NO_X) of 13.0 g/kg can be assumed (UBA, 2001a). This value is based on calculations that the DLR carried out explicitly for this study, for certain flight profiles.

The following factors should be taken into account in specifying EF (NO_X):

1. The mean estimate for 1992 is 13.6 g/kg, while that for 1995 is 13.0 g/kg.
2. The EF (NOX) has increased with respect to 1992, as a result of the increased combustion-chamber pressures and temperatures of the "average fleet".
3. The "LTO average" of the majority of the world's current aircraft fleet is thus about 14.5 g/kg (RAND, 2003).
4. The percentage of engines with very low specific nitrogen oxide emissions is still low.

Consequently, a mean EF (NO_X) of about 14.0 g/kg can currently be assumed. The values given in the IPCC Reference Manual (IPCC 1996b, p. 1.96) are considered to be too high for Germany. The primary reason for this is that the average value was determined using aircraft types (and, thus, engine types) that do not reflect the current fleet operating on intra-German routes. Furthermore, the underlying data used by the IPCC are comparatively old.

Unburned **hydrocarbons**, along with carbon monoxide, are among the most important products resulting from incomplete combustion of kerosine. 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 kerosine combustion decreases with increasing engine load. At an 80 % load level, primarily C1 and C2 fractions form, while at 7 % and 30 % thrust maximum emissions of molecules with C2 and C3 fractions occur. 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).

On the basis of NASA data, the IPCC, in "*Aviation and the Global Atmosphere", Chapter 9: Aircraft Emissions*, gives different emission factors (for all flight phases) for different years (IPCC, 1999). The values refer to all air traffic worldwide, except for military air traffic. According to this source, in 1976 the EF (HC) was 5.1 g/kg, in 1984 it was 3.3 g/kg and in 1992 it was 2.3 g/kg. An average value of 1.0 g/kg is forecast for 2015. Since engine efficiency has been improving smoothly and continuously, i.e. without major jumps, and since the level of EF (HC) is inversely proportional to such efficiency, the average of the 1992 and 2015 values may justifiably be used as the current report value. As a result, a current EF (HC) of 1.65 g/kg is assumed for all hydrocarbons (including methane).

On the other hand, this includes the C1-body fraction, in addition to the larger hydrocarbon fractions. If the species in question is not a radical one, and a pure hydrocarbon is involved, this group thus also includes methane. To determine the methane percentage, one would have to calculate back to methane on the basis of the average load level, and of other factors – a complicated procedure due to the methodological difficulties involved. In general, therefore, no reliable scientific basis is currently available for determining EF (CH_4) precisely. On the other hand, the European PARTEMIS (Measurement and prediction of emissions of aerosols and gaseous precursors from gas turbine engines) project includes chromatographic studies of emitted hydrocarbon species that support conclusions regarding the emission factor of methane. The results, which will soon be published, may well make it possible to provide a more precise value.

Similar measurements were made in the mid-1990s with one Pratt & Whitney engine (PW 305) and one Rolls Royce (RB211) engine. The measurements were published (Wiesen et al, 1994 and 1996).

Taking the available information into account, an **emission factor of 0.04 g/kg may be assumed for methane**. Methane is already included in the aforementioned figure for hydrocarbons, however. **The mean EF for NMVOC must thus be lowered accordingly and given as 1.61 g/kg**.

Carbon monoxide results from incomplete carbon oxidation in combustion of kerosine. 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.

Using a procedure similar to that used for HC, the IPCC gives an average emission factor for CO for four different years, and for all flight phases (LTO and cruising flight) (IPCC, 1999). According to the IPCC, the factor, also taking military air traffic into account, was 19.7 g/kg in 1976, 15.2 g/kg in 1984 and 11.3 g/kg in 1992. For the year 2015, NASA forecasts a value of 7.1 g/kg (IPCC, 1999). Since a continuous, largely linear decrease is also apparent in this area as well, the average of the 1992 and 2015 figures may again be taken as the current EF (CO). **An EF figure for CO of 9.2 g/kg is thus assumed**.

Since **carbon dioxide** is of predominant importance among emissions, in terms of amount, care must be taken to obtain the most precise emission factor possible (DÖPELHEUER, 2002). The basis for determining the emission factor for kerosine consists of the average composition of this fuel. Kerosine 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. As to the lengths of the hydrocarbon chains involved, the fraction with 11 to 12 carbon atoms predominates by amount. Taking into account kerosine's average hydrogen content, and its average mol-weight of 167 g/mol, kerosine can be simply described via the sum formula $C_{12}H_{23}$. In complete combustion, in strict stoichiometric terms, one kg of kerosine produces 1.24 kg of water and 3.15 kg of carbon dioxide. The **average emission factor for carbon dioxide** from kerosine may thus be assumed to be **3,150 g/kg**. This value has also been confirmed in numerous publications (including IPCC, 1999, p. 3.64).

Nitrous oxide is also a product of nitrogen oxidation in the combustion chamber, and it can occur in traces. The available data for this substance is poor. The substance has also been measured in the PARTEMIS project, the results of which have not yet been published. As described above in connection with methane, in the mid-1990s measurements were published for nitrous oxide and methane, obtained during 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). These studies yielded an **average emission factor of 0.15 g/kg for N_2O**. In general, it must be assumed that more N_2O is produced in the combustion chamber than ammonia, since N_2O is a product with a medium oxidation level. Currently, a factor of 0.1 g/kg is being used in calculations. A value of 0.32 g/kg is used in the TREMOD framework. All in all, a value of 0.15 g/kg, as given in the above publications, seems plausible.

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

Emissions from air transport have been completely recalculated to take account of a) recalculation of the relevant share for domestic flights, from total kerosine-consumption figures as given by the Energy Balances and, as of 1996, by the Federal Office of Economics and Export Control (BAFA); b) introduction of differentiation between kerosine and aviation gasoline; c) use of higher-Tier methods for NO_x; and d) the corrected emission factor for carbon dioxide.

The national share of kerosine sold has decreased continuously, from 20 % in 1990 to 8.3 % (extrapolated value) in 2007. In keeping with this trend, the proportional emissions have also decreased.

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

Within the framework of a detailed research project aimed at making original Eurocontrol data usable for these purposes, the Öko-Institut e.V. Institute for Applied Ecology and the Federal Environment Agency are working to close existing data gaps and expand use of the pertinent Tier-3 method.

As soon as Eurocontrol is able to provide data from the AEM 3 model, those data will be used in reporting, since they have a smaller level of error.

3.1.5.2 Transport – Road transport (1.A.3.b)

3.1.5.2.1 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**	**2007 - contribution to total emissions**	**Trend**
All Fuels	l / t	CO_2	11.91 %	14.13 %	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 %	-	-	-	-	-	-				
Distribution of uncertainties	-	-	-	-	-	-				
Method of EF determination	T 3	T 3	T 3	T 3	T 3	T 3				

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).

3.1.5.2.2 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 drastic reduction in the numbers of vehicles with two-stroke engines in the new German Länder. Further reductions are the result of 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 especially sharply (-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 2007, fossil-fuel emissions were 27.3 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 chapters).

Table 28: Emissions from road transports

[Gg]	CO_2 fossil	CO_2 *bio**	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
1990	150,358.33	*0.00*	60.53	1.96	1,341.45	6,527.26	1,408.97	90.20
1995	165,104.03	*106.48*	30.34	4.63	1,146.46	3,823.15	593.00	69.31
2000	171,243.27	*869.14*	15.68	4.82	997.66	2,452.04	278.41	19.68
2005	151,123.11	*5,218.30*	8.42	3.78	650.60	1.516.31	149.80	0.80
2006	147,120.45	*7,545.62*	7.62	3.56	609.11	1.383.45	137.08	0.79
2007	144,114.20	*11,737.48*	6.95	3.48	566.14	1.279.37	127.63	0.80

*) Emissions from biofuels are listed here solely for informational purposes.

CO_2 emissions from motorised road transports in Germany are calculated via a "*top-down"* approach (Tier 1 procedure) based on the amount of fuel sold in Germany. The data for such calculation are available in the *Energy Balances*. The CO_2 emissions are then determined by multiplying the figures for the relevant specific fuel-consumption categories (petrol, not including bioethanol; diesel, not including biodiesel; kerosine; LP gas) by country-specific CO_2 emission factors.

Non-CO_2 emissions are calculated with the aid of the TREMOD model ("Transport Emission Estimation Model"; IFEU, 2005)[20]. That model adopts a "*bottom-up"* (Tier 3) approach whereby mileage of the individual vehicle layers is multiplied by region-specific emission factors. For passenger cars and light duty vehicles, a "*cold start surplus*" is also added. The total consumption calculated on the basis of fuel type is compared with the consumption according to the Energy Balance. The emissions are then corrected with the aid of factors obtained from this comparison process. For petrol-powered vehicles, the evaporation emissions of VOC are calculated in keeping with the pollution-control technology used.

From the emissions and fuel consumption for the various vehicle layers, aggregated, fuel-based emission factors (kg of emissions per TJ of fuel consumption) are derived, and then the emission factors are forwarded to the CSE via a relevant interface (cf. Chapter 17.3). 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:

20 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.

Table 29: 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	After Euro1 standard

For calculation with TREMOD, extensive basic data from generally accessible statistics and special surveys were 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 2007 were calculated with the help of a fleet-shifting module in TREMOD 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 according to driving habits and the traffic situation. Within the context of field monitoring data, the passenger-car emission factors were updated for cars produced up to 1994. 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". The emissions

reduction achieved via the introduction of sulphur-free fuels was estimated by the Federal Environment Agency.

Mileage:

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

As mentioned above, CO_2 emissions in Germany are calculated on the basis of quantities of fuel sold (top-down approach).

Because fuel prices in Germany are higher – significantly, in some cases – than in almost all of Germany's neighbours (Denmark is the only exception), for some time the fuels used in Germany have included fuels purchased in other countries and brought into the country as "grey" imports (BUND, 2006).

At present, no precise data are available on this phenomenon, which is significant for 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 yet 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).

3.1.5.2.3 Uncertainties and time-series consistency (1.A.3.b)

No studies of the relevant data uncertainties have yet been carried out.

3.1.5.2.4 Source-specific quality assurance / control and verification (1.A.3.b)

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 been carried out completely.

3.1.5.2.5 Source-specific recalculations (1.A.3.b)

The submitted emissions data were calculated with TREMOD version 5.01 (IFEU, 2005). Changes with respect to the 2008 report year include an adjustment of activity rates (fuel consumption figures), for the years 2000 through 2006, 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 158).

In addition, percentage data were available for the first time on bioethanol consumption as part of petrol consumption. Because pertinent data are now more readily available, and because bioethanol consumption is becoming increasingly significant, emissions from that fuel have been calculated separately for the first time. Those emissions, like those from

biodiesel and vegetable oil, are not assigned to source category 1.A.3.b; instead, they are calculated separately, as emissions from biomass. Relevant shifts with respect to the 2008 report year resulted only for CO_2 emissions (2005: minus 0.5 million t; 2006: minus 1.0 million t).

3.1.5.2.6 Planned improvements (source-specific) (1.A.3.b)

Uncertainties for the activity data entered into TREMOD, and for the emission factors generated in TREMOD itself and in the Central System of Emissions (CSE), are to be calculated as part of a study.

3.1.5.3 Transport – Railways (1.A.3.c)

3.1.5.3.1 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**	**2007 - contribution to total emissions**	**Trend**
All Fuels	- / t	CO_2	0.23 %	0.13 %	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 %	--	--	--	--	--	--				
Distribution of uncertainties	--	--	--	--	--	--				
Method of EF determination	T1	T1	--	--	--	T1				

The “Railways” source category is a key source of CO_2 emissions in terms of trend.

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[21]. Railways' power stations for generation of traction current are allocated to the stationary component of the energy sector (1.A.1.a) and are not included in the further description that follows here.

In energy input for trains of German Railways (Deutsche Bahn AG), diesel fuel is the only energy source that plays a significant role apart from electric power.

Small quantities of solid fuels are used for historic rail vehicles – in the main, steam locomotives that are operated for demonstration and exhibition purposes. Analysable data on consumption and the relevant emissions are available for lignite, through 2002, and for hard coal, through 2000. Outside of the scope of such data, it is not possible to calculate emissions from consumption of solid fuels.

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.

3.1.5.3.2 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

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

fuel consumption and the relevant country-specific emission factors. This procedure conforms to the general Tier 1 method and the basic calculation rule pursuant to equation 2.6 of the IPCC Good Practice Guidance (2000, p. 2.46).

Activity rate:

For years through 2004, the relevant energy-consumption data were taken from the Energy Balance of the Federal Republic of Germany (AGEB, 2008). In particular, the fuel data have been taken from the following Energy Balance lines, for the following periods:

Table 30: 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

As of 2005, sales data of the Association of the German Petroleum Industry (MWV) are used as a basis. In the MWV's 2007 annual published report, such data appear on page 53, in the Table "Sectoral consumption of diesel fuel, 2001-2007" ("Sektoraler Verbrauch von Dieselkraftstoff 2001-2007"; MWV, 2008).

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, the reader's attention is called 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 diesel-fuel emission factors 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, 2005.) 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: 2.6 kg/TJ 2006: 1.6 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, a value is obtained by analogy to heavy duty vehicles without emissions-control equipment. The country-specific EF for diesel fuel, 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 31: Comparison of current EF for railway transports with the corresponding default emission factors

Gas	EF used [kg/ TJ]		Default EF [kg/ TJ]	
CH_4	Diesel fuel	1.6 - 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		
N_2O	Diesel fuel	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 (2005)

3.1.5.3.3 Uncertainties and time-series consistency (1.A.3.c)

No studies have yet been carried out of the data uncertainties for this source category. 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.

3.1.5.3.4 Source-specific quality assurance / control and verification (1.A.3.c)

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 been carried out completely.

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

Recalculations were carried out in keeping with the use of updated figures of the Association of the German Petroleum Industry (MWV) for 2005 and 2006.

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

No improvements are planned at present.

3.1.5.4 Transport – Navigation (1.A.3.d)

3.1.5.4.1 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**	**2007 - contribution to total emissions**	**Trend**
Diesel oil	- / t	CO_2	0.16 %	0.05 %	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 %	--	--	--	--	--	--				
Distribution of uncertainties	--	--	--	--	--	--				
Method of EF determination	T1	T1	--	--	--	T1				

The source category "Navigation" is a key source of CO_2 emissions from diesel oil in terms of trend.

Navigation is broken down primarily into the categories "coastal and inland navigation" and "marine transport". All domestic navigation is diesel-powered, while heavy fuel oil is also used in the international shipping sector. Emissions from international navigation are listed in the emissions inventories, as a memo item, but they are not included in total emissions.

Under source category 1.A.3d Navigation, the CSE includes coastal and inland fishing and coastal and inland shipping.

3.1.5.4.2 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).

Activity data:

For years through 1995, the relevant energy-consumption data were taken from the Energy Balance of the Federal Republic of Germany (AGEB, 2008). In particular, the fuel data have been taken from the following Energy Balance lines, for the following periods:

Table 32: Sources for AR in 1.A.3.d

Fuel type	**Energy Balance line**	**Area**	**Relevant years**
Diesel fuel	6	international	all
	77	domestic	until 1994
	64	domestic	as of 1995
Heavy fuel oil	6	international	all

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.

The majority of fuel quantities sold in this category are sold for sea navigation. Such sales have been increasing since 1998. Fuel consumption in coastal and inland-waterway navigation varies in keeping with waterway navigability. Since the mid-1990s, the overall trend for such consumption has been a decreasing one, as many ships have been refuelling abroad in order to take advantage of lower fuel prices. The abrupt decrease that occurred in 1994/1995 was due solely to a conversion in the Energy Balance, however.

As of 1996, official mineral-oil data of the Federal Office of Economics and Export Control (BAFA) are used (BAFA, 2008). In the relevant source, the figures used appear in Table 7j: "domestic deliveries, by selected use sectors" ("Inlandsablieferungen nach ausgewählten Verwendungssektoren", column 4 (i.e. deliveries to inland shipping).

Emission factors:

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

- With regard to the CO_2 emission factor for diesel fuel, 74,000 kg/TJ, and to that for heavy fuel oil, 78,000 kg/TJ, the reader's attention is called to the documentation in Annex 2 – the chapter on "CO_2 emission factors".
- The CH_4 emission factor for heavy heating oil, 3.0 kg/TJ, is based on the Federal Environment Agency (UBA) study "Air Quality Control '88" ("Luftreinhaltung '88"; (UBA, 1989b)). This value is lower than the IPCC default value for heavy fuel oil in maritime navigation, 7 kg/TJ, as shown in the Reference Manual (IPCC et al, 1997, p. 1.90, Table 1-48). For diesel fuel, the emission factor for heavy duty vehicles without emissions-reduction equipment was used. A 15% reduction of specific CH_4 emissions in the 1990-2005 period, resulting from engine improvements, was assumed, in keeping with experts' expectations. The country-specific EF, at 2.4-2.8 kg/TJ, are also lower than the IPCC default value for diesel fuel, 5 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, 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). The EF for heavy heating oil, 3.5 kg/TJ, is nearly twice as high as the corresponding recommended value in the Reference Manual (IPCC et al, 1997: p. 1.90, Table 1-48).

3.1.5.4.3 Uncertainties and time-series consistency (1.A.3.d)

No studies have yet been carried out of the data uncertainties for these source categories. 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.

3.1.5.4.4 Source-specific quality assurance / control and verification (1.A.3.d)

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 been carried out completely.

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

Recalculations were carried out to take account of harmonisation with the official mineral-oil data of the Federal Office of Economics and Export Control (BAFA) for the years 1996 through 2006.

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

No improvements are planned at present.

3.1.5.5 Transport – Other transport (1.A.3.e)

3.1.5.5.1 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**	**2007 - contribution to total emissions**	**Trend**
All fuels	l / -	CO_2	0.34 %	0.36 %	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 %	--	--	--	--	--	--				
Distribution of uncertainties	--	--	--	--	--	--				
Method of EF determination	T1	T1	--	--	--	T1				

The source category "Other transport" is a key source of CO_2 emissions in terms of level.

Emissions from construction-related transports and from gas turbines in natural-gas compressor stations are reported under this source category. Construction-related transports are a category within the Energy Balance. Gas turbines in natural-gas compressor stations, on the other hand, are a clearly defined plant type.

In the CSE, construction-related transports and gas turbines in natural-gas compressor stations are allocated to source category 1.A.3.e "Other transport".

3.1.5.5.2 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. Chap. 13.2), 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. For years until 2005, the activity data used are 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 natural-gas inputs in coking plants and city-gas plants, are provided in Energy Balance line "Transformation inputs of coking plants" (EB line 40 for the years 1990-1994, and EB line 33 for the years as of 1995). Thanks to a personal communication from the Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen), the figures for natural-gas inputs in natural-gas compressor stations are now consistent with the relevant Energy Balance figures. As of 1998, those gas-input figures are given by the total gas-input figures in Energy Balance line 33. Since the emissions in question are insignificant sub-emissions of the source category, the above-described Tier 1 method has been applied.

As of 2005, natural-gas use in natural-gas compressor stations is no longer shown as such in the Energy Balances; it has to be calculated as a share of primary-energy consumption of natural gas.

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, the reader's attention is called to the documentation in Annex 2, Chapter CO_2 emission factors.
- The country-specific CH_4 emission factors are based, for the 1990-1994 period, on the Federal Environment Agency study "Air Quality Control '88" ("Luftreinhaltung '88"; UBA 1989b). As of the 2008 report year, for the period as of 1995 updated emission factors from a Federal Environmental 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. The country-specific N_2O emission factor of 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, the reader's attention is called 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 3.1.1.2.

3.1.5.5.3 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 3.1.1.2. Results for N_2O are presented in Chapter 3.1.1.3.2, while those for CH_4 are presented in Chapter 3.1.1.3.3.

3.1.5.5.4 Source-specific quality assurance / control and verification (1.A.3.e)

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 been carried out completely.

Since the inventories, in general, are based on the Energy Balances for Germany prepared by the Working Group on Energy Balances (AGEB, 2006) – whose quality-assurance system is currently not known to us – quality assurance, quality control and verification are carried out by reviewing the Energy Balance for completeness and plausibility and by making personal enquiries as necessary in individual cases. The research project "Updating of emissions-calculation methods 2003 – Sub-project 03 – substantiation of energy figures in the Energy Balance " (FKZ 203 41 253 / 03) described the sources for the Energy Balance, thereby contributing decisively to quality assurance and control.

At present, it is not possible to carry out more detailed source-specific quality assurance / control and verification.

Natural-gas-compressor stations: The results of Chapter 3.1.1.4 apply mutatis mutandis.

3.1.5.5.5 Source-specific recalculations (1.A.3.e)

Construction-sector transport:

The availability of updated activity data for military transports for all years as of 1996 made it necessary to make adjustments in this area as well (cf. activity rate – construction-sector transport).

Natural-gas-compressor stations:

The results of Chapter 3.1.1.5 apply mutatis mutandis.

Recalculations were carried out to take account of updated activity data for the years 2003 through 2006.

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

The database for calculating emissions from construction-sector transports is to be comprehensively updated within the framework of a research project.

Natural-gas-compressor stations: The planned updating of emission factors (except for CO_2 emission factors) described in Chapter 3.1.1.6 will also cover the area of gas turbines in natural-gas-compressor stations.

3.1.6 Other: Residential, commercial/institutional, agriculture, forestry and fishing (1.A.4)

3.1.6.1 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**	**2007 - contribution to total emissions**	**Trend**
CRF 1.A.4.a (Commercial/institutional - commerce/trade/services)					
All ´fuels	l / t	CO_2	5.07 %	3.51 %	falling
CRF 1.A.4.b (Residential)					
All Fuels	l / t	CO_2	10.26 %	8.43 %	falling
CRF 1.A.4.c (Agriculture, forestry and fishing)					
All Fuels	l / t	CO_2	0.87 %	0.56 %	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 - commerce/trade/services)										
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				
Method of EF determination		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, in terms of both emissions level and trend, in all of its sub - source categories.

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).

While emissions from agricultural transports and from mobile residential sources are reported within source category 1.A.4, the relevant emissions data are obtained together with data for the transport sector. This section does not include a description of the method by which these emissions are calculated.

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 were 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. 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 households sector, while only gas from wastewater treatment / biogas are used in the sector "Commercial, institutional (commerce/trade/services) and other consumers".

3.1.6.2 Methodological issues (1.A.4)

The **activity rates** in source category 1.A.4 are based on the Energy Balance for the Federal Republic of Germany that the Working Group on Energy Balances (AGEB) prepares. For the

period prior to 1995, separate Energy Balances are used for the new and old German Länder. Lines 66 (residential) and 67 (commerce, trade, services and other consumers) are of primary importance.

Since the figures in Energy Balance line 67 (commerce, trade, services and other consumers) also include consumption by military agences, such consumption must be deducted from the relevant positions in line 67 (stationary sources within the military sector are described in source category 1.A.5.a, Chapter 3.1.7). 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.

The database for the **emission factors** used for N_2O und CH_4 is 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, Lausitz and central German regions, 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 considerably 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. This data was used to estimate the energy inputs for various system types, to make it possible to determe sectoral emission factors weighted by energy inputs. Table 33 shows the sectoral emission factors determined.

Table 33: Sectoral emission factors for combustion systems in the residential and commercial/institutional sectors for reference year 2005

Residential	CH_4 [kg/TJ]	N_2O [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.

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

Calculating reliable emission factors in this facility 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), facility 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 facility types, moreover, only inadequate data or no data at all was 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 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 facility 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 3.2.2.3 (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**.

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

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 been carried out completely.

For the purposes of quality assurance, 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 was examined with a view to validity. As a general principle, in description of the emissions behaviour of combustion systems, emissions data was 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 commerce/trade/services sectors for the year 2005. The results are presented in Table 34.

Table 34: Emissionsberechnung mit landesspezifischen Tier 2/3 Emissionsfaktoren und mit den Tier 1 Default-Emissionsfaktoren nach (IPCC 2006)

	CH4 [t]				N_2O [t]			
	Residential		Commerce/trade/ services		Residential		Commerce/trade/ services	
Emission factors	Tier 1 default	Strusch-ka 2008	Tier 1 default	Strusch-ka 2008	Tier 1 default	Struschka 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 commerce/trade/services ("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.

3.1.6.5 Source-specific recalculations (1.A.4)

Recalculations were carried out for CH_4 and N_2O **emission factors** as of the year 1996, to take account of the results of the aforementioned research project (Struschka, 2008).

The emission factors for the years 2005 ais 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 **activity data** were recalculated as of the 2003, to take account of publication of updated energy balances of the Working Group on Energy Balances (AGEB).

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

No improvements are planned at present.

3.1.7 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"*.

3.1.7.1 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**	**2007 - contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	0.93 %	0.13 %	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 %		-30/+50				-30/+50				
EF uncertainties, solid fuels, in %		-70/+100				-70/+100				
Distribution of uncertainties		L								
Method of EF determination		CS								

The source category 1.A.5 "Other" is a key source, in terms of emissions level and trend, of CO_2 emissions.

3.1.7.2 Methodological issues (1.A.5)

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 "commerce, trade, services 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, 2008), which has reported the "Energy input for heat production in the German Federal Armed Forces", by fuels and for 2000-2007, to the Federal Environment Agency. These figures are deducted from the figures in Energy Balance line 67 (commerce, trade, services) and are reported in 1.A.5, rather than in 1.A.4.

For source category 1.A.5.b, military-fuel (diesel fuel and petrol) and aircraft-fuel (kerosine) consumption data, until 1995, were drawn from a special analysis of the Working Group on Energy Balances (AGEB). For the years as of 1996, official mineral-oil data of the Federal Republic of Germany for 2007 (Amtliche Mineralöldaten der Bundesrepublik Deutschland 2007), prepared by the Federal Office of Economics and Export Control (BAFA), were used (BAFA, 2008). The consumption figures, which are given in units of 1000 t, are converted into TJ on the basis of the relevant heating statistics listed for 2005.

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 35 shows the sectoral emission factors used.

Table 35: Sectoral emission factors for combustion systems of military agencies

Military	CH_4 [kg/TJ]	N_2O [kg/TJ]
Hard coal	2.0	4.8
Lignite briquettes	242	0.37
Heating oil EL	0.017	0.56
Natural gas	0.042	0.29

3.1.7.3 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.

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

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 been carried out completely.

3.1.7.5 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 2004. 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.

For military transports (1.A.5.b "Mobile"), recalculations were carried out as of the year 1996, to take account of updating of relevant activity data on the basis of figures of the Federal Office of Economics and Export Control (BAFA). In addition, the emission factor for SO_2 from kerosine was brought into line with the value used in civil air transport, and the entire emissions time series was recalculated.

3.1.8 Comparison with the CO_2 reference procedure

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. This entailed a problem in that publication of the detailed Energy Balance editions required for the work is subject to time lags of several years. Currently, balances up to the year 2006 are available. To permit use of the Approach nonetheless, as required, for all years covered by the report, the Wuppertal Institute developed a procedure, in the framework of a research project, that is

based on the evaluation tables, publication of which is subject to smaller time lags. The project results were presented in Annex 2, Chapter 13.8 of the NIR 2007.

The results of the Reference Approach are compiled in Table 36. In Figure 21 and Figure 22, 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 0.6 %. The discrepancies vary throughout a range of 0 to + 0.9 %.

Whereas in past years comparative calculations carried out by PROGNOS AG (PROGNOS, 2000), on the basis of a research project, were used for the Reference Approach, as of last year the Reference Approach was reset to the original IPCC approach, with extensive use of IPCC default emission factors. The reasons for this change included the need to ensure international comparability; increasing difficulties in obtaining required highly detailed data on basic energy inputs (imports by regions and countries of origin); and results of discussions during the 2007 Initial Review. The methodological changes resulting through the PROGNOS research project were described in the NIR 2007, Annex 2, Chapter 13.9.

3.1.9 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 marine navigation.

3.1.9.1 Emissions from international air transports (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 %										
Distribution of uncertainties										
Method of EF determination	T1	T1				T1				

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.

3.1.9.1.1 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.

To date, a fixed percentage of 20 % has been used for the domestic / national share, a figure that has been repeatedly confirmed for the base year. The high growth rates seen in air transports have occurred primarily in the international sector, however, and thus a revision of the breakdown was called for.

Consequently, in calculation of emissions from national air transports, a function was introduced that represents domestic air transports' share of total kerosine consumption in Germany. The relevant data are based on a) the 20 % share for the base year and b), data of Eurocontrol, the European Organisation for the Safety of Air Navigation, that were calculated, as of 2003, via a Tier 3 method. These data are linked via an exponential function that was

obtained with the help of additional data, subject to larger uncertainties, of Eurocontrol. The function produces annual shares, for international air transports, of the kerosine consumption figures in the Energy Balance (AGEB, until 1995) and in the official mineral-oil data of the Federal Republic of Germany (Amtliche Mineralöldaten der Bundesrepublik Deutschland), prepared by the Federal Office of Economics and Export Control (BAFA, as of 1996); these shares are used here (AGEB, 2008; BAFA, 2008).

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

For 2007, because more-precise data were not available from Eurocontrol, the domestic-flight share was extrapolated from the data for the three previous years (cf. Chapter 3.1.5.1): this produced an international share of 91.7 %.

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

3.1.9.1.2 Uncertainties and time-series consistency (1.BU.1)

Cf. National air transport, Chapter 3.1.5.1.3.

3.1.9.1.3 Source-specific quality assurance / control (1.BU.1)

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

3.1.9.1.4 Source-specific recalculations (1.BU.1)

The entire time series has been recalculated to take account of the now-used year-specific split factor.

3.1.9.1.5 Planned improvements (1.BU.1)

Cf. National air transport, Chapter 3.1.5.1.6.

3.1.9.2 Emissions from international sea transports / transport navigation (1.BU.2)

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)	CS	D	--	--	--	D	D	D	D	D
EF uncertainties in %	--	10	--	--	--	10				
Distribution of uncertainties	--	--	--	--	--	--				
Method of EF determination	T1	T1	--	--	--	T1				

The source category international sea transports / transport navigation is not a key source.

International sea transports include international blue-water fisheries and marine transport, 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.

3.1.9.2.1 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_2O.

The activity rates for bunkering by ocean-going ships, until 1995, 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. As of 1996 figures of the Federal Office of Economics and Export Control (BAFA) are used.

For calculation of N_2O, 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, the reader's attention is called to the documentation in Annex 2, Chapter 13.7.

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

The responsible Federal Environment Agency expert has estimated the uncertainties 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 marine transports involving German ports.

The data entered into the project programme included all shipping routes, ship-specific consumption figures and a range of 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.

3.1.9.2.3 Source-specific quality assurance / control and verification (1.BU.2)

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

Source-specific verification of the CO, CO_2 and NOx emission factors was carried out by comparing the country-specific emission factors, as used to date, to the default emission factors. Verification was carried out in keeping with the MARION method.

3.1.9.2.4 Source-specific recalculations (1.BU.2)

Recalculations were carried out to take account of use of updated data of the Federal Office of Economics and Export Control (BAFA) for the years 1996 through 2006.

3.1.10 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.

3.1.11 Military

Emissions from international deployments by the Federal Armed Forces, under a UN mandate, are currently not calculated as a separate activity for purposes of German emission inventories. However, this task is to be carried out soon within the framework of the National System.

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 petroleum data 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.

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

Below, the results of the detailed source-category-based calculation of CO_2 emissions for Germany, carried out in accordance with the specifications of the *IPCC Good Practice Guidance* (2000), are compared with other national and international data on energy-related CO_2 emissions (data available to Germany), for verification purposes.

This is achieved by comparing the calculation results with data:

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

Table 36 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 21. This approach reveals the key development trends in all calculation approaches, including the Reference Approach, albeit at differing levels. In Figure 22, 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 change in methods for calculating CO_2 emissions in the iron and steel sector has made it more difficult to directly compare results for the detailed procedure and those for the reference procedure. This also applies to comparisons with the results of the Länder. In addition, recalculation of emissions from air transport has impacts on the entire time series. This confirms the presumption that national air-transport emissions had previously been overestimated. Via introduction of an annual, updated split factor for fuel consumption in national and international air transports, national emissions decreased by comparison to their levels under the previous, constantly used 20:80 breakdown.

Table 36: 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)	948.0					840.0	866.9	831.4	824.4	801.3	800.4	822.7	808.1	822.3	816.3	798.9	799.4	NE
Discrepancy between Ziesing and UBA (1.A)	**0.0**					**0.1**	**0.1**	**0.2**	**0.1**	**0.2**	**0.3**	**0.3**	**0.3**	**1.8**	**2.4**	**3.5**	**2.0**	**NE**
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	NE
Discrepancy between IEA SA and UBA (1.A)	**0.2**	**2.9**	**2.6**	**2.6**	**3.5**	**3.6**	**4.9**	**6.0**	**5.3**	**4.7**	**3.6**	**3.2**	**3.8**	**4.2**	**5.8**	**5.1**	**5.0**	**NE**
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	NE
Discrepancy between IEA RA and UBA (1.A)	**2.5**	**2.5**	**3.2**	**2.5**	**3.3**	**4.6**	**3.5**	**4.9**	**5.6**	**4.3**	**5.7**	**5.8**	**5.0**	**5.1**	**5.8**	**6.3**	**4.8**	**NE**
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**	**4.1**	**3.9**	**3.8**	**4.2**	**3.1**	**NE**
Results of the Länder (energy)	981.7	963.2	917.1	912.5	890.5	893.7	914.6	890.5	887.7	862.7	863.1	887.6	864.5	859.9	846.1	836.8	NE	NE
Discrepancy between the Länder figures (energy) and UBA's figures	**3.5**	**5.3**	**5.4**	**5.8**	**5.7**	**6.5**	**5.7**	**7.3**	**7.8**	**7.9**	**8.1**	**8.2**	**7.3**	**6.4**	**6.1**	**8.4**	**NE**	**NE**
Reference Approach, UBA (RA)	950.9	918.9	877.1	873.1	852.4	842.6	870.3	839.4	832.3	808.4	807.2	827.8	813.3	817.5	812.5	787.0	796.4	770.1
Discrepancy between UBA RA figures and UBA's figures	**0.0**	**0.2**	**0.5**	**0.9**	**0.8**	**0.2**	**0.3**	**0.9**	**0.8**	**0.8**	**0.7**	**0.5**	**0.6**	**0.6**	**0.6**	**0.9**	**0.5**	**0.9**
Sectoral approach, UBA (1.A)	948.1	915.0	870.0	862.1	842.6	839.1	865.6	829.9	823.6	799.7	798.4	820.4	806.0	808.0	797.1	771.7	784.0	755.3
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*

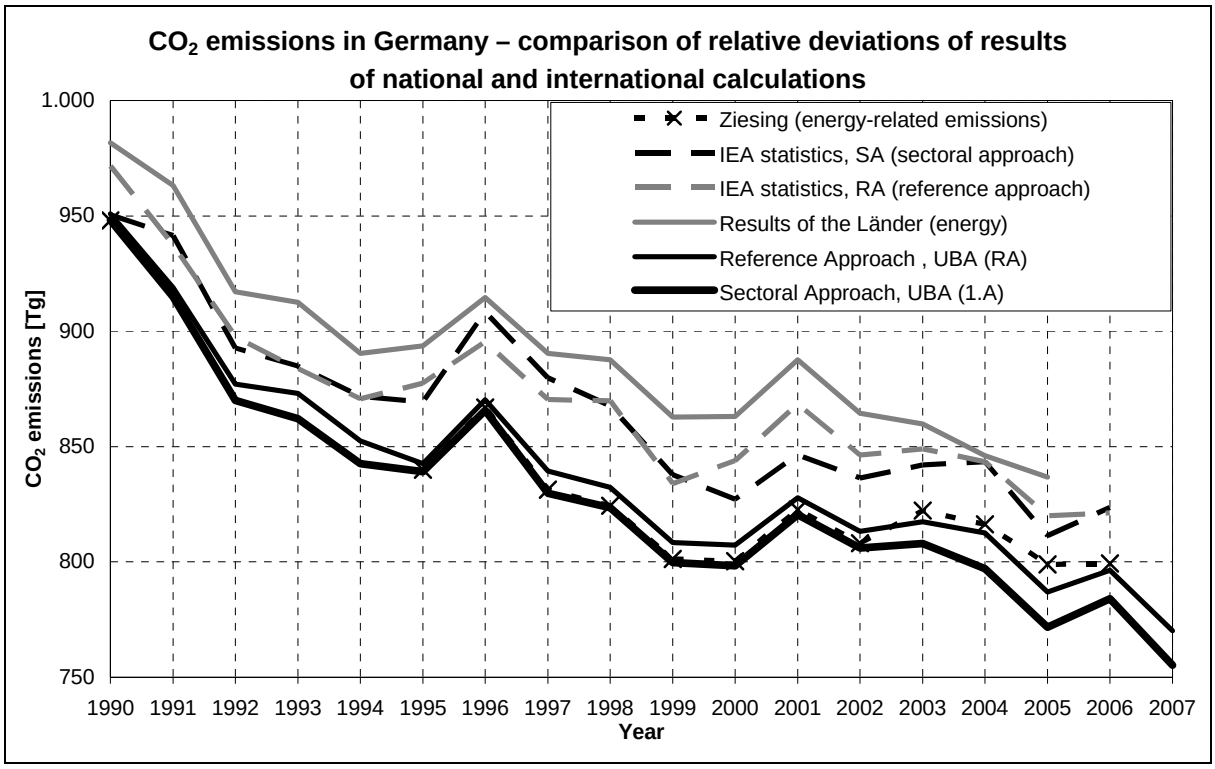


Figure 21: CO_2 emissions in Germany – comparison of results of national and international calculations

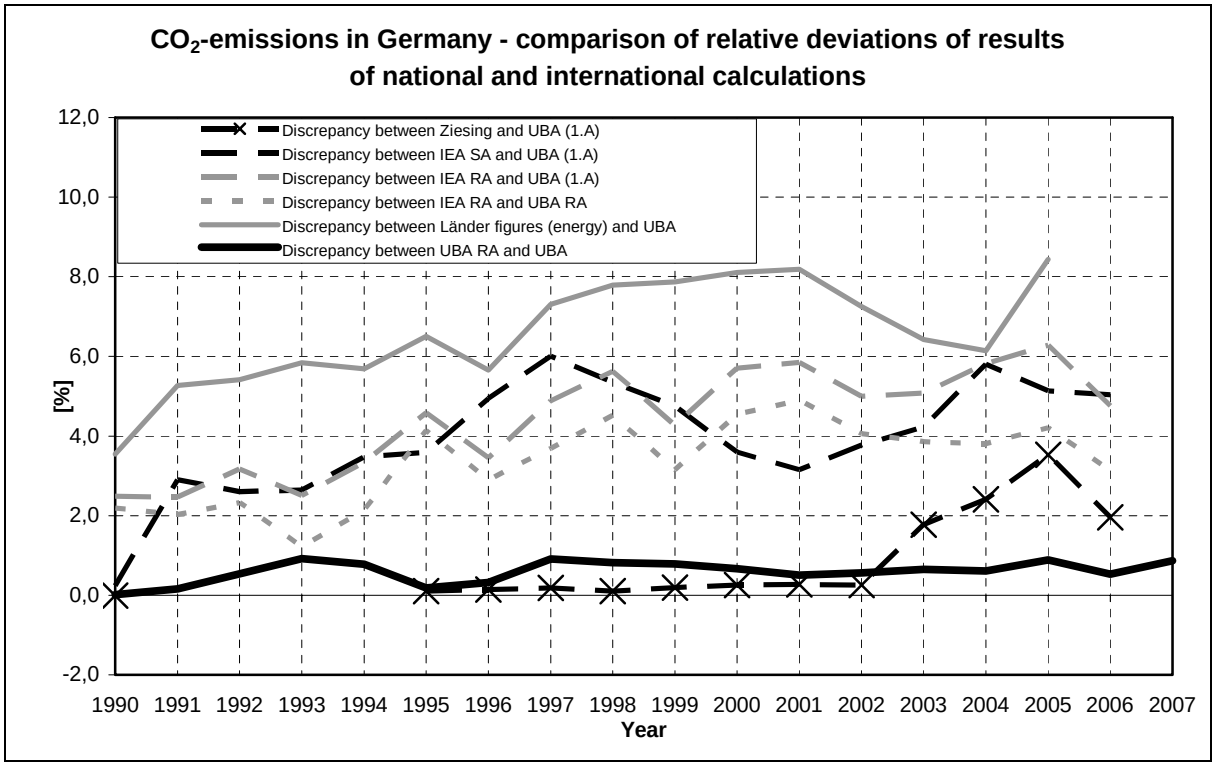


Figure 22: CO_2 emissions in Germany – comparison of relative deviations of national and international calculations

3.1.12.1 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 (2008). 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 differences worthy of note (2 to 3 %) are seen only for the years since 2003. For these years, the energy-data updates that resulted from publication of Energy Balances for the years 2004, 2005 and 2006, in the course of 2008, had the most pronounced impacts. And these impacts led to recalculations in the detailed calculations of CO_2 emissions. Those recalculations had not yet become available at the time of the article's publication.

3.1.12.2 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 2008) is 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 on the detailed data used.

However, results of the comparison confirm the data obtained via the national, detailed method (mean deviation over 17 years: 3.9 %; fluctuation between 0.2 and 6.0 %).

The results of the reference approach used by the IEA differ from those of the reference approach carried out in Germany by 3.3 %, over a 17-year average. The changes in methods have an effect in this context, since the national reference procedure takes account of allocation of 40 million t of CO_2 emissions in the iron and steel sector as process-related emissions. The IEA reference procedure does not use a comparable method.

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

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

The competent authorities and institutions of Germany's Länder co-operate in the framework of the Länder Working Group on Energy Balances (Länderarbeitskreis Energiebilanzen). This group includes representatives of the Ministries of the *Länder* responsible for the energy industry – these are generally the industry or environment ministries – as well as the energy officers of the statistical offices of the *Länder* in cases in which such officers are appointed to prepare the Energy Balance for the respective *Land*. The Working Group also includes representatives of economic institutions which prepare the Energy Balance, under commission, in selected Länder.

The principal task of this Länder Working Group is to co-ordinate the preparation of energy balances for the various Länder. Since the balance year 1995, these balances have been prepared according to a uniform agreed and binding method[22].

In 1998, the Länder Working Group on Energy Balances also adopted the preparation of CO_2 balances for the *Länder* as one of its duties. Since then, it has published CO_2 balances for all Länder. These balances are also prepared on the basis of the energy balances for the Länder, in accordance with standardised rules. Two different approaches are adopted:

Source balance – this refers to an account of emissions based on the primary energy consumption of a *Land*, subdivided according to emission sources, transformation sector and final energy consumption. The source balance allows statements to be made regarding the total volume of carbon dioxide emitted in a *Land* as a result of the consumption of fossil fuels.

Polluter principle – this refers to an account of emissions based on the final energy consumption in a given *Land*. This approach also includes each *Land's* electricity and district-heat consumption and its "foreign trade balance" (from the viewpoint of the relevant *Land*) in the CO_2 balance. The reason for this parallel calculation method is that up to 70 % of energy consumption in individual *Länder* is based on importation of electricity and district heat from other Federal *Länder*. Only with this holistic approach is it possible to balance and evaluate the effects of prepared or implemented climate protection measures in the Federal *Länder*.

Since 2002, the Länder have also recalculated energy-related CO_2 emissions for the years since 1990. The following section presents a comparison of Länder source-balance results published to date with inventories calculated at the Federal level for energy-related CO_2 emissions. One difficulty hampering the comparison, which is based on data for the years 1990 to 2005, is that pertinent information is not always available in the form of consistent time series and, as a result, not all figures required for the individual Länder are available 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 data and results used. For reasons tied to the manner in which the data was obtained, as explained above, the data and results should be seen only as an orientation, for the years 1990 through 2005.

22 Information about the methods developed and used in the working group can be found on the Internet at http://www.lak-energiebilanzen.de. The data available from that site in March 2003 was used for the purposes of this comparison.

Table 37: 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**
	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
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	82,769	81,901
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*
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
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
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
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	*54,961*
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
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	72,062
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
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	*25,643*
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	*23,031*	*23,157*
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	50,024	48,476	47,019
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
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
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
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**	**859,902**	846,058	836,839
Result for the nation as a whole	**948,089**	**914,963**	**869,981**	**862,100**	**842,550**	**839,117**	**865,631**	**829,868**	**823,551**	**799,749**	**798,378**	**820,433**	**806,012**	**808,012**	797,125	771,688
Deviation (Gg)	33,610	48,287	47,103	50,431	47,943	54,600	48,997	60,654	64,162	62,962	64,728	67,210	58,453	51,890	48,933	65,152
Deviation (%)	3.5	5.3	5.4	5.8	5.7	6.5	5.7	7.3	7.8	7.9	8.1	8.2	7.3	6.4	6.1	8.4

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 15 years in question, the total CO_2 emissions for the Länder were about 6.5 % higher than the Federal result. The extremes of the deviations ranged from 3.5 % in 1990 to 8.4 % in 2005. 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 %. This change in methods has not yet been applied in the Länder.

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

3.1.12.3.1 Planned improvements

Following the reporting process, the results of the comparison are discussed, regularly and intensively, with the representatives of the Länder Working Group on Energy Balances (Länderarbeitskreis Energiebilanzen). This year, such discussions will focus especially on the methodological changes applying to the iron and steel sector. On this basis, the method for comparison between the Länder result and the national result will be improved this year.

For comparisons within the "old" structures, the reader is referred to the 2005 inventory report.

3.2 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.

3.2.1 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 38 presents the scheme for source category allocation and the relevant calculation methods (Table 39).

Table 38: 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 39 presents calculated values for 2007 activity data, along with information regarding the origin of the data.

Table 39: Calculation of methane emissions from coal mining for 2007

			Activity data [Mt]	CH_4 emissions [Gg]
1.B.1.a. Coal mining			**201.71** (= 1.B.1.a.i + 1.B.1.a.ii)	(= 1.B.1.a.i + 1.B.1.a.ii) = 187.63+1.98 **= 189.61**
	i.	**Underground mining**	**21.307**[23] Hard-coal production 1)	= **mining and follow-up mining-related activities** = 175.36 + 12.27 **= 187,63**
		Mining activities		= AR * EF = 21.307 * 8.23 **= 175,36**
		Follow-up mining activities		**= 12,27**
	ii.	**Open-pit mining**	**180.4** Lignite mining 1)	= **mining activities** **= 1.98**
		Mining activities		= AR * EF = 180.4 * 0.011 **= 1.98**
		Follow-up mining activities		(included in 1.B.1.a.ii) IE
1.B.1.b. Coal transformation – processing			**13.82** Total for processed products 2) 1)	$AR_{H\text{-coal production}}$ *$EF_{H\text{-coal production}}$ + $AR_{lignite\ production}$ *$EF_{lignite\ production}$ = 8.44 * 0.049 + 5.38 * 0 **= 0.41**
1.B.1.c. Other				= **Decommissioned coal mines** **= 5.2**
		Decommissioned coal mines	**NO**	Potential emissions, minus gas usage **= 5.2**

1) pursuant to STATISTIK DER KOHLENWIRTSCHAFT (2007)

2) Hard-coal coke, hard-coal briquettes, lignite coke, coal dust, dry coal, fluidised-bed coal, lignite briquettes, lignite granulate

3.2.1.1 Coal mining and handling (1.B.1.a)

3.2.1.1.1 General description of the source category Coal mining and handling (1.B.1.a)

CRF 1.B.1.a					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - contribution to total emissions**	**Trend**
Solid fuels	l / t	CH_4	1.46 %	0.39 %	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	NO	NO	NO
EF uncertainties in %		-								
Distribution of uncertainties		-								
Method of EF determination		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

[23] Not including small mines

from hard-coal processing are listed in source category 1.B.1.b, while emissions from decomissioned hard-coal mines (coal-mine methane, CMM) are listed in source category 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 8 mines (all closed-pit), while lignite is mined in 4 coal fields, in a total of 14 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 2007 amounted to some 21 million t of marketable production. Lignite production in 2007 totalled 180 million t (STATISTIK DER KOHLENWIRTSCHAFT, 2007). As a result, hard-coal production increased by about 3.1 % over the previous year, while lignite production increased by about 2.3 %.

Methane emissions from hard-coal mining have decreased since 1990 as a result of decreasing production and increasing use of pit gas. Emissions from open-pit lignite mining have also decreased, also as a result of production decreases.

3.2.1.1.2 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 2007). Expert review is carried out by the competent state supervisory authority (the mining authority – Bergamt).

An implied emission factor (IEF) of 8.23 kg/t (2007) 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 (2007). According to the DEBRIV German lignite-industry association (Deutscher Braunkohlen-Industrie-Verein e.V; DEBRIV 2004), an average emission factor of 0.015 m^3 CH_4/t (corresponds to 0.011 kg CH_4/t) is assumed. This emission factor is based on a 1989 study of RWE Rheinbraun AG (DEBRIV, 2004) and is documented by publications of the Öko-Institut e.V. Institute for Applied Ecology and of the DGMK (German Society for Petroleum and Coal Science and Technology; research report / Forschungsbericht 448-2, 1992). This value is considerably lower than the emission factor used prior to 2005, 0.11 m^3 CH_4/t, which was derived from the EF for American hard lignite. Such American EF cannot be applied to German soft lignite, since the latter's temperature did not exceed 50°C during the coalification process. Significant methane releases occur only at temperatures above 80°C.

No lignite storage takes place; usage is "mine-mouth", i.e. extracted coal is moved directly to processing and to power stations.

3.2.1.1.3 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).

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.

3.2.1.1.4 Source-specific quality assurance / control and verification (1.B.1.a)

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/10^6m³ (pursuant to IPCC Reference Manual, 1996b: at 20° C, 1 atmosphere) yields the individual values listed in Table 40. 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 40: Emission factors for CH_4 from coal mining, for 2007

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	18.74	12.56	0.015	0.011
CH_4 from extraction, minus pit gas used	12.29	8.23	-	-
CH_4 from storage	0.87	0.58	-	-
CH_4 from mining (extraction and storage, minus pit-gas use)	13.16	8.81	0.015	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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance 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.

3.2.1.1.5 Source-specific recalculations (1.B.1.a)

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

3.2.1.1.6 Planned improvements (source-specific) (1.B.1.a)

No improvements are planned at present.

3.2.1.2 Solid fuel transformation (1.B.1.b)

3.2.1.2.1 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**	**2007 - 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										
Method of EF determination		CS								

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

3.2.1.2.2 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 (2007) 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 (2007).

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.

3.2.1.2.3 Uncertainties and time-series consistency (1.B.1.b)

The uncertainties in the activity rate result primarily from measurement inaccuracies in weighing of produced coke. Via surveys of experts carried out during the NASE workshop of 11/2004, the relevant error has been quantified as <3 %.

As a result of technical changes in the relevant process, and of increasing use of exhaust-gas scrubbing, the emission factor used for calculation of methane emissions from hard-coal-coke production is subject to considerable uncertainty. According to experts, a factor of ±20 % must be assumed (DMT 2005, along with information communicated personally 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.

3.2.1.2.4 Source-specific quality assurance / control and verification (1.B.1.b)

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance 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 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 Nm³/kg (1.01325 bar, 0°C) **= 0.67 Gg/10^6m³** (20°C, 1 atmosphere) *** 1.07 Nm³/m³**

3.2.1.2.5 Source-specific recalculations (1.B.1.b)

No recalculations are required.

3.2.1.2.6 Planned improvements (source-specific) (1.B.1.b)

No improvements are planned at present.

3.2.1.3 Other (1.B.1.c)

3.2.1.3.1 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**	**2007 - contribution to total emissions**	**Trend**
Solid fuels	- / t	CH_4	0.14 %	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										
Method of EF determination		CS								

The source category 1.B.1.c "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 330.1 million m³ in 2007. 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.

In emissions reporting, amounts of pit gas used must be determined separately from released amounts 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).

3.2.1.3.2 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

3.2.1.3.3 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 amounts of available methane in question have been estimated solely on the basis of experts' knowledge. In this area, an uncertainty of 50 % has been assumed.

The time series for potential methane emissions and amounts of methane used both originate from reliable sources and are consistent throughout.

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

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely.

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 1.07376 can be used to convert Nm^3 into m^3.

3.2.1.3.5 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 2007.

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

3.2.1.3.6 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 335 million m^3 and assumed that some 5 million m^3 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.

3.2.2 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.

3.2.2.1 Planned improvements (1.B.2)

Additional emission factors are currently being determined, in the interest of inventory improvement. Where adequate specific emission factors cannot be determined, the possibility of deriving default values from the IPCC Guidelines is being reviewed.

3.2.2.2 Oil (1.B.2.a)

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

CRF 1.B.2.a.i				
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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	NO	NO	NO	CS	NO	NO	CS	NO
EF uncertainties in %	20	20				20				
Distribution of uncertainties		N								
Method of EF determination	Mess	Mess				Mess				

The source category 1.B.2.a.i "Oil, exploration" is not a key source.

CH_4 and N_2O emissions for the source category are not determined at present (notation: "NE").

3.2.2.2.1.1 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 2007, 2,517 m of exploration wells were drilled, while a total of 15,698 m of new pool tests were drilled (WEG, 2007: Table on Balance of drilling success). The underlying exploration statistics do not differentiate between drilling for oil and drilling for gas.

3.2.2.2.1.2 Methodological issues (1.B.2.a.i)

Only emissions for successful wells, with such well information taken from the annual report of the Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry

association (WEG), are calculated, on the basis of the default factor for CO_2, 95 kg per producing and capable well. Currently, review is underway to determine whether additional emissions can be calculated from the number of exploratory wells, as the activity rate (WEG annual report, Table on drilling success - Bohrerfolgsbilanz), and from applicable default emission factors from IPPC Guidance 2000 (p. 2.86, Tab. 2.16).

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

The uncertainties in the source category will not be determined until suitable relevant data are available.

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

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

The results of quality assurance were taken into account in determination and documentation of emissions.

It has not yet been possible to verify the contributions to the source category, via comparisons, synopses or analysis of other countries' inventories. In some cases, the relevant evaluations, as they appear in other countries' national inventory reports, have not been published in a suitable manner. The applicability of EF from other countries' inventories, to the German inventory, remains to be reviewed.

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

No recalculations are required.

3.2.2.2.1.6 Planned improvements (source-specific) (1.B.2.a.i)

See 1.B.2 regarding planned improvements.

3.2.2.2.2 Oil, production (1.B.2.a.ii)

CRF 1.B.2.a.ii					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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	NO	NO	NO	NO	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination										

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.

3.2.2.2.2.1 Source-category description (1.B.2.a.ii)

This source category's emissions are produced in the petroleum industry's extraction (crude oil) and first treatment of raw materials (petroleum).

According to the annual report of the WEG association of oil and gas producers (WEG, 2007), German petroleum extraction in 2007 amounted to some 3.414 million tonnes.

The first treatment that extracted petroleum (crude oil) undergoes in processing facilities serves the purposes of removing gases, water and salt from the oil. Crude oil in the form in which it appears at wellheads contains impurities, gases and water, and thus does not conform to requirements for safe, easy transport in pipelines. No substance transformations take place. Impurities – especially gases (petroleum gas), salts and water – are removed, in order to yield crude oil of suitable quality for transport in pipelines.

3.2.2.2.2.2 Methodological issues (1.B.2.a.ii)

No relevant intermediate results are yet available for this source category (cf. 1.B.2, Chapter 3.2.2 NIR 2008)

The annual report of the WEG association of oil and gas producers (Wirtschaftsverband Erdöl- und Erdgasgewinnung - WEG 2007) lists the following emission factors:

Table 41: Emission factors for oil extraction

	CO_2	SO_2	NO_X	CH_4
Petroleum [kg/t]	100	0.14	0.07	0.14

3.2.2.2.2.3 Uncertainties and time-series consistency (1.B.2.a.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 default emission factors, + 25 % to + 50 % (IPCC GPG, 2000: Chapter 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

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

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out. The results of quality assurance were taken into account in determination and documentation of emissions.

It has not yet been possible to verify the contributions to the source category, via comparisons, synopses or analysis of other countries' inventories.

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

No recalculations are required.

3.2.2.2.2.6 Planned improvements (source-specific) (1.B.2.a.ii)

See 1.B.2 regarding planned improvements.

3.2.2.2.3 Oil, Transport (1.B.2.a.iii)

CRF 1.B.2.a.iii					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination										

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 category.

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

3.2.2.2.3.1 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 2007, 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 100 million tonnes of crude oil (MWV, 2008, 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 ("Petroleum supply via 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 (111,800 t in 2000, cf. DESTATIS Fachserie 8, Reihe 4, 1991-2004). As a result, this area of crude oil logistics would seem to play a negligible role.

3.2.2.2.3.2 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) for the Tier 1 approach (EF CH_4 = 5.4E-06; EF CO_2 = 4.9E-07; EF N_2O = 0 [Gg/($10^3 m^3$ oil transported via pipeline)] are used.

Precise country-specific activity rates in this area are available in the form of pipeline crude oil (petroleum) throughputs as provided by the Association of the German Petroleum Industry (MWV). Further aspects of inventory completion have been included in the inventory-improvement plan.

General information relative to fulfilment of good inventory practice, pursuant to the Guidelines, is provided in the section for 1.B.2 (cf. Chapter 3.2.2, NIR 2008).

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

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

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out. The results of quality assurance were taken into account in determination and documentation of emissions.

It has not yet been possible to verify the contributions to the source category, via comparisons, synopses or analysis of other countries' inventories.

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

No recalculations are required.

3.2.2.2.3.6 Planned improvements (source-specific) (1.B.2.a.iii)

See 1.B.2 regarding planned improvements.

3.2.2.2.4 Oil, processing, refinery (1.B.2.a.iv)

CRF 1.B.2.a.iv					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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	CS	CS
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination										

For certain areas of the CSE database, emissions of this source category are determined via the Tier 1 or Tier 3 methods.

3.2.2.2.4.1 Source-category description (1.B.2.a.iv)

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 2004, a total of 14 crude-oil refineries, and 7 lubricating-oil and used-oil refineries, were in operation in Germany. The total crude-oil input was 122.7 million t in 2007. (MWV, 2008: p. 47).

3.2.2.2.4.2 Methodological issues (1.B.2.a.iv)

The activity rates are taken from the annual special publications of the Association of the German Petroleum Industry (MWV; "Jahresbericht Mineralöl-Zahlen" ("Annual report on

mineral-oil figures")) and the Wirtschaftsverband Erdöl- und Erdgasgewinnung German oil and gas industry association (WEG; "Jahresbericht Zahlen & Fakten" ("Annual report, facts and figures").

CH_4 emissions were determined from the relevant country-specific emission factors and activity rates.

At present, no further significant intermediate results from ongoing inventory preparation are available.

General information relative to fulfilment of good inventory practice, pursuant to the Guidelines, is provided in the section for 1.B.2 (cf. Chapter 3.2.2).

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

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

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

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

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 all emission factors for this area; they range from 110 to 1660 kg/PJ. Conversion of the German emission factor for 2007, 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.

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

No recalculations are required.

3.2.2.2.4.6 Planned improvements (source-specific) (1.B.2.a.iv)

See 1.B.2 regarding planned improvements.

3.2.2.2.5 Oil, distribution of oil products (1.B.2.a.v)

CRF 1.B.2.a.v					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination										

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 category.

No decision is available for determining emissions from distribution, 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 methods (cf. source category 1.B.2.a.iii, Chapter 3.2.2.2.3).

3.2.2.2.5.1 Source-category description (1.B.2.a.v)

Petroleum products are transported via ships, product pipelines, railway tanker cars and tanker trucks, and they are transferred from tanks to other tanks. Germany's domestic sales of petroleum products totalled 108,110,000 t in 2008 (MWV, 2008, p. 51)). Pursuant to the Association of the German Petroleum Industry (MWV; loc. cit.), domestic petrol consumption amounted to 21,292,000 tonnes in 2007. The main sources of NMVOC emissions from total petrol distribution (1.B.2.a.v) were fugitive emissions from handling and transfer (filling/unloading) and container losses (tank breathing). These emissions have decreased by 89 % since 1990.

The decrease in fugitive emissions during this period 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.

Currently, about 13 million m³ of petrol fuels are transported in Germany via railway tank cars. This transport volume entails a maximum of 300,000 handling processes (loading and unloading). Some 5,000 to 6,000 railway tank cars for transport of petrol are in service. Transfer/handling (filling/unloading) and tank losses result in emissions of only 1.4 kt 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.

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.

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

Currently, the inventory covers only 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 of 1.1 kg/t crude oil is currently still being used for the petroleum / crude oil source categories 1.B.2.a.i, 1.B.2.a.ii and 1.B.2.a.iii (Level 1 calculation procedures; see 3.2.2.2.1). This factor, which includes pertinent emissions from flaring (1.B.2.c.i) and other losses (1.B.2.a.vi), was obtained from a research report of the German Society for Petroleum and Coal Science and Technology (DGMK) (DGMK 1992: p. II-98). The CH_4 emission factors for the area of refineries (1.B.2.a.iv) and storage (see also 1.B.2.a.ii and (1.B.2.a.v) were derived from a VOC emission factor (the CH_4 emission factor is equivalent to 10 % of the emission factor for VOC). They are continually updated in keeping with improvements in emissions-control technology. The original emission factor for VOC is not sufficiently well substantiated.

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

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

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely. 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.

3.2.2.2.5.5 Source-specific recalculations (1.B.2.a.v)

No recalculations are required.

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

See 1.B.2 regarding planned improvements.

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

CRF 1.B.2.a.vi					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination										

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 category.

No decision tree or other guidelines for determining distribution emissions are available. Pursuant to the reporting guidelines of the EMEP Emission Inventory Guidebook, no instructions relative to other emissions are available.

3.2.2.2.6.1 Source-category description (1.B.2.a.vi)

Emissions can occur in cleaning of tanks. Work is currently underway to take cleaning of railway tank cars into account. 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 venting when the insides of railway tank cars are cleaned amount to no more than 0.04 kt/a VOC. More thorough emissions collection upon opening of manholes of railway tank cars, 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).

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

Currently, the inventory includes emissions from cleaning of railway tank cars.

For emissions calculation, an empty tank with a saturated atmosphere is assumed to contain about 1 kg/m³ of VOC. When the tank's manhole is opened, about 14.6 m³ are released from the tank. The emissions for 2,500 such instances of cleaning processes amount to 36.5 t/a.

The calculation procedures use country-specific emission factors and activity rates.

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

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

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

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

No further verification results are available at present.

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

No recalculations are required.

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

Currently, a research project is underway that is aimed at updating the database on cleaning of railway tank cars, 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 (research report 20244372 UBA-FB 000581).

3.2.2.3 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**	**2007 - contribution to total emissions**	**Trend**
Natural gas	l / t	CH_4	0.54 %	0.65 %	rising

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

3.2.2.3.1 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)	CS	CS	-	-	-	-	NO	NO	CS	NO
EF uncertainties in %	20	20								
Distribution of uncertainties	N	N								
Method of EF determination	CS	CS								

The source category "Natural gas, exploration" is a key source pursuant to the classification of the aggregated source category 1.B.2.b Natural gas.

Source category 1.B.2.b.i is considered together with source category 1.B.2.a.i (Oil, exploration). Consequently, the aggregated, non-subdivided data of 1.B.2.b.i are included in source category 1.B.2.a.i.

3.2.2.3.1.1 Source-category description (1.B.2.b.i)

For a description of the source category, see 1.B.2.a.i.

3.2.2.3.1.2 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.

3.2.2.3.1.3 Uncertainties and time-series consistency (1.B.2.b.i)

See 1.B.2.a.i for explanations of uncertainties and time-series consistency.

3.2.2.3.1.4 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.

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 been carried out completely.

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

No recalculations are required.

3.2.2.3.1.6 Planned improvements (source-specific) (1.B.2.b.i)

See 1.B.2 regarding planned improvements.

3.2.2.3.2 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								
Method of EF determination	CS	CS								

In keeping with the classification of the aggregated source category 1.B.2.b Natural gas, the source category 1.B.2.b.ii Natural gas, production and processing is a key source.

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.

3.2.2.3.2.1 Source-category description (1.B.2.b.ii)

This source category's emissions are produced via activities of companies involved in production and processing, as well as via activities of natural-gas and coal-seam-gas companies in connection with gas extraction from reserves. Gas pretreatment takes place in

Germany, in pertinent plants. Emissions can be produced by various types of plants, throughout a spectrum ranging from first treatment to completion of processing.

First-treatment plants

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 2000, p. 16).

Acid gas

The natural gas drawn from Germany's Zechstein geological formation contains hydrogen sulphide. In its original state, the gas, known as "acid gas", has to be subjected to special treatment. Such gas is transported via separate, specially protected pipelines (due the hazardousness of hydrogen sulphide) to central processing plants that wash out its hydrogen sulphide via chemical and physical processes. The natural gas that leaves these processing plants is ready for use. The hydrogen sulphide is converted into elementary sulphur and is used primarily by the chemical industry, as a basic raw material. Sulphur production from natural gas amounts to about 1 million tonnes per year in Germany (WEG, 2006, p. 48).

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

No relevant intermediate results are yet available for this source category (cf. 1.B.2, Chapter 3.2.2 NIR 2008). The approach used in the calculation procedures is largely equivalent to that used for source category 1.B.2.a.ii.

The annual report of the WEG association of oil and gas producers (Wirtschaftsverband Erdöl- und Erdgasgewinnung - WEG 2007) lists the following emission factors:

Table 42: Emission factors for natural gas production

	CO_2	SO_2	NO_X	CH_4
Natural gas [kg/t]	27	0.1	0.029	0.16

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

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

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 been carried out completely. The results of quality assurance were taken into account in determination and documentation of emissions.

It has not yet been possible to verify the contributions to the source category, via comparisons, synopses or analysis of other countries' inventories.

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

No recalculations are required.

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

See 1.B.2 regarding planned improvements.

3.2.2.3.3 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								
Method of EF determination		CS								

The source category 1.B.2.b.iii Natural gas, transmission is a key source 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.

3.2.2.3.3.1 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 association of oil and gas producers (WEG; pipelines from pump stations to gas suppliers) and in the Federal Association of the German Gas and Water Industry (BGW; pipelines from gas suppliers to end customers).

Containers (tanks), and their transport via inland-waterway tanker ships, 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 3.2.2.3.4).

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).

3.2.2.3.3.2 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 for further information (1.B.2.a.iv).

3.2.2.3.3.3 Uncertainties and time-series consistency (1.B.2.b.iii)

See 1.B.2. for explanations of uncertainties and time-series consistency.

3.2.2.3.3.4 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.

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 been carried out completely.

3.2.2.3.3.5 Source-specific recalculations (1.B.2.b.iii)

No recalculations are required. See 1.B.2 for an explanation of source-specific recalculations.

3.2.2.3.3.6 Planned improvements (source-specific) (1.B.2.b.iii)

See 1.B.2 regarding planned improvements.

3.2.2.3.4 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								
Method of EF determination		CS								

The source category 1.B.2.b.iv Natural gas, distribution is a key source pursuant to the classification of the aggregated source category 1.B.2.b Natural gas.

Its emissions are determined in keeping with the method outlined for source category 1.B.2.a.v.

The emissions of this source category are determined in accordance with the Tier 3 method.

The Guidelines call for reporting of emissions of methane and of substances in the group of volatile organic compounds (CH_4 + NMVOC = VOC) (cf. 1.B.2.a.v):

The Guidebook mandates that emissions of the pollutants listed in 1.B.2.a.v be determined.

3.2.2.3.4.1 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 17 %, even though gas throughput has increased considerably and the distribution network has been enlarged by over 40 % 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 43: Gas-distribution network and emissions from it

Parameter	1990	1995	2000	2005	2007
Total length of pipeline network [km]	245,852	320,876	369,390	366,094	364,794
Total methane emissions [t]	199,567	208,473	191,344	165,866	158,301
Implied emission factor [kg/km]	811.7	649.7	518.0	453.1	433.9
Change in the emission factor with respect to the base year	0 %	20 %	36 %	44 %	47 %

Some of the natural gas is stored in above-ground reservoirs (spherical tanks) to permit, and guard against, interruptions of pipeline transports. Tanks filled with gas, for distribution and

transport, are transported via tanker ships (on inland waterways), railway tank cars and tanker trucks.

Gas is also sold in special containers (small tanks, flasks). Such containers are transported as unit loads, usually in larger packages, bunches or containers.

Distribution via pipelines

Relevant calculations are carried out on the basis of available network statistics on the composition of distribution networks in the low-pressure and medium-pressure sectors. In the early 1990s, emissions from distribution of city gas were also taken into account in calculations. In 1990, the city-gas distribution network accounted for a total of 16 % of the entire gas network. Of that share, 15 % consisted of grey cast iron lines and 84 % consisted of steel and ductile cast iron lines. The following table provides an overview of 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 over 210 %.

Table 44: Structure of the gas-distribution network

Gas-distribution network		Length of the distribution network			Emission factors [kg/km]		
Pressure level	**Material**	**1990 [km]**	**2007 [km]**	**Change [%]**	**1990 (city gas)**	**1990 (natural gas)**	**2007 (natural gas)**
Low pressure	Grey cast iron	17,260	0	100	1,480	7,990	5,820
	Plastic	23,894	30,048	25,8	18	70	70
	Steel and ductile cast iron	119,761	140,238	17.1	20	643	643
Medium pressure	Plastic	43,307	135,888	213.8	35	67	67
	Steel and ductile cast iron	54,222	58,620	8.1	250	974	971
Total		**258,444**	**364,794**	**41.1**			

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 fulfilment of good inventory practice, pursuant to the Guidelines, is provided in the section for 1.B.2 (cf. Chapter 3.2.2).

3.2.2.3.4.2 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 3.2.2.2.5).

3.2.2.3.4.3 Uncertainties and time-series consistency (1.B.2.b.iv)

See 1.B.2. for explanations of uncertainties and time-series consistency.

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

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

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 been carried out completely.

3.2.2.3.4.5 Source-specific recalculations (1.B.2.b.iv)

No recalculations are required. See 1.B.2 for an explanation of source-specific recalculations.

3.2.2.3.4.6 Planned improvements (source-specific) (1.B.2.b.iv)

See 1.B.2 regarding planned improvements.

3.2.2.3.5 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										
Method of EF determination										

The source category 1.B.2.b.v Natural gas, other leaks is a key source 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.

3.2.2.3.5.1 Source-category description (1.B.2.b.v)

As a result of conversion to a new method, some data resulting from the previous calculation procedure have not yet been conclusively allocated. It has not yet been possible to clarify whether the data in question consist of double counts or erroneous allocations to source category 1.B.2.b. A research project currently underway is expected to provide such clarification.

3.2.2.3.5.2 Methodological issues (1.B.2.b.v)

The relevant methodological issues cannot yet be explained.

3.2.2.3.5.3 Uncertainties and time-series consistency (1.B.2.b.v)

See 1.B.2. for explanations of uncertainties and time-series consistency.

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

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

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 been carried out completely.

3.2.2.3.5.5 Source-specific recalculations (1.B.2.b.v)

No recalculations are required. See 1.B.2 for an explanation of source-specific recalculations.

3.2.2.3.5.6 Planned improvements (source-specific) (1.B.2.b.v)

See 1.B.2 regarding planned improvements.

3.2.2.3.6 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**	**2007 - contribution to total emissions**	**Trend**
	- / -				

The source category 1.B.2.c 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 vented and flared directly into the atmosphere.

3.2.2.3.7 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, IE	CS, IE	-	-	-	CS, IE	NO/NE	NO/NE	NE	NO
EF uncertainties in %	20	20				20				
Distribution of uncertainties		N								
Method of EF determination	Mess	Mess				Mess				

Pursuant to the classification of the aggregated source category 1.B.2.c Venting and flaring, the source category 1.B.2.c.i 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.

Currently, the emissions of this source category either are not determined or are taken into account, proportionally, in another area of a source category of 1.B.2 (Notation: "NE" and "IE").

3.2.2.3.7.1 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 fulfil 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.

3.2.2.3.7.2 Methodological issues (1.B.2.c.i)

No significant intermediate results for this source category are yet available from ongoing inventory preparation.

The results of quality assurance are taken into account in determination and documentation of emissions.

3.2.2.3.7.3 Uncertainties and time-series consistency (1.B.2.c.i)

The uncertainties in the source category will not be determined until suitable relevant data are available.

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

General quality control (Tier 1), in conformance with the requirements of the QSE handbook and its associated applicable documents, has been carried out in the areas in which venting and flaring of oil occurs. The results of quality control were taken into account in determination and documentation of emissions. It has not yet been possible to verify the contributions to the source category, via comparisons, synopses or analysis of other countries' inventories.

At present, it is not possible to carry out verification solely for the area 1.B.2.c.i.

3.2.2.3.7.5 Source-specific recalculations (1.B.2.c.i)

No recalculations are required.

3.2.2.3.7.6 Planned improvements (source-specific) (1.B.2.c.i)

See 1.B.2 regarding planned improvements.

3.2.2.3.8 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)	CS, IE	CS, IE	-	-	-	CS, IE	NO/NE	NO/NE	NE	NE
EF uncertainties in %	20	20				20				
Distribution of uncertainties		N								
Method of EF determination	Mess	Mess				Mess				

Pursuant to the classification of the aggregated source category 1.B.2.c Venting and flaring, the source category 1.B.2.c.ii Venting and flaring, gas is not a key 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.

Currently, the emissions of this source category either are not determined or are taken into account, proportionally, in another area of a source category of 1.B.2 (Notation: "NE" and "IE").

3.2.2.3.8.1 Source-category description (1.B.2.c.ii)

For a description of the source category, see 1.B.2.c.i.

3.2.2.3.8.2 Methodological issues (1.B.2.c.ii)

For a description of the source category, see 1.B.2.c.i.

3.2.2.3.8.3 Uncertainties and time-series consistency (1.B.2.c.ii)

No explanations of uncertainties and time-series consistency are required.

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

No explanations relative to source-specific quality assurance / control and verification are required. Verification is not possible at present (cf. also 1.B.2.c.i).

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

3.2.2.3.8.5 Source-specific recalculations (1.B.2.c.ii)

No recalculations are required.

3.2.2.3.8.6 Planned improvements (source-specific) (1.B.2.c.ii)

See 1.B.2 regarding planned improvements.

3.2.2.4 Geothermal energy (1.B.2.d)

3.2.2.4.1 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, the sector 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 2007, a total of three geothermal power stations were in operation in Germany – the Landau and Unterhaching power stations, which were connected to the grid in the last third of that year, 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 of such systems takes place underground, and is sealed off from the air, and thus no emissions would be expected to occur during normal operation. 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 studies carried out by the GFZ German Research Center for Geosciences (Helmholtz Centre 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.

3.2.2.4.2 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 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 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 and Unterhaching power stations were not fully connected to the grid until December 2007 and April 2008, respectively (Unterhaching has been connected to the district heat network since October 2007 and to the electric grid since April 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.

3.2.2.4.3 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 explanations of uncertainties and time-series consistency are thus required.

3.2.2.4.4 Source-specific quality assurance / control and verification (1.B.2.d)

No explanations relative to source-specific quality assurance / control and verification are required. Verification is not possible at present.

3.2.2.4.5 Source-specific recalculations (1.B.2.d)

No recalculations are required.

3.2.2.4.6 Planned improvements (1.B.2.d)

No improvements are planned at present.

4 INDUSTRIAL PROCESSES (CRF SECTOR 2)

4.1 Mineral products (2.A)

Source category 2.A Mineral products is divided into sub- source categories 2.A.1 through 2.A.7. These are listed as follows in the CSE:

- 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.

Not all of the listed CSE structural elements serve purposes of greenhouse-gas reporting. This fact is noted, where necessary, in the relevant sub-chapters.

4.1.1 Mineral products: Cement production (2.A.1)

4.1.1.1 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**	**2007 - contribution to total emissions**	**Trend**
Cement production	l / -	CO_2	1.20 %	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 %	± 5	- -	- -	- -	- -	- -				
Distribution of uncertainties	N	- -	- -	- -	- -	- -				
Method of EF determination	CS	- -	- -	- -	- -	- -				

The source category "Cement production" is a key source for CO_2 emissions in terms of emissions level.

In the CSE, two different structural elements for the area of "cement" are used. The AR time series for cement production are designed to take account of dust emissions, because grinding of clinkers, as a dust source, must be considered independently from the amount of clinkers burned in Germany. Since this process is not relevant for the greenhouse-gas inventory, the following remarks refer only to production of cement clinkers.

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, 2008) clinker production in 2006 amounted to nearly 27,000 kt[24]. 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 14,306 kt CO_2 in 2007.

[24] Provisional value.

Table 45: 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	0.53	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		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

Source: VDZ, 2008

4.1.1.2 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).

With regard to the 2007 data, it should also be noted that cement production from clinkers produced in Germany is normally calculated with import and export data of the Federal Statistical Office. Since last year, export data have also been obtained from the VDZ itself, however. In 2007, the clinker exports reported to the VDZ were considerably larger than the corresponding data published by the Federal Statistical Office. For reporting purposes, the association data are used, since they are more plausible.

Table 45 summarises the activity data, and the raw-material-related CO_2 emissions as determined from clinker production, for the years 1990 through 2006.

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. In the German cement industry, dust separated from exhaust gas is returned to the burning process. As a result, carbonate release from

clinker raw materials can be determined directly from clinkers' metal-oxide content, without any need to take account of significant losses via the exhaust-gas pathway.

The emission factor of 0.53 t CO_2 / t cement clinkers was applied to the entire time series.

Raw-material-related CO_2 emissions in the cement industry are determined, in accordance with the *IPCC-GPG*, via the following equation:

CO_2 emissions = emission factor ($EF_{clinkers}$) x clinker production

(Table 45 shows calculated CO_2 emissions for the German cement industry for the years 1990 to 2007.)

4.1.1.3 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 4.1.1.6.

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 %. The uncertainties for the activity data used were thus estimated as -2 % and +2 %.

The uncertainty for the emission factors used was estimated as +/– 5 %. One source of error in this experts' assessment consists of the uncertainty regarding the average percentages of limestone and other carbonates in the clinker raw materials.

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

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely.

For purposes of quality assurance, all data used, including data from the BDZ, VDZ and from the literature, was 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.

To date, the emission factor used has also been used for purposes of the emissions trading system (ETS) in Germany. In the context of that scheme, it is subject to authority control and supported by plants' 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.

4.1.1.5 Source-specific recalculations (2.A.1)

No recalculations are required.

4.1.1.6 Planned improvements (source-specific) (2.A.1)

In a research project currently underway, the CSE-based emission factors for source category 2.A.1 will be verified and adapted as necessary.

4.1.2 Mineral products: Lime production (2.A.2)

4.1.2.1 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**	**2007 - contribution to total emissions**	**Trend**
Lime production	l / -	CO_2	0.49 %	0.56 %	rising

Gas	**CO_2**	**CH_4**	**HFC**	**PFC**	**SF_6**	**N_2O**	**NO_X**	**CO**	**NMVOC**	**SO_2**
Emission factor (EF)	D	NO	NO	NO	NO	NO	CS	NO	CS	CS
EF uncertainties in %	+5/-12[25]	--	--	--	--	--				
Distribution of uncertainties	L	--	--	--	--	--				
Method of EF determination	D	--	--	--	--	--				

The source category "Lime production" is a key source for CO_2 emissions in terms of emissions level.

The statements made below regarding source category 2.A.2 refer solely to the amounts of burnt lime and dolomite lime produced in German lime works. Information about other lime-producing and lime-using sectors is provided in Chapter 4.1.3 (CRF 2.A.3), in the interest of preserving the international comparability of Chapter 4.1.2 (CRF 2.A.2).

Due to relevant products' broad range of uses, lime production is normally less subject to economic fluctuation than is production of other mineral products, such as cement. Lime production did decrease in the years following the base year, 1990, however. This was a result of the sector's restructuring following German reunification, as well as of economic factors and of development of competing and substitute products. Following a brief increase in the mid-1990s, production then again decreased. Fluctuations in the years 2002-2006 were relatively small (with a range of 6.36 – 6.55 million t). In 2007, production increased by more than 3% over the previous year, as a result of positive economic factors.

[25] Weighted uncertainty for the areas of lime and dolomite (for individual uncertainties, cf. the CSE)

Table 46: Production and CO_2 emissions in the German lime industry

Year	Lime		Dolomite lime	
	Production	CO_2 emissions	Production	CO_2 emissions
	[t]	[Millions of t]	[t]	[Millions of 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[26]	6,691,134	5.253	458,246	0.418

Source: BV KALK, 2008

Dolomite-lime production, of which significantly smaller amounts are produced, basically exhibits similar fluctuations. On the other hand, production in the years 2003 to 2007 was considerably lower than in 2002 and the years before then (in 2003, production decreased by about 15 %). Between 1990 (the base year) and 2007, production decreased by about 22 %.

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.

4.1.2.2 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).

[26] Values for 2007 are provisional.

Activity data

The German Lime Association (BVK) collects the production data for the entire time series and makes it available for reporting purposes. Production amounts are determined via any one of several different means; their quality is thus adequately assured. Data for one small plant (for one lime producer) cannot be taken into account for any part of the entire time series. Data for another small plant (for a dolomite lime producer) have been included – although for only the period since 2006. The non-included plant's share of production is considered small (< 0.2 % of total production), and that share has been taken into account, without any extrapolation, in uncertainties estimation.

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 %. The **uncertainties** for the **activity rates** used were estimated as -2 % and +2 %. These figures apply to both burnt lime and dolomite lime.

4.1.2.3 Uncertainties and time-series consistency (2.A.2)

The German Lime Association (BVK) collects the production data for the entire time series and makes it available for reporting purposes. Production amounts are determined via any one of several different means; their quality is thus adequately assured. Data for one small plant (for one lime producer) cannot be taken into account for any part of the entire time series. Data for another small plant (for a dolomite lime producer) have been included for the first time in the current report. The non-included plant's share of production is considered small (< 0.2 % 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 -5 % and +5 %. These figures apply to both burnt lime and dolomite lime. Further relevant descriptions are provided in the NIR 2007.

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.

4.1.2.4 Source-specific quality assurance / control and verification (2.A.2)

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely.

The estimated emissions and collected production-amount 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.

4.1.2.5 Source-specific recalculations (2.A.2)

No recalculations are required.

4.1.2.6 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.

4.1.3 Mineral products: Use of limestone and dolomite (2.A.3)

4.1.3.1 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**	**2007 - 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	--	--	--	--	--	--				
Method of EF determination	--	--	--	--	--	--				

At present, emissions of this source category are not reported separately; instead, they are reported in the source categories that use limestone and dolomite. Where burnt lime or dolomite lime is used in source categories, the CO_2 released in the burning process is already included in the emissions for source category 2.A.2. Other emissions, apart from CO_2, are not considered in 2.A.3. 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 47). 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 is being considered in balance form, and the results are being 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 47: 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 48: 2.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. 4.1.8.

4.1.3.2 Methodological issues (2.A.3)

The balance includes three source categories in which limestone use is taken into account:

- 1.A.1.a Limestone use in flue-gas desulphurisation in power stations
- 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)

The inventory additions were updated with the revised data. The relevant methodological aspects are described in the pertinent source category chapters (cf. Chapters 3.1.1, 4.1.8, 4.3.1).

4.1.3.3 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.

4.1.3.4 Source-specific quality assurance / control and verification (2.A.3)

General quality control (Tier 1), in keeping with the requirements of the QSE manual and its associated documents, has 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 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.

4.1.3.5 Source-specific recalculations (2.A.3)

Recalculations are being carried out in the relevant source categories.

4.1.3.6 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).

4.1.4 Mineral Products: Soda ash production and use (2.A.4)

4.1.4.1 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**	**2007 - 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	-									
Method of EF determination	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. With respect to the calcium carbonate it uses, this 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.

4.1.4.2 Methodological issues (2.A.4)

Activity data

The Federal Statistical Office (Destatis) 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).

4.1.4.3 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 referred to the NIR 2007.

Emission factor

Since the emission factor is a substantiated "zero", there is no uncertainty.

4.1.4.4 Source-specific quality assurance / control and verification (2.A.4)

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

4.1.4.5 Source-specific recalculations (2.A.4)

No recalculations are required.

4.1.4.6 Planned improvements (source-specific) (2.A.4)

No improvements are planned at present.

4.1.5 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**	**2007 - 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	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination										

As far as is currently known, the source category "Bitumen for roofing" produces no greenhouse-gas emissions and is thus not a key source.

4.1.5.1 Source-category description (2.A.5)

Bitumen is used in production and laying of roof and sealing sheeting.

In 2007 some 189 million m^2 of roof and sealing sheeting were produced in Germany. In such production, liquid bitumen is applied, at temperatures of 150°C to 220°C, as a saturating or coating agent. This process produces significant emissions of organic substances (combined here as NMVOC).

Roofing and sealing sheeting is laid via hot and cold processes that involve use of solvent-containing primer coats. Hot processes produce significant amounts of emissions of organic substances. The relevant emissions trends depend primarily on trends in production quantities.

Other types of emissions play only a secondary role.

4.1.5.2 Methodological issues (2.A.5)

The quantity of roof and sealing sheeting produced (**activity rate**) has been taken from communications of the Verband der Dachbahnenindustrie roof-sheeting manufacturers association (VDD, 2008). At present, no data supplementation, conversions or extrapolation are being carried out.

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 has been taken from the literature (IKP, 1996). The emission factor for laying of roof and sealing sheeting has been taken from the report "Anthropogene VOC-Emissionen Schweiz 1998 und 2001" ("Anthropogenic VOC emissions of Switzerland, 1998 and 2001") (BUWAL, 2003: A2-11-12). That report also takes account of methane emissions.

NMVOC and VOC emissions are calculated in keeping with a Tier 1 method, since no pertinent detailed data are available.

Table 49: Production and laying of roof and sealing materials with bitumen, and relevant activity rates and emission factors

	Produced or used area in 2007 [millions of m^2]	EF [kg/ m^2]
Production of roof and sealing sheeting with bitumen	189	NMVOC 0.018
Laying of roof and sealing sheeting with bitumen	189	VOC 0.043

4.1.5.3 Uncertainties and time-series consistency (2.A.5)

The uncertainty for the produced area of roof sheeting is estimated to be about 5 %. The uncertainty of the emission factor for production is of the same order as that estimated in the report "Anthropogene VOC-Emissionen" ("Anthropogenic VOC emissions", BUWAL, 2003). That report estimated the relevant uncertainty as being 10 %. The total uncertainty for production and laying thus amounts to 11 %.

4.1.5.4 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 (i.e. for it to be carried out by a source-category 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.

The manner in which the production quantities (activity rate) of roof and sealing sheeting has been determined is considered plausible. On the other hand, it is not realistic to assume that the relevant quantities produced are the same as the quantities used; that assumption results from a lack of better data.

4.1.5.5 Source-specific recalculations (2.A.5)

No recalculations are required.

4.1.5.6 Planned improvements (source-specific) (2.A.5)

Negotiations with industry associations are currently underway with the aim of improving the data used in this area.

4.1.6 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**	**2007 - 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										
Method of EF determination										

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.

4.1.6.1 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 2006, a total of about 51 million t of asphalt (DAV, 2008) 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.

4.1.6.2 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 50: 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.

4.1.6.3 Uncertainties and time-series consistency (2.A.6)

As the extensive measurement data shows, the emissions lie within a comparatively narrow range. The large volume of measurement data available makes it possible to form highly reliable mean values. The only large uncertainties are found in breakdown of emissions amounts into fuel-related and process-related emissions.

The production-amount data may be considered very accurate, since the product in question is a sale-ready product, and operators report the relevant amounts to the DAV.

4.1.6.4 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 (i.e. for it to be carried out by a source-category 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.

The country-specific emission factor for NMVOC was subjected to specialised review, because the IPCC default value is considerably higher. The default factor of 320 kg/t asphalt given by the IPCC Guidelines is considered to be clearly too high. Asphalt in Germany contains only a 5 % proportion of binder bitumen, which can contribute to NMVOC emissions. The emission factor for the minerals making up the remaining 95% cannot be higher than 50 kg/t.

4.1.6.5 Source-specific recalculations (2.A.6)

No source-specific recalculations were required.

4.1.6.6 Planned improvements (source-specific) (2.A.6)

Plans call for reviewing whether CO_2 emissions from sources than fuels occur, and, if so, whether the pertinent greenhouse-gas emissions are significant.

In addition, review is to be carried out to determine the extent to which uncertainties can be estimated.

4.1.7 Mineral Products: Glass production (2.A.7 Glass)

CRF 2.A.7 Glass					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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 %	10									
Distribution of uncertainties	N									
Method of EF determination	CS									

The source category "Mineral products: glass production" is not a key source.

4.1.7.1 Source-category description (2.A.7 Glass)

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 53.7 % of total glass production in 2007) and flat glass (about 23.1 % of total glass production in 2007). Together, these sectors account for 76.8 % of total glass production.

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 4.1.4.1). 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 1450°C and 1650°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.

4.1.7.2 Methodological issues (2.A.7 Glas)

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. 4.1.3) and 2.A.4 (cf. 4.1.4).

The production figures (**activity rates**) are taken from the regularly appearing annual reports of the national glass industry association (Bundesverband Glasindustrie; BV Glas, 2008). "Production" refers to weights of produced glass; these are considered to be equivalent to weights of melted glass and, thus, to weights of input raw materials. Further processing and treatment of glass and glass objects are not considered.

The following activity rates were determined for 2007:

Table 51: Glass: Activity rates for the various industry sectors (types of glass)

Industry sector	Activity rate for 2007 [1,000 t]
Container glass	4,045.4
Flat glass	1,737.8
Special glass	493.3
Domestic glass	342.6
Glass fibre and wool	363.0
Stone wool	553.2

Source: BV Glas, 2008

The following sector-specific cullet percentages are assumed:

Table 52: Cullet percentages for the various types of glass

Industry sector	Cullet percentage [%] in the input raw material
Container glass	56 – 75 (annually varying)
Flat glass	35
Special glass	30
Domestic glass	20
Glass fibre and wool	40
Stone wool	40

Source: HVG, 2008

The cullet percentage for container glass has been taken into account only for the western German Länder since 1990. It has been taken into account since 1995 for Germany as a whole. 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.

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 (information sheet) 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 53: 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	-

4.1.7.3 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. In 2007, the GGA was disbanded under cartel law. As a result, no reliable data from that source are available as of 2007, and the data used have to be estimated with the help of data from quantity surveys carried out with regard to the Ordinance on Packaging (Verpackungs-Verordnung).

The figures on cullet use for all other glass types are considerably less precise, however, since only estimates are available for that area. 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.

4.1.7.4 Source-specific quality assurance / control and verification (2.A.7 Glass)

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. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely.

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 compared with data for the emissions trading scheme (ETS) in Germany; such comparison showed extensive agreement.

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.

4.1.7.5 Source-specific recalculations (2.A.7 Glass)

Recalculations show lower emissions as of 1990, resulting from revision of the cullet inputs. For the source category as a whole, the reduction amounts to about 15 % as of 1990.

4.1.7.6 Planned improvements (source-specific) (2.A.7 Glass)

No improvements are planned at present.

4.1.8 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**	**2007 - 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									
Method of EF determination	CS									

The source category "Mineral products: ceramics production" is not a key source.

4.1.8.1 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 was recalculated in the NIR 2006. Since then, the time series shows the production quantity for 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 54: 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	21,595	20,772	22,769	24,534	30,458	24,730	22,663	22,939	22,798	22,395	21,199
of which:											
Masonry bricks	16,524	15,691	17,302	18,827	23,925	18,827	16,965	17,298	17,048	16,591	15,383
Roof tiles	1,758	1,946	2,216	2,349	2,611	2,466	2,598	2,521	2,658	2,849	2,924
Process-related CO2 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			
	[kT]										
Ceramics products	21199	18003	16500	16443	16796	14643	16019	16035			
of which:											
Masonry bricks	15383	12771	11686	11631	11697	9881	10883	10885			
Roof tiles	2924	2642	2381	2383	2601	2485	2648	2618			
Process-related CO2 emissions											
Masonry bricks	448	372	340	338	340	288	316	317			
Roof tiles	84	76	68	68	74	71	76	75			
Total	**531**	**447**	**408**	**407**	**415**	**359**	**392**	392			

4.1.8.2 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 54. 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.

4.1.8.3 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 1000 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.

4.1.8.4 Source-specific quality assurance / control and verification (2.A.7 Ceramics)

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. To date, data from greenhouse-gas-emissions trading have not been used directly for verification, because, as a result of applicable threshold values for 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.

4.1.8.5 Source-specific recalculations (2.A.7 Ceramics)

No recalculations are required.

4.1.8.6 Planned improvements (source-specific) (2.A.7 Ceramics)

No improvements are planned at present.

4.2 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.

4.2.1 Chemical industry: Ammonia production (2.B.1)

4.2.1.1 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**	**2007 - contribution to total emissions**	**Trend**
Ammonia production	l / t	CO_2	0.36 %	0.51 %	rising

Gas	**CO_2**	**CH_4**	**HFC**	**PFC**	**SF_6**	**N_2O**	**NO_X**	**CO**	**NMVOC**	**SO_2**
Emission factor (EF)	1,5	NO	NO	NO	NO	NO	CS	NO	NO	NO
EF uncertainties in %	±50									
Distribution of uncertainties	N									
Method of EF determination	D									

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.

Most plants operate according to the *steam-reforming* principle, with naphtha or natural gas. Only 3 % of European plants use the partial oxidation procedure.

The production decrease of more than 15 % (corresponding to an amount of about 400 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. After 1990, production levels fluctuated only slightly. In 2003, production increased noticeably – by 9 % – over the previous year. In 2003, two nitric-acid producers entered the market. These additions are likely the result of the fact that ammonia is a precursor substance for nitric acid. Since then, the rate of ammonia production has been stable.

4.2.1.2 Methodological issues (2.B.1)

Carbon dioxide emissions are dependent upon the quantity and composition of the input materials. It can be assumed that all the carbon is converted into carbon dioxide and will be emitted into the air sooner or later.

In Germany, carbon dioxide is converted into urea at three production sites. At one site, part of the carbon dioxide is filled into bottles for selling. In all cases, however, subsequent emission of carbon dioxide into the air is inevitable.

At present, only two of five ammonia-production facilities in Germany use the partial oxidation process.

The emissions are calculated as follows:

Emission (kt) = Ammonia production quantity (kt) x emission factor (kt/kt)

Activity rate:

Total production comprises "Ammonia, water-free" ("Ammoniak wasserfrei" (Melde Nr. (reporting number) 4142 00 until 1994 and, as of 1995, 2415 10 750), which is far and away the largest component, and "Ammonia in aqueous solution" ("Ammoniak in wässriger Lösung", Melde Nr. 4144 00 until 1994 and, as of 1995, 2415 10 770). The amount of ammonia produced in Germany is determined by the Federal Statistical Office (DESTATIS, Fachserie (technical series) 4 Reihe 3.1). Since the relevant figures are normed to nitrogen content, the above-mentioned emission factor has to be adjusted by a stoichiometric factor of (17/14).

According to the German Institute for Economic Research (DIW), the VCI (Verband der chemischen Industrie; chemical industry association) uses annual monitoring data to divide the quantity of input natural gas into energy-related and non-energy-related consumption quantities. The pertinent data are reported to the DIW, for purposes of further use in the Energy Balance of the Federal Republic of Germany.

Emission factor:

Due to a lack of plant-specific data, an emission factor of 1,500 kg CO_2 /t NH_3 – the figure proposed as the IPCC default factor – is still being used.

Conversion with the aforementioned stoichiometric factor produces an emission factor of 1,815 kg CO_2 / t N; this is the factor used in calculations.

The emission factor for NO_X depends on the type of production in question. The Federal Environment Agency's internal estimates are 1.1 kg NO_X/t NH_3, for partial oxidation, and 0.32 to 0.175 kg NO_X/t NH_3, for *steam reforming* (with the specific figure depending on what process variation is used). For purposes of emissions calculation, the average for all types of production is assumed to be decreasing over time – from 0.45 kg NO_X/t N in 1990 to only 0.3 kg NO_X/t N in 2010. The interim-year figures used for emissions calculation were interpolated.

4.2.1.3 Uncertainties and time-series consistency (2.B.1)

Activity rate:

In keeping with the 2006 IPCC Guidelines, an uncertainty of ±5 % was assumed for the activity rate.

Emission factor:

The CO_2 emission factor is only an average value that, given the various different production processes and conditions involved, cannot fully and precisely reflect the actual situation.

For this reason, an uncertainty of 50 % is assumed for the EF used.

The NO_X emission factor is also only an average value that, given the various different production conditions involved, cannot fully and precisely reflect the actual situation. This restriction applies all the more for the interpolated figures used for the interim years.

The small production share for "Ammonia in aqueous solution" is secret for several of the years in question. For 1999, this share was estimated on the basis of ratios in neighbouring years, taking the production amounts for "Ammonia, water-free" into account. Among the years 1990 to 1994, only 1993 has a non-secret production figure; this figure was not used for the four other years.

It is possible that a change in statistical survey methods, effected from 1994 to 1995, caused an apparent production increase of about 400 kt.

4.2.1.4 Source-specific quality assurance / control and verification (2.B.1)

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 been carried out completely.

4.2.1.5 Source-specific recalculations (2.B.1)

No recalculations are required.

4.2.1.6 Planned improvements (source-specific) (2.B.1)

Ammonia production is a key source with regard to CO_2 emissions. Negotiations for institutionalising delivery of plant-specific data have been commenced in the interest of reporting plant-specifically (Tier 3), in keeping with the IPCC Guidelines.

4.2.2 Chemical industry: Nitric acid production (2.B.2)

4.2.2.1 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**	**2007 - contribution to total emissions**	**Trend**
Nitric acid production	l / t	N_2O	0.37 %	0.94 %	rising

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	5,5	CS	NO	NO	NO
EF uncertainties in %						±50				
Distribution of uncertainties						N				
Method of EF determination						CS				

The source category "Chemical industry: Nitric acid production" is a key source for N_2O emissions in terms of emissions level and trend.

In production of nitric acid, nitrous oxide occurs in a secondary reaction. In Germany, there are currently only six 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:

$$4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$$

$$\mathbf{4\ NH_3 + 4\ O_2 \rightarrow 2\ N_2O + 6\ H_2O}$$

All three oxidation reactions are exothermic. Heat may be recovered to produce steam for the process and for export to other plants and/or to preheat the residual gas. The reaction water is condensed in a cooling condenser, during the cooling of the reaction gases, and is then conveyed into the absorption column.

4.2.2.2 Methodological issues (2.B 2)

Activity rate:

The activity data are obtained from the Federal Statistical Office (DESTATIS, Fachserie 4, Reihe 3.1: manufacturing sector, production within the manufacturing sector). In general, those figures for nitric acid production are normed to N. In the present case, the Federal Environment Agency converted the figures from N to HNO_3 stoichiometrically (*63/14). Since there are no consistent time series for the time period involved, a number of adjustments had to be made:

Production figures are available for the old German Länder for 1990-1992 and for 1991-1992 for the new German Länder (Melde-Nr. (reporting number) 4123 10). The 1990 production figure for the new German Länder was not available and has been estimated.

Beginning in 1993, production figures are no longer listed separately for the new and old German Länder; for this reason, the 1993 and 1994 figures for the new and old German Länder were determined in keeping with the relevant regions' share of total production in 1992.

For 1995-2001, following conversion of federal statistics, the nitric-acid production figures of Melde-Nr. 2415 10 503, which are still normed to N, are used. Since 2002, the Federal Statistical Office no longer lists this position individually; it now lists it as part of a sum under Melde-Nr. 2415 10 500 (nitric acid, nitrating acids). For estimation of the relevant share for nitric acid, this sum value is multiplied with nitric acid's share of this sum value in 2001 (0.693).

As a result of fluctuations in production, appearance of new producers and conversion of the data-collection system for a major nitric acid producer, the trend for activity data is unstable and fluctuating. From 1990 to the present, production has more than doubled, as a result of growth in demand.

Emission factor:

The emissions depend on the technological situation and operating conditions, vary extensively from one plant to another and can even vary within the same plant.

Since 1990, the N_2O emission factor used has been consistently given as 5.5 kg N_2O/t HNO_3. In the underlying research project from 1993 (SCHÖN, WALTZ et al, 1993), it is assumed, however, that 283 kg NH_3/t HNO_3 are used for production of nitric acid, and that some 1.5 % of this ammonia are converted into N_2O. A check calculation using industry figures (3120 m^3 waste gas/t HNO_3 and 500-1000 ppm N_2O) confirmed the above emission factor, in terms of order of magnitude, by yielding 3.1-6.2 kg N_2O/t HNO_3. The emission factor for N_2O does not take account of any reduction measures that may have been implemented, however.

NO_x emissions figures for the entire period are based on UBA-specific emission factors that have decreased strongly over time. This trend is based on a forecast for 2010 pursuant to which in that year the average specific emissions will be on the order of those of state-of-the-art plants in 1997 (0.75 kg/t).

At present, no emission factors from plant data are available.

As of 2010, old plants may no longer exceed the applicable emissions standard, from TA Luft 2002, of 800 mg N_2O/m^3. This announced N_2O emissions limitation will cause the EF for nitrous oxide to fall in future.

4.2.2.3 Uncertainties and time-series consistency (2.B.2)

Activity rate:

In keeping with the 2006 IPCC Guidelines, an uncertainty of ±2 % was assumed for the activity rate.

Emission factor:

The EF used does not reflect any reduction measures, and it does not differentiate by plant types. For this reason, an uncertainty of 50 % is assumed for the EF.

4.2.2.4 Source-specific quality assurance / control and verification (2.B.2)

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 been carried out completely.

4.2.2.5 Source-specific recalculations (2.B.2)

No recalculations are required.

4.2.2.6 Planned improvements (source-specific) (2.B.2)

Nitric acid production is a key source of N_2O emissions. Negotiations for institutionalising delivery of plant-specific data have been commenced in the interest of reporting plant-specifically (Tier 3), in keeping with the IPCC Guidelines.

The planned improvements will take account of the uncertainties referred to under 4.2.2.3.

4.2.3 Chemical industry: Adipic acid production (2.B.3)

4.2.3.1 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**	**2007 - contribution to total emissions**	**Trend**
Adipic acid production	l / t	N_2O	1.49 %	0.55 %	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				
Method of EF determination						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.

4.2.3.2 Methodological issues (2.B.3)

Until around the mid-1990s, producers provided data only on amounts produced. The IPCC default emission factors were used to calculate nitrous oxide emissions for this 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 failure of system components) and of production increases.

4.2.3.3 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 %.

4.2.3.4 Source-specific quality assurance / control and verification (2.B.3)

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 been carried out completely.

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.

4.2.3.5 Source-specific recalculations (2.B.3)

No recalculations are required.

4.2.3.6 Planned improvements (source-specific) (2.B.3

No improvements are required; for this reason, none are planned.

4.2.4 Chemical industry: Carbide production (2.B.4)

4.2.4.1 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**	**2007 - 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									
Method of EF determination	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.

4.2.4.2 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.

4.2.4.3 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.

4.2.4.4 Source-specific quality assurance / control and verification (2.B.4)

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

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.

4.2.4.5 Source-specific recalculations (2.B.4)

No recalculations are required.

4.2.4.6 Planned improvements (source-specific) (2.B.4)

No improvements are planned at present.

4.2.5 Chemical industry – other: Emissions from other production processes (2.B.5)

4.2.5.1 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**	**2007 - contribution to total emissions**	**Trend**
Other	l / t	CO_2	0.54 %	1.01 %	rising

Gas	**CO_2**	**CH_4**	**HFC**	**PFC**	**SF_6**	**N_2O**	**NO_X**	**CO**	**NMVOC**	**SO_2**
Emission factor (EF), industrial soot	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										
Method of EF determination										

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 catalyst consumption in refineries.

In refinery operations, catalyst consumption occurs in catalytic cracking plants in which desulphurised vacuum and other gasoil distillates are broken down at temperatures of about 550°C, in a water-vapour atmosphere, into refinery gas, liquid gases, gasoline fractions and medium distillates. CO_2 emissions also occur in catalyst regeneration in the reforming process, which is designed to increase octane levels in raw gasoline and to generate hydrocarbon aromates via isomerisation and ring formation. The fluid catalytic cracking (FCC) process is now the leading process used for this purpose. During cracking reactions in an FCC reactor, coke is deposited on the catalyst. That coke is then burned off, via air input, in the regenerator. In the reforming process, platinum is used as the catalyst, in combination with rhenium and tin, and applied to acidic aluminium oxide. The catalyst grows ineffective as

a result of process-related deposition of coke on its active centres. In catalyst regeneration, coke is burned-off to restore proper catalytic function. CO_2 is released in these combustion processes.

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 been used thermal waste-gas treatment in their production operations. N_2O emissions no longer occur in those operations.

4.2.5.2 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 catalyst consumption 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 3.1.2).

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 55 below.

Table 55: IPCC default emission factors for CH_4 from other chemical industry processes

Carbon black	Styrene	Ethylene	1,2 - dichloroethane[27]	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

[27] 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".

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 been in service since the 1980s, and thus the pertinent emission factors can be applied to the entire time series.

For the year 2004, a CH_4-emission factor of 0.0003 kg/t methanol is available for one plant.

Table 56: National emission factors for CH_4 from other chemical industry processes

Carbon black	Styrene	Ethylene	1,2-dichlorethane[27]	Methanol
[kg CH_4/t]				
0.03	0	0	0	0

NMVOC, CO und SO_2 – emission factors

For pollutants other than the methane considered above, the emission factors listed in Table 57 were used for Germany.

Table 57: Emission factors used in Germany for other pollutants

	Carbon black [kg CO / t]	Carbon black [kg SO_2/t][28]	Ethylene [kg NMVOC / t]	1,2 - dichloroethane [kg NMVOC / t]	Polystyrene [kg NMVOC / t]	Styrene [kg NMVOC / t]
1990	4.8/ 5	19.5 / [29]	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

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

[28] Where two EF are listed, the second figure refers to the new German Länder.

[29] No EF is listed for the new German Länder, since these SO_2 emissions can be taken account of only as a lump sum.

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).

Activity rates

The production statistics of the Federal Statistical Office (Destatis) include the following products (Table 58):

Table 58: 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 (DESTATIS, 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 (DESTATIS, 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.

4.2.5.3 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.

4.2.5.4 Source-specific quality assurance / control and verification (2.B.5)

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 been carried out completely.

4.2.5.5 Source-specific recalculations (2.B.5)

Recalculation was required as a result of use of the default EF for CO_2 for carbon-black production. Higher emissions as of 1990 resulted from the recalculation.

Table 59: CO_2 emissions from carbon-black production

	New	Old	Difference
Year		**[t]**	
1990	786,675	700,000	86,675
1991	747,860	670,000	77,860
1992	739,673	660,000	79,673
1993	655,855	590,000	65,855
1994	586,338	530,000	56,338
1995	648,366	580,000	68,366
1996	618,551	560,000	58,551
1997	661,655	600,000	61,655
1998	672,905	610,000	62,905
1999	663,542	600,000	63,542
2000	678,113	610,000	68,113
2001	682,788	620,000	62,788
2002	663,640	600,000	63,640
2003	682,703	620,000	62,703
2004	665,939	601,384	64,555
2005	651,710	588,534	63,176
2006	1,236,452	1,116,592	119,860
2007	1,302,698		

Emissions from nitrous-oxide production for narcotic uses were excluded, since such emissions are reported under 3.D, in connection with narcotic uses. In that section, it is assumed, for purposes of simplification, that 100 % of the produced nitrous oxide is emitted in use. Since 1990 to the present, nitrous-oxide emissions have been decreasing by 18.6 t N_2O/year.

4.2.5.6 Planned improvements (source-specific) (2.B.5)

No improvements are planned at present.

4.3 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.

4.3.1 Metal production: Iron and steel production (2.C.1)

4.3.1.1 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**	**2007 - contribution to total emissions**	**Trend**
Steel (integrated production)	l / t	CO_2	3.83 %	4.53 %	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	-	-	-	-	-	-				
Method of EF determination	T2	-	-	-	-	-				

The source category "Iron and steel production" is a key source of CO_2 emissions in terms of emissions level and trend.

In 2007, a total of 33.5 million t of raw steel, from ore, was produced in Germany in six integrated steel works. Electrical steel production amounted to 15.0 million t.

4.3.1.2 Methodological issues (2.C.1)

This sector comprises process-related CO_2 emissions from oxygen-steel works (blown steel production) and electric-steel works.

The last Siemens-Martin steel works (Stahlwerk Brandenburg) was shut down shortly after 1990; the last Thomas steel works (Maxhütte Sulzbach-Rosenberg) discontinued production in 2002. With regard to calculation of CO emissions, there is no significant difference from the procedure for calculation of emissions from oxygen steel production. For this reason, the pertinent emissions will be calculated jointly until those processes are completely phased out.

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 3.1.4.1).

Table 60 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.

Table 60: Allocation of fossil CO_2 emissions in the iron and steel industry to process-related and energy-related emissions

	Sintering plant/ Sinter production	Blast furnace/ Pig iron production	Hot rolling mill/ Rolled steel production	Electric-steel mill/ Production of electrical steel	Iron, steel and malleable iron foundries
Hard coal	E	E/P*			
Hard-coal coke		E/P*			E
Lignite briquettes	E				
Lignite coke	E				
Heating oil - heavy		E/P*			
Other petroleum products		E/P*			
Coke breeze (classified under hard-coal coke)	E				
Natural gas	E	E**	E		E
Coking gas	E				
Blast-furnace gas	P	E/P*			
Recycled plastics		E/P*			
Electrode consumption				P	

E: Energy-related (emissions to be reported in 1.A.2)

P: Process-related (emissions to be reported in 2.C.1)

Remark: No significant fuel use occurs in oxygen steel plants. Therefore, this section does not include a separate category for such plants.

*) Breakdown via the factor for the ideal blast-furnace process; see text

**) Natural-gas use in blast-furnace wind heaters creates no process-related CO_2 emissions; it only generates energy-related CO_2 emissions

Because it is difficult to differentiate between process-related and energy-related emissions in oxygen steel production, the following actions are taken:

1. All of the CO2 emissions resulting from use of reducing agents and fuels are calculated,
2. Process-related CO2 emissions are determined from the carbon requirements for the ideal blast-furnace process and from limestone inputs in pig iron production, and CO2 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 CO2 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.

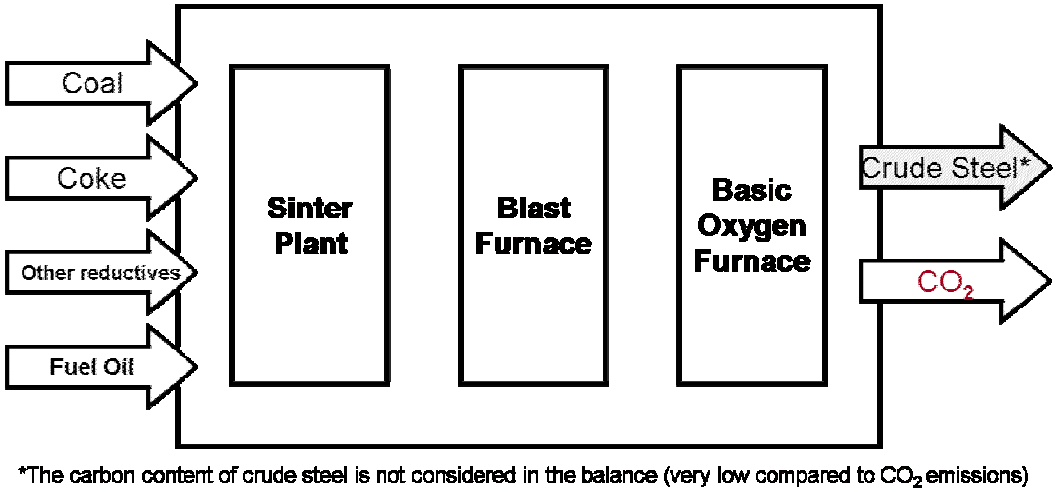


Figure 23: Carbon balance in pig-iron and oxygen-steel production

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 23). 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%, 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 61). The procedure used to compile activity rates oriented to the territory of Germany, for the period as of 1995, is described in the final report of the research project "Inputs of secondary fuels" ("Einsatz von Sekundärbrennstoffen"; UBA 2005b, FKZ 20442203/02).

Table 61: 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			2,850
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

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) 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 (DESTATIS 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). Multiplying the activity rates for limestone inputs by the stoichiometric emission factor for limestone produces the CO_2-emissions figures given in Table 62.

Table 62: Limestone inputs and resulting CO_2 emissions in sinter and pig iron production

	Limestone inputs [kt/a]		CO_2 emissions [kt/a]		
Year	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	4,210	848	1,852	373	2,225
2005	4,144	808	1,823	355	2,179
2006	4,255	850	1,872	374	2,246
2007	4,450	872	1,958	384	2,342

Soruce: through 2004: Calculations within the "limestone balance" project (UBA 2006, FKZ 20541217/02);
as of 2005: Calculations using 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 64. 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 63: Total process-related emissions to be reported under 2.C.1

	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
Year	**[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	2,178,835	65,192	42,574,125
2006	42,542,850	2,246,327	69,995	44,859,172
2007	40,712,429	2,341,755	71,622	43,125,806

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.

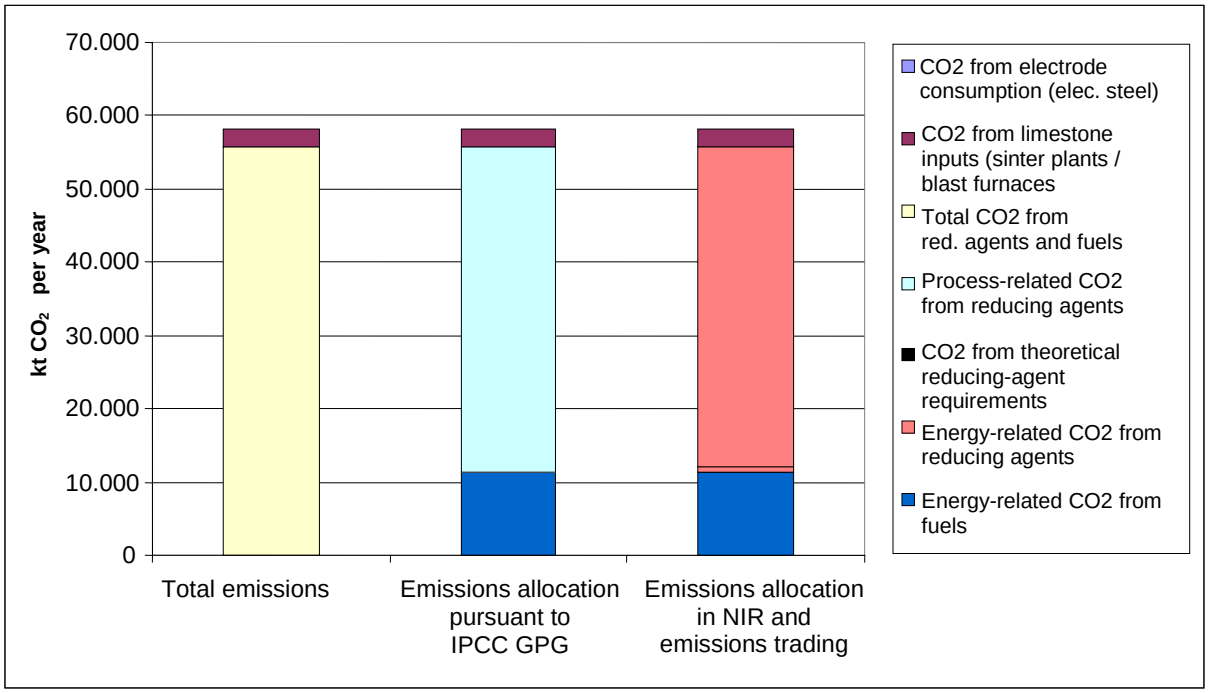
Firstly, the emission factors for all reducing agents used in the blast furnace (specifically, hard coal, dry blast-furnace coke, other solid fuels and heavy heating oil) are set to "0" with regard to the energy picture.

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 (wind heaters), are allocated completely to energy-related emissions.

All emission factors for top-gas inputs (also in power stations and in sinter production) are set to "0", since the relevant emissions were already taken into account in inputs of reducing agents into blast furnaces; such inputs lead to the formation of top gas. In contrast to the procedure used in the 2005 National Inventory Report, CO_2 emissions from top gas in the iron and steel industry 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 24. The difference, i.e. the different allocation to energy-related emissions, amounting to about 600 kt/a CO_2 via the approach described here (and referred to in Figure 24 as "energy-related CO_2 from reducing agents"), accounts for only 1.3% 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 24: Allocation of total emissions from iron and steel production to process-related and energy-related emissions

4.3.1.3 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.

4.3.1.4 Source-specific quality assurance / control and verification (2.C.1)

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely. The plausibility of determined emissions quantities has been successfully checked with the help of pertinent data of the German Emissions Trading Authority (DEHSt).

4.3.1.5 Source-specific recalculations (2.C.1)

No recalculations are required.

4.3.1.6 Planned improvements (source-specific) (2.C.1)

The emission factors for electrode consumption are being reviewed in a research project that is schedule to run until summer 2009.

4.3.2 Metal production: Ferroalloys production (2.C.2)

4.3.2.1 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**	**2007 - 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	-	-	-	-	-	-				
Method of EF determination	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.

4.3.2.2 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.

4.3.2.3 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.

4.3.2.4 Source-specific quality assurance / control and verification (2.C.2)

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 been carried out completely. Because some of the staff capacities required for this area are not yet available, it has not yet been possible to carry out quality assurance completely. No comparison with other data sources for Germany was carried out, because no other suitable data sources for 2.C.2 are available.

4.3.2.5 Source-specific recalculations (2.C.2)

No recalculations are required.

4.3.2.6 Planned improvements (source-specific) (2.C.2)

No improvements are planned at present.

4.3.3 Metal production: Primary aluminium production (2.C.3)

4.3.3.1 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**	**2007 - contribution to total emissions**	**Trend**
Aluminium production	- / t	PFC	0.20 %	0.07 %	falling

Gas	**CO_2**	**CH_4**	**HFC**	**PFC**	**SF_6**	**N_2O**	**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						
Method of EF determination	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.

4.3.3.2 Methodological issues (2.C.3)

The production figures for the year 2007 were taken from the aluminium-industry monitoring report for the year 2007 [GDA, 2008]. The average anode consumption is 430 kg of petrol coke per tonne of aluminium. Table 64 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. Chap. 13.7.2). 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 64 were compared with the emission data in pertinent BAT Reference Documents (BREF)[30] and other sources (such as VDI Guideline 2286 sheet 1).

Table 64: Activity rates and process-related emission factors for primary aluminium production in 2007

		AR	Emission factors						
	Number of smel-ters	Production [t]	CO_2 [kg/t]	CF_4 [kg/t]	C_2F_6 [kg/t]	NO_X [kg/t]	SO_2 [kg/t]	C total [kg/t]	CO [kg/t]
Primary aluminium	4	553,934	1,367	0.05	0.005	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 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[31] were calculated, in keeping with the technology used. The number of anode effects is recorded and documented in the smelters. 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.

4.3.3.3 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. 4.3.3.6).

[30] cf. http://www.bvt.umweltbundesamt.de/kurzue.htm

31 "...Organic fluorides occur only under certain conditions, and such conditions occur in the furnace repeatedly, at intervals of hours to severals days. These conditions are referred to as the "anode effect". ... The gas at the anode changes in composition from CO_2 to CO and 5 to 20 % CF_4...." (ÖKO-RECHERCHE 1996)

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.

4.3.3.4 Source-specific quality assurance / control and verification (2.C.3)

Because staff responsibilities for this area remain to be clarified, it has not yet been possible to carry out general quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents.

The industry conducts annual surveys of activity data and reports that 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 collection of this data conforms to quality assurance criteria.

Specific PFC emissions during anode effects were determined via industry measurements carried out in 1996 and 2001 at all plants in Germany that produce primary aluminium. In each case, the amount of PFCs produced depends on the duration and frequency of the relevant anode effects. In recent years, the duration and frequency of anode effects have been considerably reduced via computer-aided process control. In 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.

4.3.3.5 Source-specific recalculations (2.C.3)

No recalculations are required.

4.3.3.6 Planned improvements (source-specific) (2.C.3)

Determination of uncertainties continues, with the involvement of the industry association.

4.3.4 Metal production: SF_6 used in aluminium and magnesium foundries (2.C.4)

4.3.4.1 Source-category description (2.C.4)

CRF 2.C.4					
Key source by level (l) / trend (t)		**Gas (key source)**	**1995 - Anteil an der Gesamtemission**	**2007 - contribution to total emissions**	**Trend**
SF_6 used in aluminium and magnesium foundries	- / t	SF_6	0.01 %	0.23 %	rising

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

4.3.4.2 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 lack of the precise decomposition-level data that would support a more precise estimate.

Activity data for aluminium production

SF_6 consumption was determined via direct surveys, regarding sales, of the few providers of the SF_6-containing gas mixture. The survey for the report year 2000 revealed that the gas mixture has no longer been sold since 2000.

Since the 2002 report year, consumption data have been obtained via surveys of gas sellers' figures for SF_6 sales.

Activity data for magnesium production

Since the 2002 report year, consumption data have also been obtained via surveys of gas sellers' figures for SF_6 sales.

The described procedure has been applied to all report years other than 1996 and 1999, for which lacking yearly data were obtained via interpolation.

4.3.4.3 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 (and part of the HFC-134a used in such production is probably broken down as well). 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.

4.3.4.4 Source-specific quality assurance / control and verification (2.C.4)

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 been carried out completely.

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. In this year's report, 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. This led to identification of a new source, "aluminium casting". Sales figures and industrial usage quantities were compared for report year 2004 and showed good agreement.

4.3.4.5 Source-specific recalculations (2.C.4)

Data for the years 1996 through 2006 were recalculated, to take account of new findings resulting from a pertinent technical discussion conducted at the Federal Environment Agency in December 2007.

4.3.4.6 Planned improvements (source-specific) (2.C.4)

No improvements are planned at present.

4.3.5 Metal production: Other (2.C.5)

For this source category, only emissions from use of HFC-134a in magnesium foundries are reported.

4.3.5.1.1 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.

4.3.5.1.2 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 4.3.4.2.

The information regarding uncertainties, quality assurance and improvements, relative to use of SF_6 in magnesium production (2.C.4) also applies for use of HFC-134a, and is thus provided in the relevant sections for 2.C.4.

4.3.5.1.3 Source-specific quality assurance / control and verification (2.C.5)

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

4.4 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.

4.4.1 Other production: Pulp and paper (2.D.1)

4.4.1.1 Source-category description (2.D.1)

CRF 2.D.1					
Key source by level (l) / trend (t)		**Gas (key source)**	**1995 - Anteil an der Gesamtemission**	**2007 - 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										
Method of EF determination										

The source category "Other production" (2.D.1) is not a key source with regard to production of pulp and paper (pulp and paper industry).

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 3.1 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 2, Chapter 14.2.4.1.

4.4.1.2 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 65 were used until the 2004 report year.

Table 65: 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 66: Real emission factors, for German plants, from pulp production. (German contribution to revision of the BVT information sheet (Merkblatt) 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 2007 the following quantities were produced, in a total of 138 plants:

Table 67: Pulp and paper production, produced quantities

Product	Quantities produced in 2007	
Production of paper, cardboard and carton (PCC):	23.2	million tonnes
Raw-material production:		
Paper pulp	1,545,372	t
of this, sulphite pulp	632,784	t
of this, sulphate pulp	836,189	t
Wood pulp	1,456,023	t
Recycled paper	13,167,000	t
Quantity of recycled paper used for this purpose	(15,745,816	(t)

Source: Verband Deutscher Papierfabriken, Leistungsbericht 2008

These figures can be traced to the base year, 1990.

4.4.1.3 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.

4.4.1.4 Source-specific quality assurance / control and verification (2.D.1)

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

4.4.1.5 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.

4.4.1.6 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.

4.4.2 Other production: Food and drink (2.D.2)

4.4.2.1 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**	**2007 - 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	
Method of EF determination									CS	

The source category "Other production: food and drink" (2.D.2) 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 (IPCC, 1996a: p. 2.41). Solvent emissions related to production of margarine and vegetable oils are reported in source category 3.D. 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 about EUR 147.4 billion, the food and beverage industry was one of the most important industries in Germany in 2007. Nation-wide, 517,000 people were employed in food-industry companies (BVE 2007). Pursuant to the 1993 Classification of Economic Activities (WZ 93), the food and beverage industry is divided into nine groups and a total of 33 classes. Governmental statistical evaluations are oriented to this classification. 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 hard and hardened fats
- Cake, cookies and breakfast cereals
- Bread
- Animal feedstuffs
- Coffee roasting

Emission factors for NMVOC emissions relative to these products are listed (IPCC, 1996c: p. 2.41f).

4.4.2.2 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 DESTATIS (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).

Table 68 shows the activity rates determined, emission factors used and the relevant NMVOC emissions calculated for the year 2006.

Table 68: NMVOC from the food industry (2.D.2)

Product	Activity rates		Emission factors		Emissions [t]
Bread					
- Industrial bakeries	3,466,691	t	0.3* kg/t		1,080.0
- Craft bakeries	851,512		3.0* kg/t		2,654.4
Cake, cookies and breakfast cereals	2,559,030	t	0.1*	kg/t	255.9
Sugar	3,643,754	t	0.9*	kg/t	3,279.4
Meat, poultry, fish	1,476,716	t	0.03*	kg/t	44.3
- Meat/fish, smoked	2,879,012	t	0.0023*	kg/t	6.6
Animal fats	347,497	t	1*	kg/t	347.5
Coffee roasting	547,128	t	0.069*	kg/t	37.7
Feedstuffs	18,705,092	t	0.1*	kg/t	1,818.6
Beer	97,188,430	hl	0.002*	kg/hl	194.4
Wine					
- Red wine	4,056,668	hl	0.08	kg/hl	324.5
- White wine	6,203,877	hl	0.035	kg/hl	217.1
- Other wines	876,299	hl	0.058	kg/hl	50.8
Spirits	1,216,967	hl	2.93*	kg/hl	3,565.7

* With reduction measures taken into account

A total of 13.9 Gg of NMVOC emissions result for source category 2.D.2.

4.4.2.3 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 some 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 are 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.

4.4.2.4 Source-specific quality assurance / control and verification (2.D.2)

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

Other countries' reports contain very little information about 2.D.2, and thus no comparisons are possible at present.

4.4.2.5 Source-specific recalculations (2.D.2)

Source-specific recalculations were carried out in all source areas, with the exception of red-wine and white-wine production.

4.4.2.6 Planned improvements (source-specific) (2.D.2)

No improvements are planned at present.

4.5 Production of halocarbons and SF_6 (2.E)

CRF 2.E				
Key source by level (l) / trend (t)		**Gas (key source)**	**1995 - Anteil an der Gesamtemission**	**2007 - contribution to total emissions**	**Trend**
Production of HCFC-22	l / t	HFC	0.33 %	0.02 %	falling
Production of halocarbons and SF_6: fugitive emissions	l / t	PFC	0.18 %	1.07 %	rising

Gas	**CO_2**	**CH_4**	**HFC**	**PFC**	**SF_6**	**N_2O**	**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			-		-					
Method of EF determination			-		-					

The source category "Production of halocarbons [here, only HFC] and SF_6" is a key source of HFC emissions in terms of trend. It is subdivided into 2.E.1 By-product emissions and 2.E.2 Fugitive emissions.

4.5.1 By-product emission (2.E.1)

4.5.1.1 Source-category description (2.E.1)

For process-related reasons, production of H-CFC-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 H-CFC-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 H-CFC-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.

4.5.1.2 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 H-CFC-22 production, H-CFC-23 concentrations in exhaust gas (as measured annually), sales of HFC-23 and quantities of HFC-23 delivered to the cracking plant. For the 1995 report year, 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 H-CFC 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. These are reported in aggregated form, together with emissions from the CRF sub - source category 2.E.2, since they are confidential.

4.5.1.3 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.

4.5.1.4 Source-specific quality assurance / control and verification (2.E.1)

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 been carried out completely.

4.5.1.5 Source-specific recalculations (2.E.1)

No recalculations are required.

4.5.1.6 Planned improvements (source-specific) (2.E.1)

No improvements are planned at present.

4.5.2 Production-related emissions (2.E.2)

4.5.2.1 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.

4.5.2.2 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

As the sole HFC producer in Germany, the company enjoys confidentiality protection. While emissions and production quantities are reported to the Federal Environment Agency, they are reported only as aggregated with emissions for CRF sub- source category 2.E.1 and emissions from use of SF_6 in sport shoes, from use in welding and from use in AWACS maintenance as described under 2.G.

4.5.2.3 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.

4.5.2.4 Source-specific quality assurance / control and verification (2.E.2)

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 been carried out completely.

4.5.2.5 Source-specific recalculations (2.E.2)

No recalculations are required.

4.5.2.6 Planned improvements (source-specific) (2.E.2)

No improvements are planned at present.

4.5.3 Other (2.E.3)

No other sources of greenhouse-gas emissions are known.

4.6 Consumption of halocarbons and SF_6 (2.F)

CRF 2.F					
Key source by level (l) / trend (t)		**Gas (key source)**	**1995 - Anteil an der Gesamtemission**	**2007 - contribution to total emissions**	**Trend**
Consumption of halocarbons and SF_6	l / t	PFC	0.51 %	0.28 %	falling

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			-	-	-					
Method of EF determination			s. Text	s. Text	s. Text					

The source category "Consumption of halocarbons and SF_6" is a key source of PFC 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 from source category 2.F from use of fluorinated greenhouse gases. The remaining emissions are distributed among the sources "foams" and "aerosols" and, in small amounts, "fire extinguishers", "solvents" and "coatings".

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 69: Overview of methods and emission factors used for the current report year, in source category 2.F (Consumption of halocarbons and SF_6).

		Method	Gas			Emissionsfaktor (dimensionslos)		
			HFC	PFC	SF_6	(CS)	Application	Waste management
1. Air-condition and refrigeration systems	**2.F.1**							
Household refrigeration	2.F.1a	Tier 2a	HFC			NO	0.003	NE
Commercial refrigeration	2.F.1b			PFC		0.002	0.015 - 0.15	0.3-0.5
Refrigeration for transports (vehicles and containers)	2.F.1c					0.005	0.15 - 0.25	1
Industrial refrigeration	2.F.1d					0.0015	0.07	0.3
Stationary air-conditioning systems	2.F.1e					0.01	0.06	0.3
Room air conditioners						NE	0.025	NE
Mobile air-conditioning systems	2.F.1f							
- Trucks						2 g / unit	0.10 - 0.15	0.3
- Automobiles						2 g / unit	0.1	
- Busses						5 g / unit	0.15	
- Ships						0.01	0.05	
- Railway vehicles						0.002	0.15 - 0.25	
- Agricultural machines						5 g / unit	0.15 - 0.25	
2. Foam production	**2.F.2**							
Hard foam with 134a	2.F.2a	Tier 2a	HFC			0.1	0.005	NO
Hard foam with 365mfc/245fa/227ea						0.15	0.01	
Integral foam						1	NO	
PUR foam (134a)						1 g / can	1	
PUR foam (152a)						1 g / can	1	
XPS foam (134a)						C	0.0066	
XPS foam (152a)						1	NO	
3. Fire extinguishers	**2.F.3**	CS	HFC			0.001	0.014	NO
4. Aerosols	**2.F.4**							
Metered dose inhalers	2.F.4a	CS	HFC			0.15 g/can (10 ml)	1	NO
Other aerosols / novelties	2.F.4b/c	Tier 2				0.015	1	
5. Solvents	**2.F.5**	Tier 2				NE	1	
6. Semi-conductor production	**2.F.6**	Tier 2a		PFC	SF_6	NO	CS	
7 Electrical operating equipment	**2.F.7**							
Switching equipment	2.F.7a	Tier 3a			SF_6	0.02	0.001 – 0.01	0.02
Other	2.F.7b	CS				0.15 - 1	NO	NO
8 Other	**2.F.8**							
Insulated glass windows	2.F.8a	Equ. 3.24 ff			SF_6	0.33	0.01	1
Car tyres	2.F.8b	Equ. 3.23				NE	NE	1
Sports shoes	2.F.8c	Equ. 3.23						
Trace gas	2.F.8d	Equ. 3.22				1	NO	NO
AWACS maintenance	2.F.8e	CS					1	
Welding	2.F.8f	CS				NO	1	NO
Optical glass fibre	2.F.8g	CS				0.7	NO	NO
Photovoltaics	2.F.8h	CS				0.5	NO	NO

Equ. = Equation; 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) or modelled (M).

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 that 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.

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:
   $EM_{production} = EF_{production} *$ domestic new consumption

   Equation 1

2. Application emissions are based on the average annual stock of relevant pollutants (the activity rate), and they are calculated via the following formula:
   $EM_{application} = EF_{application} *$ Stocks

   Equation 2

   These 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:
   $EM_{disposal} = EF_{disposal} *$ New additions (n-X)

   Equation 3

The data for the years 1991 to 1994 – to the extent HFC use was already occurring – were completed in connection with the last report. The data are based on various research reports and discussion records from 1996, and in 2005 they were checked to the extent possible by an external expert. The data are described in the research project "Surveys of inventory gases (F gases)" ("Erhebung von Inventargasen (F-Gasen)") of January 2007.

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.

4.6.1 Refrigeration and air-conditioning systems (2.F.1)

4.6.1.1 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 69).

In Germany, the leading pure-HFC refrigerants 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. The emission factors for waste disposal are the standard values from the IPCC Guidelines of 1996.

For some sub - source categories, disposal emissions occurred for the first time in 2003.

4.6.1.2 Methodological issues (2.F.1)

4.6.1.2.1 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. In preparation for its use, 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.

4.6.1.2.2 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 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 R-404A refrigerant mixture was not widely used until 1994. R-407C's share of the refrigerant market, in the commercial refrigeration sector, is estimated to have been less than 1% in 1994.

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 H-CFCs).
- 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 refrigeration, disposal emissions occurred for the first time in 2003. These are calculated via Equation 3.

Emission factors

As a rule, filling of refrigeration systems produces only small quantities of emissions. Except for $EF_{disposal}$, the emission factors used are the result of surveys of experts and of evaluations of the literature.

For "initial emission", IPCC-GPG gives a figure of 0.5 to 3 percent of the initial filling quantity. As a result, the country-specific $EF_{production}$ will be 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.

4.6.1.2.3 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.

Refrigeration 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. It 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 69. Except for $EF_{disposal}$, the emission factors used are the result of surveys of experts.

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.

4.6.1.2.4 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.

4.6.1.2.5 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.

4.6.1.2.5.1 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.

There is no domestic production of room air-conditioners. Room air conditioners are normally already filled when imported. "VRF" units (multi-split units with up to 7 internal units) make up one 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 devices, split devices, multi-split devices and VRF 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 split and multi-split units are not taken into account, because they represent only very small quantities within the model. The situation is different for VRF systems. On the basis of surveys of experts, we assume installation losses of 5 g per internal unit.
- Emissions from stocks are calculated with Equation 2.
- No disposal emissions have occurred to date.

The country-specific emission factor 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, split, multi-split, VRF), unit sizes and refrigerant types.

4.6.1.2.5.2 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.
- No disposal emissions have occurred to date.

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.

Filling losses are far below the range given in IPCC-GPG (2000). In addition, that range is not based on fill amounts; it is stated in terms of fixed losses per system.

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.

4.6.1.2.5.3 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 be reported until the 2010 report year.

4.6.1.2.6 Mobile air-conditioning systems (2.F.1.f)

"Mobile air-conditioning systems" comprises vehicle air-conditioning systems in passenger cars, trucks and utility vehicles, buses, agricultural machinery, rail vehicles and ships. Hydrofluorocarbons (HFCs) have been used in mobile air-conditioning systems since 1993. Today, almost all HFC-based refrigerants in such systems use HFC-134a. 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, buses and agricultural machines.

- Determination of the average rates of installation of air-conditioners in automobiles, trucks / utility vehicles, buses 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 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 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 was retroactively increased from 0.25 to 0.3, and it thus now is equivalent to 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.

4.6.1.3 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.

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 is considered 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 largely quantified for the 2009 report. Current planning calls for the uncertainties for units in refrigerated vehicles to be quantified for the 2010 report.

4.6.1.4 Source-specific recalculations (2.F.1 all)

The quantities of R508B used in the the area of commercial refrigeration systems were recalculated for the 2009 report. This led to changes in the data for R23 and R116. For 2007, those quantity figures were decreased, in comparison to the corresponding figures for previous years, in accordance with pertinent data of the Federal Statistical Office, which became available for the the first time.

In the area of industrial refrigeration systems, disposal is being taken into account as of the 2009 report. This has necessitated recalculations for the years 2003 through 2006.

The emissions calculations for automobile air conditioners had contained errors. Correction of those errors necessitated recalculations for all the data.

In the area of air conditioners for trucks / utility vehicles, a service lifetime of 12 years is no longer being assumed as of the 2009 report. The service lifetime is now considered to be 10 years, and this has necessitated data recalculations for the years 2003 through 2006.

The data for air conditioners in railway vehicles have had to be recalculated as a result of review of data-collection procedures. Air conditioners have been used in trams since 2000, and such air conditioners have been taken into account as of report year 2007.

As to air conditioners on ships, the 2009 report now takes account of the fact that ocean-going cargo ships have been commonly equipped with air conditioners since 1997 – and not only since 2000, as was previously assumed. This change has necessitated recalculations for the years 1997 through 2006.

In the area of refrigerated vehicles, a 50% share for R404A in small vehicles with up to 5t permissible gross weight has been assumed since the reported year 2006. This reduces the average stocks, and the emissions, for R134a in 2006. In addition, the emission factor for small vehicles has been raised from 15 to 30%.

4.6.1.5 Planned improvements (2.F.1 all)

Plans for the next report call for review and updating of the model assumptions for commercial refrigeration systems, industrial refrigeration systems, refrigerated vehicles and stationary air conditioning systems.

For household air conditioners, as of next year it will be assumed that old units are disposed of at the end of an average service lifetime of 15 years.

In addition, pertinent lacking uncertainties will be filled in next year.

4.6.2 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 H-CFCs.

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 PU hard foam, PU integral foam, PU foam sealant (one-component foam – OCF) and XPS insulation foam.

4.6.2.1 PU foam products (2.F.2)

4.6.2.1.1 Source-category description (2.F.2)

The group of PU 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 PU hard foams. HFCs have been giving way to hydrocarbons such as pentane.

The time series, which does not begin until after 1995, 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 H-CFC.

Along with HFC-134a and 152a, 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 hard foams was discontinued in 2004.

4.6.2.1.2 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 largely equivalent to the standard values given in IPCC-GPG (2000). They have been checked with national experts, however, and adjusted in part. For example, the emission factor for production of PU 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).

4.6.2.2 PU foam sealants (2.F.2)

4.6.2.2.1 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 H-CFCs, 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 in use since 1992, while HFC-152a has been used since 2002 as a substitute for HFC-134a.

4.6.2.2.2 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 manufacturers.

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 per year in Germany
- HFC content per can, in grams
- Applicable percentage shares for the various HFC types
- 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 that are sold annually in Germany
- Number of cans with blowing agent 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.

4.6.2.3 XPS hard foam (2.F.2)

4.6.2.3.1 Source-category description (2.F.2)

HFC consumption and emissions from production of XPS insulation boards have occurred only since 2001, since H-CFCs 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.

4.6.2.3.2 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[32] or by its industry group EXIBA[33] .

Trials with HFC collection and recovery have been conducted, but to date no relevant systems have been implemented, for both technical and economic reasons.

[32] CEFIC – The European Chemical Industry Council

[33] EXIBA – European Extruded Polystyrene Insulation Board Association

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 to 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 %, 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. It varies between 0.26 and 0.3. The two $EF_{production}$ are provided by the industry association CEFIC[34] or by its sector association EXIBA[35].

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 and HFC-152a (WEILBACHER 1987). The EF_{use} from that laboratory study is used. 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).

4.6.2.4 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 PU 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. They have not yet been quantified, however.

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

[34] CEFIC – The European Chemical Industry Council

[35] EXIBA – European Extruded Polystyrene Insulation Board Association

also applies to the export rate and the HFC production emissions determined for use of HFC-134a.

The production emissions in use of HFC-152a, 100 %, do not agree with the existing IPCC estimates. Nonetheless, the industry association considers them to be realistic.

The value for the emissions rate from current stocks, as determined by a laboratory study, will be used as long as no reliable measurements with insulation boards in actual service have been carried out; such measurements could be considered more conclusive than laboratory values.

4.6.2.5 Source-specific recalculations (2.F.2)

The hard-foam-product data have been recalculated for 2006, since a review of data collection identified a need for corrections.

In keeping with pertinent consultation with experts, in the 2009 report, the emission factor $EF_{production}$ for PU foam sealants has been retroactively changed for the years as of 2003. Review of data collection, and data cross-checking with a company (PDR) that recycles PU foam cans, revealed a need for recalculation of data for PU foam sealants as of 2002.

The procedure used for calculation of emissions of XPS hard foam was simplified, since the relevant industry association reports new domestic HFC consumption; that consumption no longer has to be calculated from the total produced volume of XPS insulation (in m^3). Data recalculation was not required, however.

4.6.2.6 Planned improvements (source-specific) (2.F.2)

Review and updating of the underlying model assumptions for PU foam sealants are planned for the next report.

4.6.3 Fire extinguishers (2.F.3)

4.6.3.1 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. 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.

4.6.3.2 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 such activity rates are available in Germany, 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.

Fire extinguishing systems have average service lifetimes of up to 35 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.

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 data for HFC-23 are based on estimates of the Federal Environment Agency made by analogy to HFC-227ea.

4.6.3.3 Uncertainties and time-series consistency (2.F.3)

The uncertainties for the "fire extinguishing agents" sub- source category have been systematically quantified.

4.6.3.4 Source-specific recalculations (2.F.3)

The values for R227ea were recalculated as of 2006, since the company in question reduced its market share.

4.6.3.5 Planned improvements (source-specific) (2.F.3)

No improvements are planned at present.

4.6.4 Other aerosols (2.F.4)

This area includes metered-dose inhalers (MDI), which are used in medical applications, as well as general aerosols and so-called "novelty aerosols".

4.6.4.1 Metered-dose inhalers (2.F.4.a)

4.6.4.1.1 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 beta-mimetics.

4.6.4.1.2 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 emission data 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 all enter into calculations.

4.6.4.2 Other aerosols (2.F.4.b)

4.6.4.2.1 Source-category description (2.F.4.b)

In Germany, six types of general 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.

Use of HFC-134a began in 1992. The data for the period prior to 1995 are based on experts' assessments.

Domestic filled quantities of HFCs have remained constant since 1995. Other relevant products include novelty aerosols (artificial snow, party-streamer sprays, etc.), which emit some 100 t of HFCs per year. No novelty sprays are produced in Germany, however.

4.6.4.2.2 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 (EF_{use} = 1) is assumed; this is appropriate and justified. Of the sprays sold in Germany, it is assumed that one-half are used in the same year they are purchased and the other half are used in the following year. This is in keeping with IPCC-GPG (2000).

The $EF_{production}$ is based on experts' assessments.

Activity data

In keeping with a bottom-up approach, all quantity data are provided directly by producers, fillers and operators, as well as by relevant industry associations. In the case of general aerosols, filling emissions (= production emissions) are also taken into account. Estimates are based on EU-wide data.

4.6.4.3 Uncertainties and time-series consistency (2.F.4 all)

The surcharge factor for hospitals and doctors' samples can vary, by ±2%, from the above-cited 13%.

All of the uncertainties have been entered into the CSE.

In comparison to the emissions data for metered-dose inhalers, the data for other aerosols are not considered to be very 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. At present, the uncertainties cannot be quantified.

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.

4.6.4.3.1 Source-specific recalculations (2.F.4 all)

Consumption of medicinal sprays in 2006 was recalculated in keeping with new findings from surveys of the Federal Statistical Office. Changes have also resulted in the data for "general aerosols". Calculation errors had to be corrected in this area.

4.6.4.3.2 Planned improvements (source-specific) (2.F.4 all)

No improvements are planned at present.

4.6.5 Solvents (2.F.5)

4.6.5.1 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.

4.6.5.2 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, for other aerosols they are summed with data for HFC-134a.

4.6.5.3 Uncertainties and time-series consistency (2.F.5)

All of the uncertainties for the sub- source category "solvents" have been identified.

4.6.5.4 Source-specific recalculations (2.F.5)

No recalculations have been carried out.

4.6.5.5 Planned improvements (source-specific) (2.F.5)

No improvements are planned at present.

4.6.6 Semiconductor manufacturing (2.F.6)

4.6.6.1 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 PFC time series shows a continual emissions increase until the year 2000, since the number of reporting companies has increased. This group includes not only new plants; it also includes plants that were already producing in 1995 but not yet participating in monitoring (no extrapolations were carried out). For this reason, emissions prior to 1999 were systematically underreported. The increase thereafter is due mainly to increased production.

4.6.6.2 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 react 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.

4.6.6.3 Source-specific recalculations (2.F.6)

No recalculations have been carried out.

4.6.6.4 Planned improvements (source-specific) (2.F.6)

No improvements are planned at present.

4.6.7 Electrical equipment (2.F.7)

4.6.7.1 Source-category description (2.F.7)

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.

4.6.7.2 Methodological issues (2.F.7)

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.F8 – electrical operating equipment for energy transmission and distribution, with sub- source categories – 2007 inventory	Activity data			Emissions	
	Annual consumption, production	Stocks	Decommis-sioned	Production	Operation
	(Tonnes of SF_6)				
Electrical operating equipment for energy transmission and distribution 2.F.8 (Total), including:	742,8	1762,7	7,3	17,6	7,98
MV switching systems and equipment (in hermetically sealed pressurised systems)*	163,8	685,97	0,28	1,31	0,69
HV switching systems and equipment (in hermetically sealed pressurised systems)**	514,1	931,5	7,03	6,35	6,89
Subtotal: HV and MV switching systems and equipment	677,9	1617,47	7,31	7,66	7,58
Other electrical operating equipment ***	65,8	145,2	IE	9,87	0,41

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)

4.6.7.3 Uncertainties and time-series consistency (2.F.7)

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, the staff responsible for operating equipment in service was repeatedly replaced. 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.

4.6.7.4 Source-specific recalculations (2.F.7)

No recalculations have been carried out.

4.6.7.5 Planned improvements (source-specific) (2.F.7)

No improvements are planned at present.

4.6.8 Other (2.F.8)

This source category includes uses in insulating glass windows (2.F.8.a Insulating glass windows), in automobile tyres (2.F.8.b Automobile tyres), in sport shoes (2.F.8.c Sport shoes), as trace gases (2.F.8.d Trace gas), in radar systems (2.F.8.e AWACS maintenance), in welding (2.F.8.f Welding), in production of optical glass fibre (2.F.8.g Optical glass fibre) and in solar technology (2.F.8.h Photovoltaics).

4.6.8.1 Insulating glass windows (2.F.8.a)

4.6.8.1.1 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. As necessary, they are filled with gas. Exports of assembled windows play no significant role.

Since 4 July 2007, a ban has been in force in the EU on sale of windows, for residential uses, that are filled with fluorinated greenhouse gases. As of 4 July 2008, that ban will also include 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.

4.6.8.1.2 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 being 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.

4.6.8.2 Automobile tyres (2.F.8.b)

4.6.8.2.1 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.

4.6.8.2.2 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.

4.6.8.3 Sport shoes (2.F.8.c)

4.6.8.3.1 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 was used. Use of that substance was discontinued in 2006, and now nitrogen is used in most cases. No sport shoes with SF_6-cushioned soles are produced in Germany. Sale of footwear

produced with fluorinated greenhouse gases has been prohibited in the EU since 4 July 2006.

4.6.8.3.2 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. The data has been available to the Federal Environment Agency since the 2001 report year, but it is published only in aggregate form, for reasons of confidentiality.

4.6.8.4 Trace gas (2.F.8.d)

4.6.8.4.1 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 ground-level and atmospheric airflows and gas dispersions.

4.6.8.4.2 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. As of report year 2007, total domestic use of SF_6 as a trace gas has been down sharply from previous years.

4.6.8.5 AWACS (airborne warning and control system) maintenance (2.F.8.e)

4.6.8.5.1 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.

4.6.8.5.2 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.

4.6.8.6 Welding (2.F.8.f)

4.6.8.6.1 Source-category description (2.F.8.f)

In the 2007 report year, reported data includes, for the first time, data on welding applications. 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.

4.6.8.6.2 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.

4.6.8.7 Optical glass fibre (2.F.8.g)

4.6.8.7.1 Source-category description (2.F.8.g)

In report year 2007, data for the application "optical glass fibre" are being reported for the first time, in keeping with findings gained from surveys of the Federal Statistical Office. According to gas suppliers, use in 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.

4.6.8.7.2 Methodological issues (2.F.8.g)

Emissions occur in production of optical glass fibre cable.

Emission factors

The 2006 IPCC Guidelines[36] 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 have been checked against the Federal Statistical Office's pertinent annual surveys.

4.6.8.8 Photovoltaics (2.F.8.h)

4.6.8.8.1 Source-category description (2.F.8.h)

In report year 2007, data for the application "photovoltaics" are being reported for the first time, in keeping with findings gained from surveys of the Federal Statistical Office. According to gas suppliers, use of SF_6 in solar technology began in 2002. SF_6 and other fluorine compounds are used in Germany in wafer production, in circuit etching and for cleaning of reaction chambers in the production process. Since the process gas used has lower purity than the gas used in the similar production process in the semiconductor industry, use for photovoltaics is reported separately. A considerable number of companies in Germany now used SF_6 in production.

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, when the number of production operations and, thus, the quantities of SF_6 used, increased sharply.

4.6.8.8.2 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

[36] IPCC GL 2006, Vol. 6, chapter 6: Electronics Industry

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[37] 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.

4.6.8.9 Uncertainties and time-series consistency (2.F.8 alle)

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 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.

4.6.8.10 Source-specific recalculations (2.F.8)

For insulating glass windows, the 2006 data were recalculated to take account of new annual-new-consumption data from surveys of the Federal Statistical Office. As a result, SF_6 emissions from that application increased by 0.74 t for the year 2006.

In the 2007 report year, data is being reported for the first time for the applications welding (2.F.8.f), optical glass fibre (2.F.8.g) and photovoltaics (2.F.8.h), in keeping with the availability of new findings resulting from pertinent surveys of the Federal Statistical Office.

According to gas suppliers, use of SF_6 in welding began in 2001. Use in connection with optical glass fibre (2.F.8.g) and photovoltaics (2.F.8.h) did not begin until 2002.

Higher emissions for the years 2001 through 2006 result for source category 2.F.8 as a result of necessary recalculations for those report years.

4.6.8.11 Planned improvements (source-specific) (2.F.8)

No improvements are planned at present.

[37] IPCC GL 2006, Vol. 6, chapter 6: Electronics Industry, Table 6.5

4.6.9 Source-specific quality assurance / control and verification (2.F all)

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 been carried out completely. 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[38], production and sales figures[39], 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.

4.7 Other areas (2.G.)

For reasons of confidentiality, SF_6 emissions from production of SF_6 (2.E), from use in sport shoes (2.F.8 Other – sport shoes), from use in AWACS maintenance (2.F.8 Other – AWACS maintenance) and from use in welding (2.F.8 Other – welding) are reported under 2.G.

No other sources of greenhouse-gas emissions are known.

[38] Surveys pursuant to Art. 11 of the Environmental Statistics Act (UstatG).

[39] Surveys pursuant to the Foreign Trade Statistics Act (AHStatGes) and production statistics.

5 SOLVENTS AND OTHER PRODUCT USE (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 industry, trade and commerce and households, as well as detailed information about release of N_2O during its use. Emissions from direct use of CO_2 in products have been neglected to date.

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" (3.D). In the CSE, "Other" (3.D) includes emissions of laughing gas (cf. Chapter 5.2), emissions from selective catalytic reduction (SCR) systems and the above-detailed other solvent uses that cannot be allocated to source categories 3A through 3C.

N_2O emissions from source category 3.D Other are reported separately from the other parts of Chapter 5.2, in keeping with the fact that emissions from substance release of N_2O, in the various possible applications, have been studied in a research project and are now reported in greater detail. That research project considered the various pertinent potential emissions sources (including explosives production), as listed in the IPCC Good Practice Guidance (2000), and it specified methods, prepared documentation, carried out relevant recalculations and made pertinent additions to the inventory. NMVOC emissions from source category 3.D Other were not covered by the aforementioned research project.

5.1 Solvents - NMVOC (3.A-3.C & 3.D)

5.1.1 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**	**2007 - 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	CS	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination										

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[40].

Category 3D "other" includes the following applications and activities:

- Treatment of glass and rock wool

40 In the present area, this involves "SNAP Level 3" detailing.

- 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[41]. For purposes of the definition of solvents, the term "solvent use" is also defined in keeping with the EC solvents directive[42].

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 toluene diisocyanate (TDI), and methyl ethyl ketone (butanone), which is used as a solvent in printing inks and as a base material for synthesis of methyl ethyl ketone peroxide. VOC (either substances or fractions of substances or products) in uses 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.

5.1.2 Methodological issues (3.A-3.C & 3.D)

NMVOC emissions are calculated in keeping with a product-consumption-oriented approach. 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.

41 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.

42 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.

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 3A – 3D, 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 an initial 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 will be 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 low-solvent paints, lacquers and glues, 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:

$EM_{indirect\ CO2} = EM_{NMVOC}$ * molar mass CO_2 / molar mass C * 75%

5.1.3 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.

5.1.4 Source-specific quality assurance / control and verification (3.A-3.C & 3.D)

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.

The NMVOC-emissions data for 2001 and 2002, as used in the emissions inventory, were obtained via a research project and were evaluated, in the framework of this project, for methodological and material consistency, plausibility and completeness. In the course of this review, the relevant methods were optimised in co-operation with the affected industry sectors.

Comparisons with older emissions calculations involve product-based reviews, as well as correction of errors resulting from erroneous production statistics. In the past, relevant quantities (> 100 kt) of base substances for the chemical industry were erroneously reported as "other organic solvents". This correction led to a reduction – also amounting to ca. 100 kT – of total emissions in the area of source category 3.

In a partial result of another research project, the survey methods were adapted to the latest changes in the underlying basic statistical systems; this adaptation led to inventory improvements for the years beginning with 2003.

5.1.5 Source-specific recalculations (3.A-3.C & 3.D)

For the 2009 report, indirect CO_2 emissions from NMVOC have been calculated for the first time. Recalculations were carried out for the entire time series.

5.1.6 Planned improvements (source-specific) (3.A-3.C & 3.D)

To reduce data uncertainty in the area of NMVOC, for other emissions-relevant source-category areas, plans call for comparing the input figures used (quantities and VOC concentrations) with industry data.

In addition, as part of periodical updates of source-category emissions, discussions have to be carried out with industry associations, aimed at reaching agreements on regular provision of differentiated industry data. These activities are being continued.

5.2 Other - N_2O (3.D)

5.2.1 Narcotic use of N_2O (3.D.1)

5.2.1.1 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**	**2007 - 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) N_2O als Anästhetika						CS				
EF uncertainties in %										
Distribution of uncertainties						N				
Method of EF determination						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_2O-emissions source. In addition, food-technology applications, and various other technical applications, can be considered possible sources.

N_2O in medical applications

In medicine, nitrous oxide, which has analgesic properties, is used for narcotic purposes. It is the oldest narcotic in use, and it is among those with the fewest side-effects. 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. Globally, medical N_2O emissions account for some 10 % of total nitrous oxide emissions (INNOVATIONS-REPORT, 2004). While medical use of N_2O is not prohibited, there is strong resistence – especially among German anaesthetists – against widespread, general use of the substance.

Use of xenon as an anaesthetic could bring about a further reduction of N_2O 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 cannot serve as a substitute for nitrous oxide – only as a supplement.

The 1990 figure for N_2O emissions from medical applications is based on an extrapolation of a statistical plant survey conducted in 1990 in the territory of the former GDR. At the time, it was ascertained that one plant for the production of N_2O for narcotic purposes had existed in the former GDR. Also at the time in question, the plant had not yet been operational for long (it was constructed in 1988). The annual production capacity was approximately 1200 t. Research indicated that there were no exports or imports of this substance, and thus it was assumed that all of the production was used for domestic consumption. Via the per-capita emissions calculated from this for the former GDR, and assuming identical conditions, N_2O emissions of 6200 t were estimated, as a rough approximation, for Germany in 1990. The

N_2O figure for 2001 was obtained via a written memorandum of the Industriegaseverband e.V. (IGV) industrial-gas association. This figure was tied to a range of 3,000 ~ 3,500 t/a. The mean value from this range (3,250 t/a) was then used for generation of an N_2O-emissions time series. For the period between 1990 and 2001, a linear reduction of N_2O use in this sector is assumed, due to a lack of other pertinent data.

The reduction in N_2O use in this period results from acceptance of the "low-flow method"[43] 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 between 2002 and 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. Nitrous oxide is generally certified for use with foods; no maximum amounts that may not be exceeded are mandated. Use of nitrous oxide as a food additive is considered safe. (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[44] 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 are 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 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

[43] 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)

[44] Personal communication from the Industriegaseverband e.V. (IGV) industrial-gas association

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"[45].

5.2.1.2 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 %[46]) and food-technology applications (less than 5 %[47]) . From this information, the pertinent share for the food-technology industry is estimated at 3 %, and thus the corresponding share for the "technical applications" 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 applications. 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.

5.2.1.3 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
5. 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

[45] Written communication from the Industriegaseverband e.V. (IGV) industrial-gas association

[46] Personal communication from the Industriegaseverband e.V. (IGV) industrial-gas association

[47] Personal communication from the Industriegaseverband e.V. (IGV) industrial-gas association

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.

6. With these results, the time series can be considered to show a normal distribution (distribution type).
7. 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.

5.2.1.4 Source-specific quality assurance / control and verification (3.D.1)

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has not been carried out. The data for this source category was collected by an external expert, on behalf of the Federal Environment Agency. Quality control was carried out by the external expert.

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.

5.2.1.5 Source-specific recalculations (3.D.1)

No recalculations are required.

5.2.1.6 Planned improvements (source-specific) (3.D.1)

No improvements are planned at present. At the same time, plans call for close cooperation with the Industriegaseverband e.V. industrial-gas association to continue in future, so that it will remain possible to obtain data.

5.2.2 Explosive (3.D)

5.2.2.1 Source-category description (3.D)

CRF 3.D					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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) Explosives						CS				
EF uncertainties in %						±40 %				
Distribution of uncertainties						N				
Method of EF determination						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[48] , 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[49] . This yields a figure of 51.8 kt for the amount of explosives used in Germany. Of this amount, ANFO accounts for a share of 60 %, emulsion explosives account for 25 % and dynamite accounts for 15 %. ANFO explosives consist of 94 % ammonium nitrate and 6 % fuels. The corresponding relationship for emulsion explosives is 80 % to 20 %; for dynamite, 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[50], for which analyses have been carried out that

[48] Amatol x/y : military explosives. pourable mixtures, i.a. of x % TNT and y % ammonium nitrate

[49] Personal communication: Federal Office for Material Research and Testing (BAM).

[50] 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

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).

5.2.2.2 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[51] , 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. Together with the above-presented time-series trend for N_2O emissions, the time-series trend for the pertinent emission factors can also be obtained:

5.2.2.3 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 5.2.2.2). The same deviation (2 %) is used for the maximum value, and thus U_{max} is 7 %. A normal distribution is assumed.

5.2.2.4 Source-specific quality assurance / control and verification **(3.D)**

The data for this source category was collected by an external expert, on behalf of the Federal Environment Agency. Quality control was carried out by the external expert.

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.

5.2.2.5 Source-specific recalculations (3.D)

No recalculations are required.

[51] 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.

5.2.2.6 Planned improvements (source-specific) (3.D)

No improvements are planned at present.

6 AGRICULTURE (CRF SECTOR 4)

For the 2008 agricultural emissions inventory (covering the years 1990-2006), the IPCC Guidelines 2006 and the draft chapters of the UNECE Atmospheric Emission Inventory Guidebook were applied for the first time, on a trial basis. With this move, Germany acted on the SBSTA's suggestion that it gather experience with the IPCC Guidelines 2006 (cf. FCCC/SBSTA/2007/4, paragraph 56). Germany's approach in this matter was expressly approved by the Expert Review Team on the occasion of the Initial Review in June 2007. The results obtained via that approach diverged considerably from those obtained with earlier methods. The comparability of pertinent procedures and results suffered as a result. In the 2008 agricultural emissions inventory, this problem was addressed via the following temporary measure: the data for 2006 were carried over on the basis of the 2007 report.

The present 2009 agricultural emissions inventory has now been prepared, for the first time, in keeping with the aforementioned updated methods.

Source category description:

Emissions are assigned to the relevant emissions sources in accordance with the reporting categories CRF (Common Reporting Format, IPCC) and NFR (Nomenclature for Reporting, UNECE / EMEP).

Source category 4 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 exemptions are considered to be irrelevant (NO).

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. Dinitrogen (N_2) emissions levels have to be known before the N amounts 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.

CO_2 emissions from agricultural soils, as a result of fertiliser use (liming) have been calculated using the data records described in this chapter, and they are reported under CRF 5.B.

Origins of the activity data

Activity data are taken from official German agricultural statistics, in keeping with availability. Every other year until 2003, results of the complete animal census for German districts are available. For the years in between, and for the years thereafter, only animal head counts for the various Länder are available. The animal censuses cover all cattle, all swine, horses and sheep and all poultry. The data from the last highly detailed animal census (2003) are available, and they have a spatial resolution at the rural district level. For reasons of data

protection, the relevant data records are incomplete. The data from the 2007 animal census (the 2005 census) were used.

German agricultural statistics do not include population figures for goats, mules and asses, fur-bearing animals and buffalo. Some indications as to the sizes of the relevant populations are available, however:

In the past, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) estimated the goat populations for the entire national territory. Since 2005, that time series has been updated by the Federal Statistical Office, and used for purposes of the inventory.

As to mules and asses, about 6,000 to 8,000 asses, and about 500 mules, are kept in Germany (DÄMMGEN et al., 2007). The pertinent emissions are considered negligible (NE).

Official animal censuses do not include all horses, and thus the pertinent figures for horses are likely to be too low. They have been corrected in part (DÄMMGEN, 2005).

The figures for sheep have to be corrected for some years (cf. DÄMMGEN, 2005). As to animals raised for fur, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) obtained the pertinent figures for calculation of NH_3 emissions from the Länder, in one instance for 2000; in some cases, the figures have been estimated.

CH_4 and N_2O emissions are not quantified (NE) for fur-bearing animals (CRF category "Others"), due to a lack of suitable calculation procedures.

The figures for buffalo were provided by the German buffalo association (Deutscher Büffel-Verband).

The population figures used for calves, weaners, laying hens and pullets diverge from the relevant aggregated figures in the official statistics.

Complete land-use data are gathered in Germany every four years. In the inventories, the area figures are used throughout an entire context of activity, area and harvest data. In addition, they serve as input data for modelling important parameters for describing animal-keeping methods and manure management (see below). The data from the last survey (2003) are available in a usable form (i.e. broken down to the district level).

Origins of the variables determining the emission factors

A number of important figures needed for emissions calculation pursuant to a Tier 2 method are not available in official statistics. Such figures were taken from the open literature, from association publications and from regulations for agricultural consulting in Germany.

Models have been prepared for important parameters relative to keeping of animals, storage of farm manure and application of such manure. The initial data for these models was collected via surveys and obtained from special evaluations of statistical data.

The calculation methods and provision of activity data are described in detail in DÄMMGEN et al. (2008).

6.1 Enteric fermentation (4.A)

In the area of animal husbandry, CH_4 emissions from enteric fermentation (4.A) must be reported. Microbial conversion in stomachs of ruminants – especially conversion of cellulose

– releases CH_4. The quantities released per animal and unit of time depend on the animal species in question, individual-animal efficiency and feed composition.

In the CSE, source category 4.A Enteric fermentation is divided into the main sub-categories of cattle, sheep and goats, horses, mules and asses, swine and buffalo. Germany subdivides the main categories of cattle, swine and horses into sub- source categories (cf. Table 71).

Category CRF 4.A "Cattle" consists of the sub-categories "dairy cows" and the aggregated head counts for other cattle ("non-dairy cattle", "other cattle"). The group of "other cattle" includes calves, heifers, fattening bulls, suckling cows and stud bulls.

The source category "Horses" (CRF 4.A.6) is sub-divided into large horses and small horses. No figures for mules and asses are reported.

The German inventory divides source category CRF 4.A.8 "Swine" into sows, weaners, fattening pigs and boars.

Emissions from enteric fermentation in the poultry sector are not calculated, since those emissions are insignificant and since no method for such calculation has been described (NA).

In some cases, the animal head counts listed in official statistics cannot be directly allocated to sub- source categories. Allocations are described in detail in DÄMMGEN et al. (2008).

6.1.1 Source-category description (4.A)

CRF 4.A					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - contribution to total emissions**	**Trend**
Enteric fermentation, dairy cattle (CRF 4.A.1.a)	l / -	CH_4	0.76 %	0.77 %	rising
Enteric fermentation, non-dairy cattle (CRF 4.A.1.b)	l / t	CH_4	0.85 %	0.75 %	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 %		10								
Distribution of uncertainties		N								
Method of EF determination		CS/C/D/ T1/T2								

Within the source category "Enteric fermentation" (4.A), 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.

Germany reports on the 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 and buffalo. Methods are lacking for treating poultry in this context (NA); in accordance with the IPCC (IPCC, 1996b, Chapter 4, Tab. A-4), the relevant quantities are considered negligible and are not calculated (not occurring - NO).

6.1.1.1 Calculated emissions

The total emissions over time are shown in Table 70.

In Germany, almost all CH_4 emissions from enteric fermentation come from keeping of cattle (2007: 92 %). The pertinent shares from keeping of swine are small (2007: 4 %), and those

for all other animals are small enough to be neglected. 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. 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 emissions are calculated for individual districts. Aggregated data on CH_4 emissions (national and at the Länder level) have been compiled by HAENEL et al. (2008).

Table 70: CH_4 emissions E_{CH4} from animal husbandry (enteric fermentation)

[Tg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	1.04	0.92	0.90	0.91	0.90	0.90	0.91	0.88	0.88	0.88
[Tg a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006	2007		
E_{CH4}	0.87	0.89	0.85	0.84	0.82	0.82	0.80	0.81		

6.1.2 Methodological issues (4.A)

For determination of emissions from enteric fermentation, two different detailed methods are proposed: a simple method, with constant emission factors based on internationally accepted estimates (Tier 1 procedure), and a method that reflects the emissions process and that leads to variable emission factors (that depend on place and time) (Tier 2 procedure).

In principle, in both methods the emissions are calculated via the following steps:

- Determination with regard to properties and to 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

The IPCC (2006) calls for the more detailed Tier 2 method to be used in cases in which a country has listed methane emissions from animal husbandry as a key source for its inventories.

The Tier 2 method requires differentiated characterisation of livestock herds. Where a sub-category accounts for a significant share of digestion-related methane emissions, the emissions must be determined pursuant to a Tier 2 method. This means that a country-specific or region-specific, time-dependent emission factor for the animals in question must be determined from suitably variable gross-energy intake, in accordance with the following equation:

Equation 4: Determination of specific emission factors

$$EF_i = \frac{GE_i \cdot x_m \cdot \alpha}{\eta_{CH4}}$$

Where
- EF_i Emission factor for each sub-category i [kg an^{-1} a^{-1} CH_4]
- GE_i Gross energy consumption of the sub-category i [MJ an^{-1} d^{-1}]
- x_m Methane-conversion rate (percentage of gross energy that is converted to methane) [MJ MJ^{-1}])
- α Conversion factor for time units (365 d a^{-1})
- η_{CH4} Energy content of methane (55.65 MJ (kg CH_4)$^{-1}$)

The gross energy intake is calculated on the basis of the *detailed characterisation of livestock* populations, from national data, and the methane-conversion rate for cattle (except for dairy cows and calves), buffalo and sheep is calculated in accordance with IPCC-2006 (Tables 10-12 and 10-13). Since the methane-conversion rate x_m (IPCC: Y_m) is an important factor in this equation, it should also be differentiated by animal species, age/weight and feed. For calves, national data were used (cf. DÄMMGEN et. al., 2008). For dairy cows, the methane-conversion rate was calculated, for the first time, as a function of concentrated-feed percentages of total feed (cf. DÄMMGEN et. al., 2008). For swine and horses, the inventory uses the values recommended by the IPCC (1996b), since the IPCC (2006) does not provide the relevant factors.

Total emissions are then determined as follows:

Equation 5: Complete emissions from the "Enteric fermentation" source category

$$E_{CH4} = \beta \cdot \sum EF_i \cdot n_i$$

where:

	E_{CH4}	Methane emissions [Gg a^{-1}]
	$EF_{iCH4,}$	Emission factor for each sub-category i [kg an^{-1} a^{-1}]
	n_i	Population size for each sub-category i [number of spaces]
	β	Conversion factor for mass units [10^{-6} Gg kg^{-1}]

In analysis of key sources in agriculture, CH_4 emissions from dairy cows and other cattle in category 4 A, "Enteric fermentation", were identified as key sources. This creates a need for differentiated characterisation of livestock herds.

The procedure for calculation of emissions from manure management, with the help of a Tier 2 method, requires detailed calculation of input data (in the present context, excretion of volatile solids, (VS)[52] and of nitrogen). Since emissions from manure management in connection with swine are a key source, emissions from enteric fermentation for this animal category must also be calculated in accordance with the Tier 2 method.

6.1.2.1 Characterisation of animal populations

The total animal population is divided into main and sub-categories for which activity data and emission factors are available. Disaggregation is carried out wherever emission factors differ significantly. The following table compares the German sub-categories and the IPCC proposals.

[52] Volatile solids (VS): the easily convertible carbon fractions in excrement, given as loss on ignition at 800 °C.

Table 71: Detailed characterisation of animal herds pursuant to IPCC, and the breakdown used for Germany

	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 replacement, pulling power	Suckling cows, bulls (mature male cattle)
	Young animals	Heifers, calves, young male cattle	Calves, male and female young cattle (heifers and bulls / male beef cattle)
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	Broilers Laying hens in liquid-manure and solid-manure systems Free-range husbandry	Broilers Young hens Laying hens (solid manure)
	Turkeys	Turkeys for breeding Turkeys in stall husbandry Turkeys in free-range husbandry	Male and 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, fur-bearing animals, buffalo, geese

Columns 1 and 2 pursuant to IPCC (2006)

6.1.2.1.1 Numbers of animals

The main basis for the activity data consists of the animal censuses of 1990, 1992, 1994, 1996, 1999, 2001, 2003, 2005 and 2007. For cattle, swine and sheep, the Federal Statistical Office provides annual population figures. The animal population figures were not interpolated for description of the years without animal population figures; in each case, the figures were carried forward (HAENEL et al., 2008). The gaps in the new German Länder data for the years 1990 to 1993 were closed by means of experts' assessments.

6.1.2.1.2 Dairy cows

In the category of dairy cows, the official statistics provide information about slaughter weights; pertinent weights of living animals can be derived from these figures. Figures for milk production are taken from public district-level statistics. The relevant associations publish milk-fat and milk-protein data (spatial resolution: at the Länder level). The important variables relative to keeping of dairy cows (in the present context, duration of grazing

periods) were modelled on the basis of data outside of official statistics (surveys and special evaluations).

6.1.2.1.3 Other cattle

In the category of cattle other than dairy cows ("other cattle"), the types of animals differentiated – in addition to dairy cows – include calves, male and female fattening animals (heifers and male beef cattle), suckling cows and stud bulls (mature males). The slaughter weights of the various types of cattle are taken from official statistics and converted to weights of living animals. For stud bulls, constant weights have been taken from the literature. Details on feeding and yields were taken from standard works on agriculture and discussed with experts. All other variables were modelled, as was done for dairy cows. The animals listed under "female beef cattle" are used either for herd replacement or for slaughter, depending on the market situation. Cows used for replacement and cows destined for slaughter do not differ in terms of the feed they are given and the conditions under which they are kept.

The herd characterisations, in terms of ages and weights, as used in animal censuses do not correspond to available data on energy balances and feeding. Only about half of the calves listed in animal censuses are treated as calves for purposes of the inventory. The other half is divided among the categories of heifers and fattening bulls.

6.1.2.1.4 Swine

The following categories are differentiated in the "swine" category: sows, weaners, fattening pigs and boars. The necessary details for relevant description were obtained from breeder associations and from the feedstuff industry. The lacking data for the new German Länder for the period immediately after 1990 were obtained via discussions with experts.

6.1.2.1.5 Horses

The applicable number of horses was corrected, to account for special features of German animal censuses (DÄMMGEN, 2005). This correction takes account of the division made between large horses and small horses. Large horses and small horses differ in terms of their energy and feed requirements. The circumstances typical for Germany were derived from the literature and then used (see DÄMMGEN et al., 2008).

6.1.2.1.6 Sheep

The head counts for sheep had to be corrected, since the December censuses of the years 1990 through 1996 did not take proper account of lambs (DÄMMGEN, 2005). In addition, it was necessary to differentiate between lambs and other sheep.

6.1.2.1.7 Poultry

Detailed description of emissions in poultry operations made it necessary to correct pullet and laying-hen head counts. In the "turkeys" category, it was necessary to differentiate between male and female animals.

6.1.2.1.8 All other animals

Further sub-grouping is not required for all other animals for which calculations are carried out in accordance with Tier 1 methods. There are no default emission factors for sub-categories. What is more, it is not useful to use such factors in cases in which the relevant national data are not available. Detailed data on animal herds (national and at the Länder level), as well as additional information, are provided by HAENEL et al (2008).

6.1.2.1.9 Compilation of relevant animal head counts

The relevant head counts for mammals (animal places) are presented in Table 72. The head counts for cattle, swine and sheep have decreased, while those for horses, goats and all poultry – and especially broilers (both male and female) and turkeys – have increased.

Table 72: Number of relevant animal places, based on the measure "1990 = 100 %"

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Dairy cows	100	89	84	83	82	82	79	76	75	72
Other cattle	100	88	83	81	81	81	80	78	77	77
Swine	100	84	86	84	80	77	79	80	85	84
Sheep	100	87	84	84	84	85	83	81	81	82
Goats	100	96	100	102	106	111	117	128	139	150
Horses	100	100	108	108	122	122	133	133	133	150
Poultry	100	100	91	91	97	97	99	99	99	104
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
Dairy cows	72	72	70	69	67	67	64	64		
Other cattle	76	77	73	71	68	67	66	66		
Swine	83	83	84	85	83	87	85	87		
Sheep	83	84	83	82	82	80	77	77		
Goats	156	178	178	178	178	189	200	200		
Horses	150	161	161	167	168	160	160	172		
Poultry	104	107	107	108	108	106	106	111		

6.1.2.2 Calculation of CH_4 emissions from keeping of dairy cows

In principle, the emission factor is determined by means of the approach proposed in IPCC (2006). The relevant body weight is calculated on the basis of slaughter-weight (carcass) data (resolution: Länder and years). The maintenance energy is calculated using the constant factor that is normally used in Germany. Milk-yield data are available for (nearly) every district and every year. Data on milk-fat and milk-protein concentrations are taken from reports of the relevant associations (resolution: Länder and years). Weight gain is calculated from the difference between heifer slaughter weight and dairy-cow slaughter weight. Digestibility has been formulated as a function of yield, under a typical feeding framework (national data; resolution: districts and years). In keeping with the recommendation in IPCC (2006), the methane-conversion rate x_m was calculated as a function of the roughage percentage in feed pursuant to SAUVANT and GIGER-REVERDIN (2007). The time series for CH_4 emissions from enteric fermentation is shown in Table 73.

Table 73: CH_4 emissions E_{CH4} from dairy-cow husbandry (enteric fermentation)

[Tg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	0.46	0.41	0.41	0.42	0.41	0.42	0.42	0.40	0.40	0.40
[Tg a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
E_{CH4}	0.39	0.40	0.39	0.39	0.38	0.38	0.37	0.38		

The average milk yield for Germany, weighted by Länder and oriented to the base year 1990, is 12.9 kg $space^{-1}$ d^{-1}, which differs slightly from the IPCC's suggested value for western Europe, 11.5 kg $space^{-1}$ d^{-1} (IPCC, 1996b: Table A-1). For 2007, the corresponding value is 19.2 kg $space^{-1}$ d^{-1}. The pertinent difference is significant. A compilation of all relevant information is provided by HAENEL et al. (2008).

On a national average, the CH_4 emission factors increased from 72.0 kg $space^{-1}$ a^{-1} CH_4 (1990) to 92.5 kg $space^{-1}$ a^{-1} CH_4 (2007). A detailed overview of the emission factors used is found in HAENEL et al. (2008). The manner in which the factors were obtained is described in DÄMMGEN et al., 2008). Table 74 shows the development of mean emission factors $IEF_{CH4,\ ent}$ during the period covered by the report, for use of the conversion rates pursuant to SAUVANT and GIGER-REVERDIN (2007), about 0.053 MJ MJ^{-1}.

Table 74: CH_4 emission factors IEF_{CH4} from dairy-cow husbandry (enteric fermentation)

[kg pl^{-1} a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
IEF_{CH4}	72.0	73.3	75.6	78.5	78.7	79.8	80.4	80.6	82.0	83.7
[kg pl^{-1} a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
IEF_{CH4}	85.2	87.1	87.2	89.1	89.4	90.7	91.1	92.5		

6.1.2.3 Calculation of CH_4 emissions from keeping of other cattle (calves, heifers, fattening bulls, suckling cows, stud bulls)

To calculate the energy and feed requirements of growing animals, one requires certain figures pertaining to the life phase in question (initial and final weight, weight gain, duration of the life phase in question). Such figures are obtained, or derived, from slaughter statistics, publications of the Committee for Requirement Standards (Ausschuss für Bedarfsnormen) of the Society of Nutrition Physiology (Gesellschaft für Ernährungsphysiologie) and standard works on agricultural planning. In cases in which no national data was available, the default values pursuant to IPCC (2006) were used. The fact that suckling calves are not ruminants was taken into account in calculations. A suitably lower methane-conversion rate was chosen. With regard to the factors determining the emission factors, and to the resulting emission factors, cf. HAENEL et al. (2008); for details on derivation of the emission factors, cf. DÄMMGEN et al. (2008).

Emissions from keeping of suckling cows and stud bulls are calculated from energy requirements, in keeping with the Tier 2 method, and under the assumption that weights remain constant.

The following mean emission factors for the year 2007 resulted:

Table 75: CH_4 emission factors IEF_{CH4} from keeping of cattle, with the exception of dairy cows (enteric fermentation) (2007)

Sub-category	EF_{CH4} [kg place^{-1} a^{-1} CH_4]
Calves	3.7
Heifers	40.0
Bulls	56.4
Suckling cows	61.4
Stud bulls (mature males)	77.5
Average	42.4
IPCC (2006) default	57

The time series for emissions of other cattle is shown in Table 76, while the time series for the mean emission factors is presented in Table 77.

Table 76: CH_4 emissions E_{CH4} from keeping of non-dairy cattle (enteric fermentation)

[Tg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	0.51	0.44	0.44	0.43	0.42	0.43	0.43	0.42	0.42	0.42
[Tg a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
E_{CH4}	0.42	0.43	0.40	0.39	0.37	0.37	0.36	0.37		

Table 77: CH_4 emission factors IEF_{CH4} from keeping of non-dairy cattle (enteric fermentation)

[kg pl^{-1} a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
IEF_{CH4}	39.0	38.5	40.3	40.9	39.7	40.1	41.0	40.7	41.3	41.5
[kg pl^{-1} a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
IEF_{CH4}	42.0	42.5	41.9	41.8	41.6	41.8	42.1	42.4		

6.1.2.4 Calculation of CH_4 emissions from enteric fermentation in sows and growing swine (weaners, fattening pigs) and boars

To calculate emissions from sows, one must know the number and weight of relevant raised weaners. Such information is obtained from breeders' associations and from experts. The energy and feed requirements of growing animals are determined from applicable initial and final weights, weight gain and duration of the relevant life phase. Such figures are obtained, or derived, from publications of the Committee for Requirement Standards (Ausschuss für Bedarfsnormen) of the Society of Nutrition Physiology (Gesellschaft für Ernährungsphysiologie), from breeders' associations and from standard works on agricultural planning.

For the purposes of the present inventory, the numbers of weaners given by the statistics are broken down into the categories of suckling pigs and weaners. Suckling pigs are included together with sows, while calculations for weaners are carried out separately.

As a result of Germany's special situation directly after 1990, many statistics were not collected. For example, very little or no detailed information was available on keeping of swine in the new German Länder between 1990 and 1996. Those data were obtained from discussions with experts. The data used are shown in the overview in HAENEL et al. (2008), while the animal-population calculations, and the manner in which pertinent methods were derived or adjusted, are presented in DÄMMGEN et al. (2008).

Emissions from keeping of boars were calculated from energy requirements, under the assumption of a constant weight of 120 kg animal^{-1}.

The data resulting for 2007 are shown in the following table.

Table 78: CH_4 emission factors IEF_{CH4} from keeping of swine (enteric fermentation) (2007)

Sub-category	IEF_{CH4} [kg place^{-1} a^{-1} CH_4]
Sows	1.81
Weaners	0.39
Fattening pigs	1.48
Breeding boars	1.48
Average	1.19
IPCC default	1.5

6.1.2.5 Calculation of CH_4 emissions from all other mammals (sheep, goats, horses, buffalo)

For all other mammals, the Tier 1 approach was used, as follows:

Equation 6: Tier 1 method for determining emissions from the source category "Enteric fermentation"

$$E_{CH4,i} = EF_i \cdot n_i$$

Where $E_{CH4,i}$ CH_4 emissions for an animal category [kg a^{-1} CH_4]
EF_i Emission factor for each animal category i [kg place^{-1} a^{-1} CH_4]
n_i Number of occupied animal spaces in a category i [spaces]

For sheep, goats, heavy horses and buffalo, the default values (emission factors) pursuant to IPCC (2006)-10.28 were used. For light horses, an $EF_{CH4,\ po}$ = 12 kg place^{-1} a^{-1} CH_4 was determined:

Table 79: Emission factors: Default values (EF_d) pursuant to IPCC, and the resulting emission factors (IEF) used in this report

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 2007 [kg place^{-1} a^{-1} CH_4]
Sheep	8	(Table 10.10)	
Goats	5	(Table 10.10)	
Horses	18	(Table 10.10)	16.3
Buffalo	55	(Table 10.10)	

For the reasons discussed above, Germany does not report emissions of mules and asses (NE).

6.1.3 Uncertainties and time-series consistency (4.A)

6.1.3.1 Relevant animal head counts

The uncertainties in the animal head counts in each class (with the exception of horses) are on the order of less than 6 % (DÄMMGEN, 2005). For the new *Länder*, herd sizes and their regional distribution for the years 1990 and 1991 were calculated using the RAUMIS model (HENRICHSMEYER et al., 1996), which provides regional data for agricultural production and products. As the data sources do not vary with the years, the time series is considered to be basically consistent.

The Agricultural Statistics Act (Agrarstatistikgesetz) was amended in 1998. This changed the survey bases for determining animal populations – 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. Derivation of the corrections is described in DÄMMGEN (2005).

In all likelihood, the number of horses in Germany is about 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). The head counts for horses are thus systematically erroneous.

With regard to sheep, the shift in the time series results in that the May count also includes lambs, while the December count does not.

6.1.3.2 Emission factors

The uncertainties in the methane emission factors are on the order of 30 % (EMEP, 2000: Chapter B1040-6). The primary sources of inaccuracy in these figures include the methane-conversion factor (for cattle, 0.06 ± 0.005, i.e. 10 %, cf. IPCC, 2006) and the actual feed-ration composition, especially that for cattle.

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

It was not possible to carry out general quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents, since the relevant staff unit was in the process of being restructured.

The data is reviewed for transcription errors made between the original data and the calculation tables, and it is checked for errors with regard to units and orders of magnitude. Future QC/QA will necessitate better resolution in the activity data (in particular, feeding data at the district level will be required). In addition, emission factors, except where confidential, will be made publicly available via the German Emission Factor Database (GEREF). This will enable experts to review and comment on the data.

Comparison to the mean emission factors (Implied Emission Factors) for neighbouring countries, as provided in the *Data Locator* of the UNFCCC Secretariat, shows that Germany's emission factor differs from those of neighbouring countries in terms of order of magnitude. The reason for this is that the national methane-conversion rate has been used.

Table 80: Methane emissions from enteric fermentation in dairy cows, in various countries – a comparison of Implied Emission Factors (IEF)[53]

	IEF_{CH4}	Milk yield	Weight	Pregnant-cow percentage
	[kg place^{-1} a^{-1} CH_4]	kg place^{-1} d^{-1}	[kg animal^{-1}]	[%]
Austria	115.04	16.17	700	90
Belgium	116.92	16.80	600	
Czech Republic	114.95	20.22	585	90
Denmark	126.22	23.29	575	90
Germany	**92.45**	**19.19**	**594**	**80**
France	104.29	51.54		
Netherlands	Other source categories for cattle			
Poland	94.31	11.86	500	
Switzerland	109.93			79
United Kingdom	102.75	18.46	577	

Source: UNFCCC 2006, Table 4.A

[53] IEF: Emission factor calculated from emissions and numbers of dairy cows. Figures for Germany for 2007; data of other countries for 2006.

The present inventory lists errors or uncertainties (size and distribution) for virtually all activity data, emission factors or other data used to calculate emission factors.

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) have been eliminated in the present inventory.

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.

6.1.5 Source-specific recalculations (4.A)

The provisional animal-head-count figures for 2006 were replaced with final figures.

The head-count time series for farmed-buffalo populations was completed and corrected.

With respect to the corresponding figures in the last inventory, the resulting changes are considerable for dairy cows, and noticeable for other cattle and swine (cf. Table 82 through Table 84).

The reasons for this are as follows:

Use of the methane-conversion rate given in IPCC (2006), 0.065 MJ MJ^{-1} (instead of 0.060 MJ MJ^{-1}), and recalculation of the methane-conversion rate for dairy cows, resulted in emissions changes.

Recalculation of feed digestibility for dairy cows (higher digestibility) led to a reduction of emissions. The slight increase in energy requirements, resulting from recalculation of lactation energy (inclusion of milk protein), is no longer apparent as a result.

For fattening bulls, the feed composition was updated, and that led to increases in feed intake, excretion and emissions.

Table 81: Comparison of the animal-place figures used in the NIR 2008 and the NIR 2009, for buffalo

Places, in 1000s	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008										
NIR 2009	0.000	0.000	0.000	0.000	0.000	0.000	0.048	0.172	0.297	0.421
Places, in 1000s	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
NIR 2008	0.626	0.611	0.740	0.879	1.006	1.136	1.136			
NIR 2009	0.626	0.625	0.755	0.894	1.021	1.187	1.324	1.541		

Table 82: Comparison of the mean CH_4 emission factors used in the NIR 2008 and the NIR 2009 for animal husbandry (enteric fermentation); here, dairy cows.

[kg place^{-1} a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	94.8	95.7	99.1	101.6	101.3	102.3	103.3	103.3	104.9	106.6
NIR 2009	72.0	73.3	75.6	78.5	78.7	79.8	80.4	80.6	82.0	83.7
[kg place^{-1} a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
NIR 2008	108.1	110.1	109.9	111.5	111.8	113.3	113.3			
NIR 2009	85.2	87.1	87.2	89.1	89.4	90.7	91.1	92.5		

Table 83: Comparison of the mean CH_4 emission factors used in the NIR 2008 and the NIR 2009 for animal husbandry (enteric fermentation); here, other cattle.

[kg place^{-1} a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	36.2	36.0	36.7	36.9	37.1	36.9	36.7	36.5	36.9	37.0
NIR 2009	39.0	38.5	40.3	40.9	39.7	40.1	41.0	40.7	41.3	41.5
[kg place^{-1} a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
NIR 2008	37.2	37.5	37.2	37.4	37.2	37.2	37.2			
NIR 2009	42.0	42.5	41.9	41.8	41.6	41.8	42.1	42.4		

Table 84: Comparison of the mean CH_4 emission factors used in the NIR 2008 and the NIR 2009 for animal husbandry (enteric fermentation); here, swine.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	1.19	1.18	1.19	1.21	1.23	1.24	1.25	1.26	1.27	1.27
NIR 2009	1.10	1.08	1.09	1.11	1.13	1.14	1.15	1.15	1.16	1.15
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
NIR 2008	1.27	1.27	1.27	1.28	1.28	1.28	1.28			
NIR 2009	1.16	1.16	1.16	1.17	1.17	1.17	1.18	1.19		

The figures for emissions from enteric fermentation in horses were determined with inclusion of corrected head counts for heavy and light horses. The resulting emission factors thus now vary over time and by place. They have not changed with regard to the last inventory, however.

Overall, the resulting CH_4 emissions from enteric fermentation, for the past few years, are now considerably lower. The relevant changes are shown in Table 85.

Table 85: Comparison of the total CH_4 emissions for animal husbandry (enteric fermentation) as calculated for the NIR 2008 and the NIR 2009. Figures are for Germany.

[Tg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	1.15	1.01	0.99	0.99	0.99	0.99	0.98	0.95	0.94	0.95
NIR 2009	1.04	0.92	0.90	0.91	0.90	0.90	0.91	0.88	0.88	0.88
[Tg a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006	2007		
NIR 2008	0.93	0.94	0.91	0.90	0.88	0.87	0.87			
NIR 2009	0.87	0.89	0.85	0.84	0.82	0.82	0.80	0.81		

6.1.6 Planned improvements (source-specific) (4.A)

The basis for the data outside of official statistics is unsatisfactory in some areas (for example, feed-ration composition). An attempt is to be made to establish a procedure, in Germany, via which such data could be obtained by expanding agricultural statistics or conducting surveys. A relevant research programme began in 2007 (and is scheduled to run until 2009).

6.2 Manure management (4.B)

6.2.1 Source-category description (4.B)

CRF 4.B				
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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/D	NO	NO	NO	D	D	-	CS	NO
EF uncertainties in %		30				30				
Distribution of uncertainties		N				N				
Method of EF determination		D/T1/T2				CS/T1				

The source category "Manure management" (4.B) 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. NMVOC emissions can also include sulphur-containing compounds. 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 the present inventory, Germany reports on emissions from management of manure of cattle, swine, sheep, goats, horses, buffalo, fur-bearing animals (only NH_3) and poultry, but not on emissions from management of mule and ass manure (NE).

6.2.1.1 Methan-Emissionen aus dem Wirtschaftsdünger-Management (4.B)

6.2.1.1.1 Calculated emissions

Table 86 presents the time series for CH_4 emissions from manure management. It shows an emissions decrease that is limited primarily to the years after German reunification and that

points primarily to decreases in herd sizes. Cattle and swine each contribute about half of the total emissions (cattle: 54 % in 1990; 49 % in 2007) (swine: 44 % in 1990; 50 % in 2007). As these figures indicate, emissions from keeping of horses, sheep, goats and buffalo are negligible by comparison.

Table 86: CH_4 emissions E_{CH4} from animal husbandry (manure management).

[Tg a^{-1} CH_4.]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	0.30	0.26	0.26	0.26	0.27	0.26	0.27	0.26	0.27	0.27
[Tg a^{-1} CH_4.]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
E_{CH4}	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26		

6.2.1.2 NMVOC emissions from manure management

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 has used that inventory's relative emission factors to prepare a first estimate of NMVOC emissions from animal husbandry (details in DÄMMGEN et al., 2008). The time series for NMVOC emissions is shown in Table 87. Beginning in about 1994, following a decrease in animal-herd sizes, resulting from German reunification, emissions remained constant. Although no figures for horses are available, due to the lack of a relevant calculation procedure, their emissions can be assigned largely to "keeping of cattle".

Table 87: NMVOC emissions E_{NMVOC} from animal husbandry (manure management), given as NMVOC and NMVOC-C.

[Tg a^{-1} NMVOC, or Tg a^{-1} C]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NMVOC}	0.33	0.29	0.28	0.28	0.27	0.27	0.27	0.27	0.27	0.27
$E_{NMVOC-C}$	0.16	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13
[Tg a^{-1} NMVOC, or Tg a^{-1} C]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
E_{NMVOC}	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26		
$E_{NMVOC-C}$	0.13	0.13	0.13	0.13	0.12	0.13	0.12	0.13		

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}.

6.2.1.3 Nitrous oxide, nitrogen monoxide and ammonia emissions from manure management

The results of calculations of NH_3, N_2O and NO emissions are shown in Table 88. N_2O and NO emissions have been decreasing considerably with regard to the base year. Cattle account for the major part of N_2O and NO emissions (81 % in 1990, and a decrease to 75 % in 2007). With respect to 1990, a total of 63 % of NH_3 emissions were emitted by cattle farms, 28 % were emitted by swine farms and 7 % were emitted by poultry operations. A total of 81 % of (direct) N_2O and NO emissions originate in keeping of cattle, while 15 % originate in keeping of swine and 1 % originate in keeping of poultry. In 2007, the respective shares for NH_3 were 59 %, 28 % and 11 %. The respective shares for N_2O and NO in 2007 were 75 %, 19 % and 2 %.

Table 88: N_2O, NO and NH_3 emissions E_{N2O}, E_{NO} and E_{NH3} from animal husbandry (manure management).

[Tg a^{-1} N_2O, NO and NH_3]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{N2O}	0.009	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
E_{NO}	0.0013	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
E_{NH3}	0.59	0.52	0.51	0.51	0.51	0.51	0.51	0.50	0.50	0.50
[Tg a^{-1} N_2O, NO and NH_3]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
E_{N2O}	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008		
E_{NO}	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0010	0.0011		
E_{NH3}	0.50	0.51	0.50	0.50	0.49	0.49	0.49	0.50		

6.2.2 Methodological issues (4.B)

6.2.2.1 Methodological issues and requirements CRF 4.B (CH_4)

IPCC (2006) provides for two methods for determining CH_4 emissions from manure management. For emissions calculation pursuant to the Tier 1 method, numbers of animals are multiplied by constant VS excretions[54] and by default emission factors that are constant for specific climate regions.

This Tier 1 method is not used in its simple form.

The Tier 2 method calls for consideration of variable VS excretions that depend on yields and diet. Furthermore, the method combines these with emission factors that reflect the frequency, in Germany, of various procedures for storage of solid and liquid manure, and of grazing periods, and that take climate effects into account. The resulting emission factors then vary for each category, by place and time. The emission factor is determined via the following equation:

Equation 7: Determination of the emission factor for methane from manure management, pursuant to the Tier 2 method

$$EF_i = VS_i \cdot \alpha \cdot B_{0i} \cdot \rho_{CH4} \cdot \sum_{jk} MCF_{jk} \cdot MS_{ijk}$$

Where
- EF_i Emission factor for sub-category i [kg place^{-1} a^{-1} CH_4]
- VS Volatile solids (excretion of readily decomposable material, dry mass - DM) for the sub-category i [kg place^{-1} d^{-1} DM]
- α Conversion factor for time units (α = 365 d a^{-1})
- B_{0i} Methane-formation potential for sub-category i, with regard to VS [m^3 kg^{-1}]
- ρ_{CH4} Methane density (ρ_{CH4} = 0.67 kg m^{-3})
- MCF_{jk} Methane-conversion factor for storage system j in climate region k [kg kg^{-1}]
- MS_{ijk} Share of sub-category i whose farm manure is treated in storage system j, in climate region k

In the German inventory report, CH_4 emissions from management of manure from dairy cows, cattle and swine were not classified as a key source. For the present inventory, they were calculated nonetheless, as were VS excretions of laying hens, pullets, broilers and turkeys, taking mean outputs / weight gains and feeding into account.

The calculations are carried out for districts (DÄMMGEN et al., 2008).

Mixed procedures that combine elements of the Tier-1 and Tier-2 methods (UNECE: improved procedures) use default values for VS excretions and combine them with the

[54] VS (volatile solids): the easily convertible carbon fractions in excrement

frequency distributions for manure-management systems in the relevant region. In Germany, this applies to sheep, goats, horses, buffalo, geese and ducks.

Germany does not have national data records suitable for use in describing emissions from farm-manure storage. IPCC (2006) contains default values for maximum methane-formation rates and for emission factors (methane conversion factors, *MCF*) (IPCC, 2006, p. 10.77, Table 10A-4; p. 10.44, Table 10.17). The pertinent values are shown in Table 89.

To some extent, MCF are temperature-dependent. The relevant temperatures were taken from DÄMMGEN et. al. (2008).

Table 89: Maximum methane-formation capacity B_0 and methane-conversion factor (*MCF*) pursuant to (IPCC(2006)-10.77, Table 10A-4; IPCC(2006)-10.44, Table 10.17)

Size	Amount	Units
B_o	0.24	m^3 kg^{-1} CH_4
***MCF*, liquid-manure systems**		
with floating cover	temperature-dependent, 0.10 through 0.15	kg kg^{-1} C
without floating cover	temperature-dependent, 0.17 through 0.25	kg kg^{-1} C
***MCF*, solid manure**	0.02	kg kg^{-1} C
***MCF*, deep straw bedding**	temperature-dependent, 0.17 through 0.25	kg kg^{-1} C
***MCF*, pasture grazing**	0.01	kg kg^{-1} C

6.2.2.2 Methodological issues and requirements, CRF/NFR 4.B (NH_3, N_2O, NO und N_2)

Since 2004, the mass-flow procedure pursuant to EMEP/CORINAIR has been used to calculate losses of gaseous N species (cf. DÄMMGEN et al., 2008). It considers *all* flows of N species, both in succession and in parallel, in keeping with the scheme shown in Figure 25.

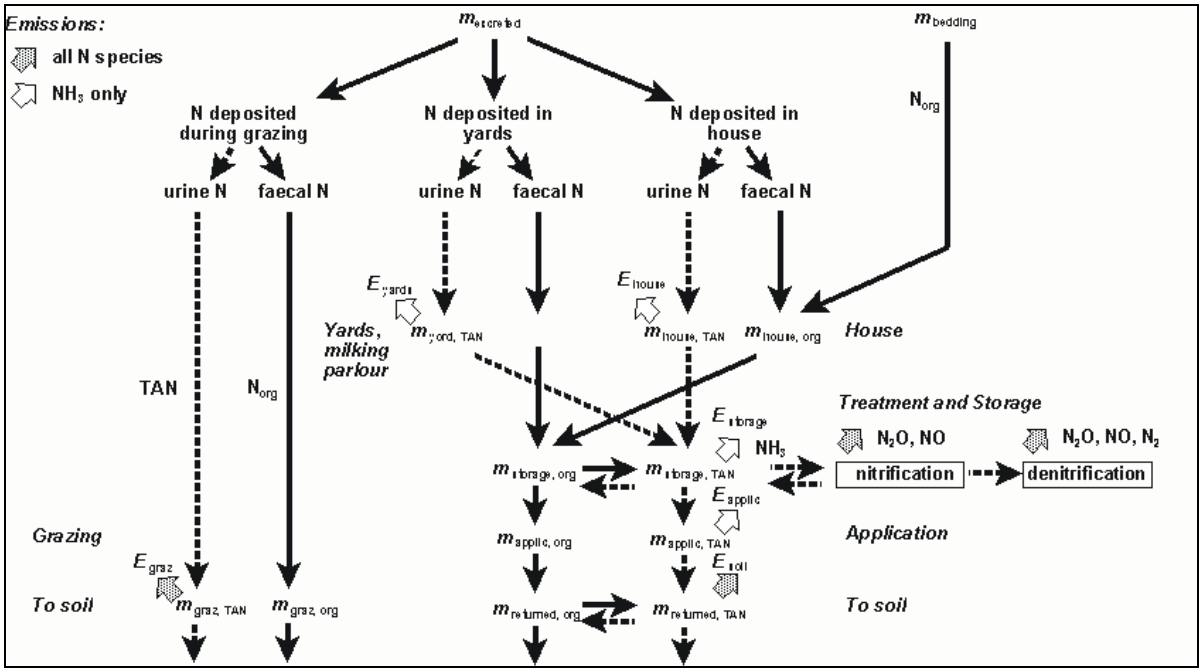


Figure 25: Nitrogen flows in manure management for a given mammal category.[55]

The first step is to determine the relevant quantities of excreted N ($m_{excreted}$), of readily reacting TAN (total ammoniacal nitrogen) in the urine of mammals and of uric acid excreted by birds. Some uric acid is converted into TAN. To take account of grazing periods and animals' behaviour, excretion amounts are divided into amounts in pastures and amounts in stalls. In the substance-flow model, 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.

Total N_2O emissions are determined pursuant to IPCC (2006), with the following equation:

Equation 8: Determination of N_2O emissions from manure management

$$E_{N2O-N} = \sum_{i,j} n_i \cdot m_{ex,i} \cdot x_{i,j} \cdot EF_j$$

Where
E_{N2O-N} N_2O-N emissions from manure management [kg a^{-1} N]
n_i Number of occupied animal places in category i [number of places]
$m_{ex,i}$ Mean annual N excretion of category i [kg $place^{-1}$ a^{-1} N]

[55] Solid lines: organically bound N; dotted lines: TAN; the horizontal flows stand for immobilisation and mineralisation; broad arrows refer to emissions:

E_{yard}: NH_3 emissions from paved areas, including milking stalls;
E_{house}: NH_3 emissions from stalls;
$E_{storage}$ NH_3, N_2O, NO and N_2 emissions from storage;
E_{applic} NH_3 emissions during and after spreading;
E_{graz}: NH_3, N_2O, NO and N_2 emissions during and after grazing;
$E_{returned}$ N_2O, NO and N_2 emissions from the soil (for details, see DÄMMGEN et al., 2006)

$x_{i,j}$	Percentage of the annual excretions of category i that is subject to a certain manure-management system j [kg kg^{-1}].
$EF_{N2O\text{-}N,\ J}$	N_2O emission factor for manure-management system j, with respect to N excretion [(kg N_2O-N) (kg N)$^{-1}$]

The N_2O emission factor given in IPCC (2006) refers to the amount of N that is excreted or stored. Due to a lack of better relationships, here as well the N_2O emissions are set in relation to this amount, although they are subtracted from the remaining amount of TAN. A similar procedure is carried out for NO and N_2. During storage, part of the organically bound N is mineralised ($N_{org} \rightarrow$ TAN).

Losses during application are calculated solely for NH_3. They refer to the amount of TAN that is available following storage in farm manure. The relevant partial emission factors are taken from EMEP (2002b).

Pursuant to IPCC (2000, 2006), the parameters for the above formula 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), however. The pertinent values are shown in Table 90.

Table 90: Partial emission factors for nitrogen oxides and dinitrogen for emissions from farm-manure storage (with respect to excreted N)

Species	Farm manure type	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 feces	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 feces	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 feces	0.003

The emission factors for NO and N_2 were derived from the N_2O emission factors, in agreement with findings of experiments carried out in the UK by JARVIS & PAIN (1994):

$EF_{N2O} = 10\ EF_{NO} = 1/3\ EF_{N2}$

The same factors are used in the UK, Switzerland and Denmark.

All of the stall categories commonly found in Germany are considered. Information on frequency distribution is provided, in aggregated form, by HAENEL et al. (2008).

The figures are determined for each administrative district, with the help of the RAUMIS agricultural sector model (HEINRICHSMEYER et al., 1996). In principle, a different emission factor results each year for each animal category and each district (DÄMMGEN et al., 2008).

Pursuant to key-source analysis, category 4.B is not a key source of N_2O emissions. 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 (cf. Chapter 6.2.2.4).

6.2.2.3 Relevant animal head counts

Normally, emissions of N-containing compounds for a given animal category are calculated using the numbers of animals in the entire relevant population. The *cattle* category is subdivided into dairy cows, calves, fattening bulls, heifers, suckling cows and stud bulls. In the *swine* category, sows, weaners, fattening pigs and boars are treated separately. The emission factors for sows include emissions from suckling pigs. In the cattle and swine categories, the head counts from official statistics have to be converted to meet the mass-flow procedure's requirements relative to population homogeneity.

In the *sheep* category, N-species emissions are calculated from statistics – corrected to account for the amendment of the Agricultural Statistics Act (Agrarstatistikgesetz) – for lambs and other sheep. CH_4 emissions, on the other hand, are determined from the size of the entire sheep population (cf. DÄMMGEN, 2005).

Official animal censuses provide only incomplete head counts of horse populations. In addition, the relevant animal census data are corrected to compensate for impacts of the amendment of the Agricultural Statistics Act (Agrarstatistikgesetz) (cf. DÄMMGEN, 2005).

The census figures for pullets are not suited to the task of defining homogeneous animal categories with respect to excretions. The figures for pullets are derived from those for laying hens (HAENEL & DÄMMGEN, 2007a).

For turkeys, male and female birds differ so markedly in terms of feeding and weights that they have to be considered separately. The keys used for this area are the sex ratios as obtained from hatching facilities, as well as figures from the literature. The pertinent details are provided in DÄMMGEN et al. (2008).

6.2.2.4 Excretions

C species:

In the categories of cattle, swine and poultry (except geese), excretions of "volatile solids" are calculated in accordance with Tier 2 determinations of energy and substance flows. For all other animal species, the default values pursuant to IPCC (2006: Tables 10A-9 and 10A-6) were used. Excretions of light horses and ponies were derived from those of heavy horses, in a procedure oriented to the smaller animals' reduced energy requirements:

Sheep	0.40	kg place^{-1} d^{-1} C
Goats	0.30	kg place^{-1} d^{-1} C
Heavy horses	2.13	kg place^{-1} d^{-1} C
Light horses and ponies	1.38	kg place^{-1} d^{-1} C
Buffalo	3.9	kg place^{-1} d^{-1} C

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.

NMVOC emissions are calculated via use of calculated quantities of NH_3 emissions, since the two substance groups are linked via their formation mechanism.

N species:

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. A detailed description of this procedure is provided by DÄMMGEN et al. (2008), while an assessment of the procedure is provided by DÄMMGEN & LÜTTICH (2005). 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, suckling cows and stud bulls, national data from the literature are used. For details, cf. DÄMMGEN et al. (2008).

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 fodder composition. Feeding data was used as a basis for calculations relative to boars.

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, egg output is also taken into account (HAENEL & DÄMMGEN, 2007a, 2007b, DÄMMGEN et. al., 2008). For all other animals, N-excretion figures were taken from the German literature (DÄMMGEN et al., 2008). Specifically, the following figures were used:

Calves	18.3 kg	place^{-1} a^{-1} N
Suckling cows	82.0 kg	place^{-1} a^{-1} N
Stud bulls (mature males)	84.0 kg	place^{-1} a^{-1} N
Boars	27.7 kg	place^{-1} a^{-1} N
Sheep, not including lambs	10 kg	place^{-1} a^{-1} N
Lambs	3 kg	place^{-1} a^{-1} N
Goats	11 kg	place^{-1} a^{-1} N
Heavy horses	53.6 kg	place^{-1} a^{-1} N
Light horses	33.4 kg	place^{-1} a^{-1} N
Geese	0.55 kg	place^{-1} a^{-1} N
Ducks	0.74 kg	place^{-1} a^{-1} N
Buffalo	70.0 kg	place^{-1} a^{-1} N

For animals with lifetimes < 1 a, the figures for were calculated for keeping facilities with average rotation periods.

The percentage of total ammoniacal N (TAN) with respect to total nitrogen was calculated as follows:

Dairy cows, heifers and fattening bulls	variable
Calves, suckling cows and stud bulls	0.60 kg kg^{-1} N
Sows	0.72 kg kg^{-1} N
Boars	0.70 kg kg^{-1} N
Weaners	0.66 kg kg^{-1} N

Fattening pigs	variable
Sheep	0.40 kg kg^{-1} N
Horses	0.40 kg kg^{-1} N
Laying hens, broilers	variable
Young hens	variable
Turkey cocks and turkey hens	variable
Ducks	0.54 kg kg^{-1} N
Geese	0.70 kg kg^{-1} N
Buffalo	0.50 kg kg^{-1} N

6.2.2.5 Grazing periods, stable types and stabling periods

In the cattle category, 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 stable portions.

All of the stall categories commonly found in Germany are considered (DÄMMGEN et al., 2008). The relevant data have been compiled, in aggregated form, in the CRF report tables 4.B(a) and 4.B(b) (Additional Information).

6.2.2.6 Processing of liquid and solid manure

A distinction should be made between processed and unprocessed manure (aspects to consider for example, include liquid-manure separation, biogas collection, composting of solid manure). As a result of a lack of pertinent background information about manure processing (frequency distributions), as well as of certain calculation procedures (for solid-manure composting), no suitably differentiated calculations can be carried out at present, however.

6.2.2.7 Storage

A distinction is made between solid and liquid manure. The storage procedures commonly used in Germany, and formation of floating covers, 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. CRF Table 4.B(b) lists the frequency distributions for the various forms of aggregated storage.

6.2.2.8 Spreading

The spreading method used, and the time of subsequent working of manure into the soil, play an important role in calculation of NH_3 emissions and in determination of the N quantities added to the soil via manure. For liquid manure, a distinction is made between broad distribution, towed tubes and towed "shoes"; for solid manure, only broad distribution is considered. Farmland (fallow and with vegetation) and grassland are differentiated. A graduated scale of periods required to work manure into the soil is used (< 1 h, < 4 h, < 6 h, < 12 h,< 24 h, no working into the soil).

6.2.3 Uncertainties and time-series consistency (4.B)

The uncertainties listed in the EMEP/CORINAIR manual (EMEP, 2003) also apply, for the time being, to Germany; i.e. about 6 % for animal head counts (cf. also DÄMMGEN, 2005) and 30 % for emission factors for CH_4 and NH_3. The errors for the other emission factors are not known. Figures for N_2O, NO and N_2 are taken from IPCC (2006), p. 10.62.

As a result of amendment of the Agricultural Statistics Act (Agrarstatistikgesetz), the time series from official statistics is inconsistent with regard to animal-population figures; i.e. there is a break between 1998 and 1999. This applies especially to the categories of sheep and horses. A correction procedure for both categories has been developed and applied. As to horse head counts, it must be noted that agricultural censuses cover only part of the horses in question and that "recreational horses" are often kept outside of agricultural operations. With regard to sheep, the shift in the time series results in that the May count also includes lambs, while the December count does not.

The figures on manure management have been modelled on the basis of a database that is considered inadequate (transfer of survey data collected in model districts to other districts; cf. UBA, 2002a).

6.2.4 Source-specific quality assurance / control and verification (4.B)

It was not possible to carry out general quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents, since the relevant staff unit was in the process of being reorganised.

The data is reviewed for transcription errors made between the original data and the calculation tables, and it is checked for errors with regard to units and orders of magnitude. Future QA/QC procedures pre-suppose the further development of methods and a better breakdown of activity data (cf. Chapter 6.1.4). In addition, better data are needed for description of manure management.

In particular, such data would include parameters for feeding, yields (slaughter weight, duration of fattening period, etc.), keeping method (pasture grazing, type of stabling), type of storage, manure-spreading methods, etc.. In future, such data are to be obtained via surveys conducted by the Federal Statistical Office.

The present inventory lists errors or uncertainties, and their frequency distributions, for virtually all activity data, emission factors or other data used to calculate emission factors. The total error arising from the individual errors in the terms of a complex emission function should be determined by means of an error-propagation calculation. This is to take place in future, resources permitting.

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 and from keeping of swine; lack of calculations for goats) have been eliminated. The mass-flow procedure was reviewed by the EAGER experts' group, and the results obtained in Europe were compared. A summarising description with regard to cattle is provided by REIDY et al. (2008).

The level of the MCF for liquid-manure systems pursuant to IPCC (1996b) or IPCC-GAUM (2000) was discussed in the final report of the "Initial Review under the Kyoto Protocol and Annual 2006 Review under the Convention". The MCF used in the present inventory, which come from IPCC (2006), eliminate the need for any further discussion. The missing tables needed for purposes of explaining calculations have been included in the documentation (LÜTTICH et al., 2007). Such tables especially include the list of the N quantities excreted per animal category, with regard to losses (losses pursuant to CRF 4.B and 4.D) and the N quantities added to the soil.

A comparison of the obtained findings with findings of neighbouring countries shows that the emission factors for Germany lie within the customary ranges for dairy cows, other cattle and swine. For poultry, the mean emission factor for Germany is the same as the default value from IPCC (1996b). Discussion 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}).

Table 91: 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

	***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	22.68		30.50	20
Czech Republic	14.0			
Denmark	18.61	4.78	74.53	10
Germany	*19.62*	*3.10*	*83.5*	*13.5*
France	18.43	5.10	21.2	45 / 72
Netherlands	Other source categories for cattle			
Poland	9.36	4.45	6.8	39
Switzerland	24.01	5.57		
United Kingdom	25.24	3.44	30.6	39
IPCC default	21 through 29	5.1	27	

Source: UNFCCC 2008, Table 4.B(a)

Table 92: Methane emissions from storage of farm manure from other cattle, in various countries – a comparison of Implied Emission Factors (*IEF*)[56] and important emissions-relevant parameters

	***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	7.4	1.95	23.85	39
Belgium	10.3		30.30	20
Czech Republic	6.0			
Denmark	1.72	1.36	23.89	10
Germany	*5.68*	*1.37*	*62.21*	*13.3*
France	19.74	2.7	39.25	45 / 72
Netherlands	Other source categories for cattle			
Poland	5.97	2.10	15.4	39
Switzerland	2.99			
United Kingdom	4.30	2.65	6.0	
IPCC default	6 through 8	2.6	22.5	

Source: UNFCCC 2008, Table 4.B(a)

Table 93: Methane emissions from storage of farm manure from swine, in various countries – a comparison of Implied Emission Factors (*IEF*)[57] and important emissions-relevant parameters

	***IEF*$_{CH4}$**	**VS excretions**	**Frequency of Liquid-manure systems**	**Mean *MCF* for liquid-manure systems**
	[kg space^{-1} a^{-1} CH_4]	**[kg space^{-1} d^{-1}]**	**[%]**	**[%]**
Austria	5.99	0.40	71.5	39
Belgium	8.60	0.50	100	20
Czech Republic	3.00			
Denmark	2.66	0.40	92	10
Germany	4.55	*0.287*	*86.9*	*16.3*
France	20.93		83 through 85	45 / 72
Netherlands	3.89			
Poland	6.54	0.50	28.6	39
Switzerland	3.08	0.50	93	
United Kingdom	3.00		31.3	
IPCC default	6 through 8	0.50	"pit": 70 %	

Source: UNFCCC 2008, Table 4.B(a)

[56] IEF: calculated emission factor that takes account of both emissions and cattle populations (calves, heifers, fattening bulls, suckling cows, stud bulls). Figures for D for 2007; data of other countries for 2006.

[57] IEF: calculated emission factor that takes account of emissions and swine populations (sows, weaners, fattening pigs, stud boars). Figures for D for 2007; data of other countries for 2006.

Table 94: Methane emissions from storage of farm manure from poultry, in various countries – a comparison of Implied Emission Factors (*IEF*)[58] and important emissions-relevant parameters

	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	0.10	0.03	1.55
Czech Republic	0.08		
Denmark	0.02	0.01	2.0
Germany	0.03	*0.021*	*2.25*
France	0.12	0.10	
Netherlands	0.03		
Poland	0.08	0.10	1.10
Switzerland	0.12	0.10	
United Kingdom	0.08		
IPCC default	0.02 through 0.09	0.02 through 0.07	

Source: UNFCCC 2008, Table 4.B(a)

6.2.5 Source-specific recalculations (4.B)

6.2.5.1 Source-specific recalculations (CH_4)

Provisional animal population figures for 2006 were replaced with final figures.

For dairy cows, ration digestibility was redefined. This led to a considerable decrease in excreted VS quantities.

Feeding data were updated for bulls (mature males). This led to changes in the excretion figures.

For the first time, excretions of pullets, laying hens, broilers and turkeys were calculated via a Tier 2 method (HAENEL & DÄMMGEN, 2007a, b; DÄMMGEN et al., 2008). Excretion figures for ducks were brought into line with the country's latest scientific findings.

For buffalo, assumptions with regard to farm-manure management were modified. The time series for the relevant animal populations was completed.

The *MCF* given in IPCC (2006) diverge – in some cases, considerably – from the corresponding values specified in IPCC (1996b) and IPCC (2000).

The aforementioned changes offset each other to some extent. The pertinent differences are shown in the following tables. For fur-bearing animals, the emission factor (figures for 2000) is 0.68 kg place^{-1} a^{-1} CH_4. The emission factor for buffalo has increased from 3.1 kg place^{-1} a^{-1} CH_4 to 5.4 kg place^{-1} a^{-1} CH_4.

[58] IEF: emission factor calculated from emissions and poultry populations. Figures for D for 2007; data of other countries for 2006.

Table 95: Comparison of figures for CH_4 emissions E_{CH4} from animal husbandry (total manure management) as given in the NIR 2008 and the NIR 2009.

[Tg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	0.28	0.25	0.24	0.24	0.26	0.26	0.26	0.26	0.26	0.26
NIR 2009	0.30	0.26	0.26	0.26	0.27	0.26	0.27	0.26	0.27	0.27
[Tg a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006	2007		
NIR 2008	0.25	0.26	0.25	0.24	0.23	0.24	0.24			
NIR 2009	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26		

Table 96: Comparison of CH_4 emission factors IEF_{CH4} from dairy-cow husbandry (total manure management) as given in the NIR 2008 and the NIR 2009.

[kg $place^{-1}$ a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	14.3	14.4	14.9	15.1	18.5	18.6	18.7	18.6	18.8	19.3
NIR 2009	13.8	14.3	14.6	14.9	17.6	17.7	17.7	17.7	17.9	18.4
[kg $place^{-1}$ a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006	2007		
NIR 2008	19.5	19.7	19.7	18.8	18.8	18.9	18.9			
NIR 2009	18.6	19.0	19.0	19.2	19.3	19.4	19.4	19.6		

Table 97: Comparison of CH_4 emission factors IEF_{CH4} from keeping of other cattle (i.e. not including dairy cows; manure management) as given in the NIR 2008 and the NIR 2009.

[kg $place^{-1}$ a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	7.7	8.0	7.9	8.0	8.0	8.0	8.0	8.0	8.1	8.1
NIR 2009	5.6	5.6	5.8	5.8	5.4	5.4	5.6	5.5	5.6	5.6
[kg $place^{-1}$ a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006	2007		
NIR 2008	8.1	8.2	8.0	8.0	8.0	8.0	8.0			
NIR 2009	5.7	5.8	5.6	5.6	5.6	5.6	5.6	5.7		

6.2.5.2 Source-specific recalculations (NMVOC)

NMVOC emissions are calculated using the NH_3 emissions for the animal species in question. Since changes occurred in this area (see the following chapter), the NMVOC emissions also had to be recalculated. The changes are not apparent in Table 98, however.

Transfer errors were corrected in the calculations with respect to sheep.

Table 98: Comparison of figures for NMVOC emissions E_{NMVOC} from animal husbandry (manure management) as listed in the NIR 2008 and NIR 2009.

[Tg a^{-1} NMVOC]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	0.33	0.29	0.28	0.28	0.27	0.27	0.27	0.27	0.27	0.27
NIR 2009	0.33	0.29	0.28	0.28	0.27	0.27	0.27	0.27	0.27	0.27
[Tg a^{-1} NMVOC]	2000	2001	2002	2003	2004	2005	2006	2007		
NIR 2008	0.26	0.26	0.26	0.26	0.26	0.26	0.26			
NIR 2009	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26		

6.2.5.3 Source-specific recalculations (NH_3, N_2O, NO, N_2)

The frequency distribution of procedures for keeping farm animals, of grazing periods and of various manure storage and spreading procedures were recalculated in RAUMIS for the years 2003 through 2005, on the basis of the pertinent 1999 statistics, since no consistent data records were available for 2003.

The changes, as described in IPCC (2006), in the emission factors for N_2O from manure management lead not to changes in the N_2O emissions themselves but to proportional changes in pertinent NO and N_2 emissions. This in turn leads to changes – considerable, in part – in the N and TAN flows following storage. The areas affected include NH_3 emissions for spreading, as well as all indirect N_2O emissions.

N excretions were updated for dairy cows, fattening bulls, calves, suckling cows, swine and buffalo.

N excretions were calculated in detail (Tier 2) for fattening bulls, laying hens, broilers, pullets and turkeys.

For sheep, the relative distribution of manure-management systems was changed.

A transfer error was corrected with regard to excretions from sheep grazing. The N quantities entering the soil via manure spreading decreased as a result.

N excretions (national, weight-independent standard figures) of horses and ponies were brought into line with the latest findings. Figures for sows are now calculated as a function of weight gain. This has led to slight changes in the initial weights of weaners. The energy analyses and the resulting carbon-cycle calculations are carried out in the customary manner.

The present inventory uses a value of 0.70 kg kg^{-1} N, which is internationally customary and is justified for Germany, for the TAN concentrations in excretions of sows and boars. In the categories of fattening pigs and weaners, TAN concentrations are now calculated as a function of weight gain and feeding.

N excretions for pullets, laying hens and broilers were calculated as a function of weight gain / output. N excretions of geese, ducks and turkeys were brought into line with the latest findings. A number of transcription errors were eliminated.

Last year, the emission factors for NO and N_2 emissions from manure were based on findings regarding the relevant emissions from soils. Those factors have been replaced with factors that were determined experimentally in the UK. All European countries in which inventories of N species are calculated in accordance with the mass-flow procedure now use the same experimentally determined factors.

Quantities of imported poultry excrement were reassessed, following pertinent consultations with Dutch colleagues. Those quantities decreased. It was not possible to prepare a complete time series for the period as of 1990, however.

This leads to changes in NH_3 and NO emissions, as the following tables show:

Table 99: Comparison of figures for N_2O emissions E_{N2O} from animal husbandry (manure management) as listed in the NIR 2008 and NIR 2009

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2008	13.2	11.7	11.3	11.2	9.4	9.7	9.5	9.4	9.4	9.6
2009	9.3	8.2	8.0	8.0	8.2	8.3	8.4	8.2	8.2	8.2
[Gg a^{-1} N_2O]	2000	2001	2002	2003	2004	2005	2006	2007		
2008	9.4	9.6	9.3	10.0	9.9	9.8	9.8			
2009	8.1	8.2	8.0	7.9	7.7	7.8	7.7	7.8		

Table 100: Comparison of figures for NO emissions E_{NO} from animal husbandry (manure management) as listed in the NIR 2008 and NIR 2009

[Gg a^{-1} NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2008	1.8	1.6	1.5	1.5	1.3	1.3	1.3	1.3	1.3	1.3
2009	1.26	1.11	1.09	1.10	1.12	1.13	1.14	1.12	1.12	1.12
[Gg a^{-1} NO]	2000	2001	2002	2003	2004	2005	2006	2007		
2008	1.3	1.3	1.3	1.4	1.3	1.3	1.3			
2009	1.11	1.12	1.09	1.08	1.06	1.06	1.04	1.06		

Table 101: Comparison of figures for NH_3 emissions E_{NH3} from animal husbandry (manure management) as listed in the NIR 2008 and NIR 2009

[Tg a^{-1} NH_3]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2008	0.62	0.54	0.53	0.53	0.52	0.52	0.52	0.51	0.51	0.51
2009	0.59	0.52	0.51	0.51	0.51	0.51	0.51	0.50	0.50	0.50
[Tg a^{-1} NH_3]	2000	2001	2002	2003	2004	2005	2006	2007		
2008	0.50	0.51	0.50	0.50	0.49	0.49	0.49			
2009	0.50	0.51	0.50	0.50	0.49	0.49	0.49	0.50		

6.2.6 Planned improvements (source-specific) (4.B)

The mass-flow-model method and its parameters are being reviewed, expanded and harmonised via international cooperation (REIDY et al., 2008). The emphases of this work include solid-manure management in swine husbandry and keeping of broilers (male and female birds). Description of duck husbandry is being improved with regard to use of a Tier 2 method for describing CH_4, N_2O and NH_3 emissions.

Improving the database for derivation of emission factors will be the focus of a project that is to run from 2007 through 2009. Description of TAN concentrations of N excretions of cattle is to be standardised with the help of a metabolically oriented model.

In future, frequency distributions for stall types and storage procedures, which previously were obtained from the RAUMIS agricultural-sector model, are to be produced directly by the Federal Statistical Office. A survey to be conducted in the framework of the 2010 agricultural census ("Landwirtschaftszählung 2010") will cover those aspects.

6.3 Rice cultivation (4.C)

No rice is cultivated in Germany (NO).

6.4 Agricultural soils (4.D)

The source category "Agricultural soils" comprises direct and indirect emissions of nitrogen species (N_2O and NO) and CH_4 consumption by agricultural soils and plant stocks. Use of urea fertilisers, which releases CO_2, is reported under CRF 5.G.

In the CSE, source category 4.D Agricultural soils includes crop cultivation with and without fertiliser use.

6.4.1 Source-category description (4.D)

CRF 4.D					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - contribution to total emissions**	**Trend**
Agricultural soil, direct soil emissions (CRF 4.D.1)	l / t	N_2O	1.81 %	1.97 %	rising
Agricultural soil, indirect emissions (CRF 4.D.3)	l / -	N_2O	0.53 %	0.56 %	rising

Gas	**CO_2**	**CH_4**	**HFC**	**PFC**	**SF_6**	**N_2O**	**NO_X**	**CO**	**NMVOC**	**SO_2**
Emission factor (EF)	IE	C	NO	NO	NO	C/D	C/D	NO	C	NO
EF uncertainties in %		50				30-1000				
Distribution of uncertainties		N				-				
Method of EF determination		C				C/D/T 1/T2				

With regard to N_2O emissions, the source category "Agricultural soils" (4.D) is a key source of direct and indirect emissions, in terms of levels, and it is a key source of direct emissions in terms of trend.

EMEP (2004) classifies agricultural soils as a key source for NH_3.

Microbial reactions (nitrification and denitrification) with nitrogen compounds lead to emissions of nitrous oxide. The IPCC methods assume that nitrification and denitrification reaction increases 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.

Direct N-inputs leading to N_2O emissions include application of mineral and farm fertilisers, application of sewage sludge, legume cultivation, working of plant residues into the soil, inputs of animal excretions in pastures and N-mineralisation in cultivation of organic soils.

The inventory provides information about direct N_2O, NO and NH_3 emissions from these sources, to the extent pertinent methods have been described.

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.

The results of the calculations are shown in Table 102. The 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. NH_3 emissions, which decreased somewhat in the early 1990s, were higher in 2005 than they were in 1990.

Table 102: N_2O, NO and NH_3 emissions E_{N2O}, E_{NO} and E_{NH3} from agricultural soils (does not include NH_3 emissions from grazing)

[Gg a^{-1} N_2O], [Gg a^{-1} NO] and [Gg a^{-1} NH_3]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{N2O}	100.8	94.2	91.3	90.1	85.7	89.7	90.3	90.3	91.2	93.6
E_{NO}	96.6	89.2	86.0	84.0	78.2	83.0	83.6	83.4	84.5	87.4
E_{NH3}	74.6	67.0	62.0	66.9	62.2	69.8	70.0	71.5	73.6	79.4
[Gg a^{-1} N_2O], [Gg a^{-1} NO] and [Gg a^{-1} NH_3]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
E_{N2O}	95.1	93.8	91.0	89.9	92.8	91.3	90.5	87.63		
E_{NO}	89.6	86.5	83.5	82.7	85.1	83.6	82.8	78.7		
E_{NH3}	82.1	86.1	85.5	84.8	88.5	81.3	87.3	84.2		

For 2007, a 29 % share of N_2O emissions from soils can be allocated to use of mineral fertilisers; other such allocations include 19 % to management of organic soils, 16 % to spreading of farm fertilisers, 11 % to indirect emissions from leaching and 10% to crop residues. The remaining emissions consist of emissions from grazing, sewage sludge, legumes and indirect emissions from deposition of reactive N species.

In the area of NH_3 emissions, the share for use of mineral fertilisers greatly exceeds the share for legume cultivation: it amounted to 98 % in 1990 and 99 % in 2007.

In principle, plant stocks are always also sources of volatile organic compounds. Such emissions have been estimated for important crops (Table 103).

Agricultural soils are sinks for atmospheric methane that is oxidised by methanotrophic bacteria (Table 104).

Fertilisation with urea releases CO_2 (Table 105).

Table 103: NMVOC emissions E_{NMVOC} from agricultural plants.

[Mg a^{-1} NMVOC]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NMVOC}	0.151	0.194	0.191	0.193	0.194	0.194	0.176	0.188	0.201	0.221
[Mg a^{-1} NMVOC]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
E_{NMVOC}	0.210	0.218	0.236	0.228	0.235	0.243	0.254	0.269		

Table 104: CH_4 consumption E_{CH4} of agricultural soils.

[Tg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	0.032	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
[Tg a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
E_{CH4}	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030		

Table 105: CO_2 emissions E_{CO2} from urea use.

[Tg a^{-1} CO_2]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CO2}	0.48	0.43	0.40	0.45	0.42	0.48	0.48	0.50	0.52	0.56
[Tg a^{-1} CO_2]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
E_{CO2}	0.58	0.64	0.65	0.63	0.67	0.60	0.65	0.64		

6.4.2 Methodological issues und Anforderungen (4.D)

The IPCC (2006), p. 11.6 ff., describes Tier-1a, Tier-2 and Tier-3 procedures for determining **direct nitrous-oxide emissions** from agricultural soils. The Tier 1 procedure applies default emission factors to the various N discharges. The Tier 2 procedure requires emission factors

for different mineral fertilisers and different soils. Such data are lacking for Germany. For this reason, the Tier 1 procedure is used.

In principle, both procedures use the following calculation steps:

1. Determination of N input from agricultural activities
2. Determination of emission factors for the various types of N inputs
3. Calculation of total emissions

The Tier 1 procedure differentiates between two different emission factors – one for emissions from N inputs and one for emissions from cultivation of organic soils (IPCC, 2006: p. 11.7):

Equation 9: Tier 1 procedure for determination of direct N_2O emissions from agricultural soils

$$E_{N_2O,\,direct} = \left[\left(m_{SN} + m_{AM} + m_{BN} + m_{CR} + m_{SS}\right) \cdot EF_1 + \left(A_{OS} \cdot EF_2\right)\right]$$

Where
$E_{N2O,\,direct}$ N_2O emissions [kg a^{-1} N]
m_{SN} N input via mineral fertilisers, adjusted for NH_3 and NO_X emissions [kg a^{-1} N]
m_{AM} N input via manure fertilisers, adjusted for NH_3 and NO_X emissions [kg a^{-1} N]
m_{BN} N fixing by legumes [kg a^{-1} N]
m_{CR} N input via plant residues [kg a^{-1} N]
m_{SS} N input via sewage sludges [kg a^{-1} N]
EF_1 Emission factor for emissions from N inputs [EF_1 = 0.01 kg kg^{-1} N]
A_{OS} Area of cultivated organic soils [ha]
EF_2 Emission factor for emissions from cultivation of organic soils [EF_2 = 8 kg ha^{-1} a^{-1} N]

In IPCC (2006), p. 11.6, N_2O emissions from N quantities originating from biological N-fixing are considered not relevant for the time being.

N_2O emissions from animal excrement in connection with grazing should also be reported under direct emissions from soils; the relevant methods description and default EF are provided by IPCC (2006).

Indirect emissions are calculated via the following steps:

1. Determination of indirect N inputs via determination of N losses from agriculture due to emissions, surface run-off, leaching and wastewater management
2. Determination of emission factors for the various input types
3. Calculation of total emissions

The equation for determination of indirect N_2O emissions from agricultural soils is as follows:

Equation 10: Tier 1 procedure for determination of indirect N_2O emissions from agricultural soils

$$E_{N2O,indirect} = E_{N2O,ge} + E_{N2O,l} + E_{N2O,s}$$

Where
$E_{N2O\ (indirect)}$ indirect N_2O emissions [kg a^{-1} N_2O]
$E_{N2O,ge}$ N_2O emissions from emissions of NO_x and NH_3 from fertiliser, manure and liquid manure and their subsequent atmospheric deposition [kg a^{-1} N_2O]
$E_{N2O,l}$ N_2O emissions from surface run-off and leaching of applied fertilisers [kg a^{-1} N_2O]
$E_{N2O,s}$ N_2O from disposal of wastewater in surface waters [kg a^{-1} N_2O]

Since Germany uses the mass-flow procedure to calculate N-species emissions, these emissions are inserted directly into calculations of indirect emissions. No wastewater discharge into surface waters occurs (NO).

In most cases, the calculation methods comply with specifications for the simpler method described in the CORINAIR manual (EMEP, 2003). Specific details are provided in the relevant sections.

6.4.2.1 Methane consumption of agricultural soils (4.D)

Calculation of CH_4 deposition is based on a proposal of BOECKX & VAN CLEEMPUT (2001), who summarise the available results of European measurements. The proposal calls for differentiation between grassland (EF_{CH4} = -2.5 kg ha^{-1} a^{-1} CH_4) and cropland / land for vegetable cultivation (EF_{CH4} = - 1.5 kg ha^{-1} a^{-1} CH_4) (in this regard, see the more detailed description in DÄMMGEN et al, 2008).

6.4.2.2 Emissions of non-methane volatile organic compounds from agricultural soils and crops (first estimate) (4.D)

Levels of NMVOC emissions from plants were estimated using the procedure set forth in the CORINAIR manual (EMEP, 2006). The present inventory draws on the more detailed set of emission factors provided by KÖNIG et. al. (1995) (for details, cf. DÄMMGEN et al., 2008).

6.4.2.3 Nitrous oxide and nitrogen monoxide emissions from agricultural soils (fertiliser use) (4.D)

For calculation, emissions of the two gases are assumed to be proportional, on the average, to N discharges into the system. N inputs from mineral fertilisers are taken from official statistics. Mineral fertiliser sales (for each German Land) serve as the activity data. The inputs from farm manure result from calculation of N flows in manure management (for details, cf. DÄMMGEN et al., 2008). The emission factor for N_2O (0.01 kg kg^{-1} N) was taken from IPCC 2006, Table 11.11, while that for NO (0.012 kg kg^{-1} N) was obtained from STEHFEST & BOUWMAN (2006).

6.4.2.4 Ammonia emissions from agricultural soils (application of mineral fertilisers) (4.D)

NH_3 emissions from application of mineral fertilisers are calculated as a function of fertiliser type (urea, ammonium nitrate with lime, etc.), mean spring temperature and fertilised system (cropland, grassland). 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. For the first time, land used for vegetable cultivation has been taken into account; it has been included with cropland. The emissions were then obtained via the following equation:

Equation 11: Procedure for plausible disaggregation of fertiliser inputs. Calculation of relevant quantities per administrative district

$$m_{\text{fert, i, d}} = x_{\text{fert, d}} \cdot m_{\text{fert, i, sold}}$$

Where
- $m_{\text{fert, i, d}}$ Quantity of a type of fertiliser i used in a district / Land d [Gg a^{-1} N]
- $x_{\text{fert, I, d}}$ Share of fertiliser type i applied in a district d, with respect to the quantity sold in the relevant state (Land) [kg kg^{-1}]
- $m_{\text{fert, i, sold}}$ Quantity of fertiliser type I sold in a state (Land) [Gg a^{-1} N]

Equation 12: Procedure for plausible disaggregation of fertiliser inputs. Calculation of a district's shares of total consumption

$$x_{\text{fert, d}} = \frac{\sum_{\text{j}} A_{\text{j, d}} \cdot m_{\text{rec, j}}}{\sum_{\text{j}} A_{\text{j, FS}} \cdot m_{\text{rec, j}}}$$

Where $A_{\text{j, d}}$ Area under cultivation with crop j in district d [ha]
$m_{\text{rec, j}}$ recommended quantity of fertiliser for crop j [kg ha^{-1} N] (cf. Table 106)
$A_{\text{j, FS}}$ Area under cultivation with crop j in Land FS [ha]

Table 106: Recommended quantities of fertiliser

Crop	Recommended fertilisation kg ha^{-1} N	Source	Crop	Recommended fertilisation kg ha^{-1} N	Source
Winter wheat	220	LWK-NI (2007)	Endive lettuce	120	Hortigate (2005)
Spring wheat	200	LWK-NI (2007)	Lamb's lettuce	80	Hortigate (2005)
Rye	150	LWK-NI (2007)	Head lettuce	80	Hortigate (2005)
Winter barley	190	LWK-NI (2007)	Lollo lettuce	80	Hortigate (2005)
Spring barley	130	LWK-NI (2007)	Radicchio	80	Hortigate (2005)
Oats	100	LWK-NI (2007)	Romaine lettuce	100	Hortigate (2005)
Triticale	190	LWK-NI (2007)	Arugula	80	Hortigate (2005)
Grain maize	180	LWK-NI (2007)	Other lettuces	80	Hortigate (2005)
Silo corn	180	LWK-NI (2007)	Spinach	90	Hortigate (2005)
Rape	200	LWK-NI (2007)	Rhubarb	120	Hortigate (2005)
Sugar beets	160	LWK-NI (2007)	Asparagus	80	Hortigate (2005)
Fodder beets	160		Celery	140	Hortigate (2005)
Clover, clover-grass mixtures, clover-alfalfa mixtures (fodder production on arable land)	0		Florence fennel	140	Hortigate (2005)
			Celeriac	140	Hortigate (2005)
			Horseradish	140	Hortigate (2005)
Alfalfa	0		Carrots	80	Hortigate (2005)
Grass (fodder production on arable land)	270	KTBL (2004), p. 301	Radish	70	Hortigate (2005)
Potatoes	160	LWK-NI (2007) (2003)	Wild / exotic radish	100	Hortigate (2005)
Broad beans	0		Red beets	180	Hortigate (2005)
Fodder peas	0		Pickling cucumbers	140	Hortigate (2005)
Other pulses	0		Gherkins	140	Hortigate (2005)
Meadows and pastures	130	KTBL (2004), p. 301	Winter squash	120	Hortigate (2005)
Cauliflower	220	Hortigate (2005)	Zucchini	170	Hortigate (2005)
Broccoli	190	Hortigate (2005)	Sweet corn	150	Hortigate (2005)
Chinese cabbage	80	Hortigate (2005)	Bush beans	80	Hortigate (2005)
Kale	160	Hortigate (2005)	Broad beans		Hortigate (2005)
Kohlrabi	130	Hortigate (2005)	Climbing beans	120	Hortigate (2005)
Brussels sprouts	300	Hortigate (2005)	Fresh peas	110	Hortigate (2005)
Red cabbage	190	Hortigate (2005)	Bunching onions	150	Hortigate (2005)
White cabbage	195	Hortigate (2005)	Onions	90	Hortigate (2005)
Savoy	195	Hortigate (2005)	Parsley	180	Hortigate (2005)
Oak leaf lettuce	80	Hortigate (2005)	Leek	160	Hortigate (2005)
Iceberg lettuce	120	Hortigate (2005)	Chives	200	Hortigate (2005)

The relevant fertiliser quantities are obtained from official statistics, while the pertinent emission factors are obtained from EMEP (2006).

6.4.2.5 Carbon dioxide emissions from urea use (4.D)

Urea ($(NH_2)_2CO$) reacts with water (H_2O) pursuant to the relationship

$(NH_2)_2CO + H_2O \rightarrow 2\ NH_3 + CO_2$.

This reaction is complete. The emission factor for CO_2 is thus 44/28, with respect to the N in urea.

6.4.2.6 Nitrous oxide and nitrogen monoxide emissions from agricultural soils (legumes) (4.D)

IPCC (2006)-11.6 proposes that N_2O emissions from legumes not be calculated, since there are no indications of significant emissions from that source. Since NO is released from the same sources, the emission factors for N_2O and NO have been set as "zero".

6.4.2.7 Nitrous oxide and nitrogen monoxide emissions from agricultural soils (harvest residues) (4.D)

The N quantities remaining in the soil with harvest residues are calculated from the area under cultivation and the crop-specific N residues. N_2O and NO emissions from reactions with harvest residues in the soil are considered to be proportional to the N quantities remaining in the soil.

The calculation procedure (which is described in IPCC(2006)-11.13 as a Tier-2 procedure):

Equation 13: Determination of emissions of N species from harvest residues

$$E_{N2O,CR} = \left(\sum_i A_i \cdot x_{renew,i} \cdot x_{mow,i} \cdot y_i \cdot x_{DM,i} \cdot \left(a_{above,i} \cdot x_{N,above,i} + a_{below,i} \cdot x_{N,below,i} \right) - m_{N,straw} \right) \cdot EF_{N2O,CR} \cdot \beta \cdot \gamma_{N2O}$$

$$E_{NO,CR} = \left(\sum_i A_i \cdot x_{renew,i} \cdot x_{mow,i} \cdot y_i \cdot x_{DM,i} \cdot \left(a_{above,i} \cdot x_{N,above,i} + a_{below,i} \cdot x_{N,below,i} \right) - m_{N,straw} \right) \cdot EF_{NO,CR} \cdot \beta \cdot \gamma_{NO}$$

Where	$E_{N2O,CR}$	N_2O emissions from harvest residues [Gg a^{-1} N_2O]
	A_i	Cultivation area for a crop i [ha]
	$x_{renew,i}$	Percentage amount of crop i that is harvested annually [ha ha^{-1}]
	$x_{mow,i}$	1 / number of harvests (mowings) of crop i per year
	y_i	Yield of crop i [kg ha^{-1}]
	$x_{DM,i}$	Dry matter content of crop i [kg kg^{-1}]
	$a_{above,i}$	Ratio of above-ground biomass to yield of crop i [kg kg^{-1}]
	$x_{N,above,i}$	N content of above-ground biomass of crop residue of crop i [kg kg^{-1} N]
	$a_{below,i}$	Ratio of below-ground biomass to yield of crop i [kg kg^{-1}]
	$x_{N,below,i}$	N content of below-ground biomass of crop residue of crop i [kg kg^{-1} N]
	$m_{N,straw}$	N quantity removed with straw used as straw bedding [kg N]
	$EF_{N2O,CR}$	N_2O emission factor for harvest residues ($EF_{N2O,CR}$ = 0.01 kg kg^{-1} N_2O-N)
	β	Conversion factor for weight units (β = 10^{-6} Gg kg^{-1})
	γ_{N2O}	Conversion factor for masses (γ_{N2O} = 44/28 g g^{-1} mol mol^{-1})
	$E_{NO,CR}$	NO emissions from harvest residues [Gg a^{-1} NO]
	$EF_{NO,CR}$	NO emission factor for harvest residues ($EF_{NO,CR}$ = 0.007 kg kg^{-1} NO-N)
	γ_{NO}	Conversion factor for masses (γ_{NO} = 30/14 g g^{-1} mol mol^{-1})

Pertinent details are provided in Table 107. A similar procedure is used for crop residues from vegetable cultivation (cf. DÄMMGEN et. al., 2008). The cultivation-area and yield figures are taken from official statistics. The calculations were carried out for administrative districts for the years 1999 and 2003.

Table 107: Database for calculating N_2O, NO and N_2 emissions from harvest residues

Crop	Default yields	Dry matter content	$a_{above, i}$	$x_{N, above}$	$a_{below, i}$	$x_{N, below}$
	[kg ha^{-1}]	[kg kg^{-1}]	[kg kg^{-1}]	[kg kg^{-1} N]	[kg kg^{-1}]	[kg kg^{-1} N]
Winter wheat		0.89	0.9	0.0055	0.44	0.009
Spring wheat		0.89	0.9	0.0055	0.56	0.009
Rye		0.88	1.4	0.0055	0.53	0.011
Winter barley		0.89	1.0	0.0055	0.44	0.014
Spring barley		0.89	1.1	0.0055	0.46	0.014
Oats		0.89	1.2	0.0055	0.55	0.008
Triticale		0.88	1.4	0.0055	0.53	0.008
Grain maize		0.65	1.3	0.0070	0.51	0.007
Silo corn		0.30	1.2	0.0035	0.48	0.007
Rape		0.92	1.7	0.0070	0.59	0.010
Sugar beets		0.22	0.8	0.0029	0.36	0.014
Beets		0.22	0.3	0.0024	0.26	0.014
Clover, clover-grass mixtures, clover-alfalfa mixtures (fodder production on arable land)	50,000	0.15	0.5	0.0050	1.2	0.012
Alfalfa	50,000	0.20	0.3	0.0060	0.52	0.019
Grass (fodder production on arable land)	34,000	0.15	0.5	0.0050	1.20	0.012
Potato	0	0.22	0.1	0.0040	0.22	0.014
Broad beans	0	0.90	2.1	0.0150	0.59	0.022
Fodder peas	0	0.90	2.1	0.0150	0.59	0.022
Other pulses	0	0.90	2.1	0.0160	0.59	0.022
Meadows and pastures	45,000	0.15	0.5	0.0050	1.2	0.012

Sources: Detailed description, including relevant figures for vegetables, in DÄMMGEN et al. (2008)

The calculations use default emission factors for determination of emissions from use of mineral and farm fertilisers: EF_{N2O-N} = 0.01 kg kg^{-1} N (IPCC 2006: 11.11); EF_{NO-N} = 0.012 kg kg^{-1} N (STEHFEST & BOUWMAN, 2006); EF_{N2} = 0.08 kg kg^{-1} N (derived from the ratio of N_2 to N_2O-N; cf. DÄMMGEN et. al., 2008). The same emission factors are applied to the N quantities bound in harvest residues, with the exception of EF_{NO-N} = 0.007 kg kg^{-1} N (EMEP, 2003: B1020-12).

The areas under cultivation and harvests are listed in HAENEL et al. (2008).

6.4.2.8 Nitrous oxide emissions from organic soils (4.D)

Nitrous oxide emissions from cultivation of *organic soils* are calculated in accordance with the simpler method. In that method, emissions are proportional to the area in question. Since no statistical data on use of such soils is available, the areas in question have been estimated via superpositioning of land-use maps and soil maps (for details, see DÄMMGEN et al., 2008). The emission factor used was the default factor $EF_{2CG, Temp}$ IPCC, 2006: Table 11.1: 8 kg ha^{-1} a^{-1} N_2O-N.

6.4.2.9 Nitrous oxide emissions from excrement produced during grazing (4.D)

In treatment of manure via the mass-flow procedure, emissions of N species that result from grazing on pastures are calculated for each species and district, using the relative quantities of excretions occurring on pastures, and then summed for all German Länder (for details, cf. DÄMMGEN et al., 2008). N_2-emissions levels influence the amount of N that is input into the soil.

The following emission factors are used (EMEP, 2003: B1020-8; IPCC, 2006-11.11):

NH_3	0.075 kg kg^{-1} N	(all animals)
N_2O	0.02 kg kg^{-1} N	(cattle, buffalo, swine, poultry)
N_2O	0.01 kg kg^{-1} N	(sheep, goats, horses)
NO	0.02 kg kg^{-1} N	(cattle, buffalo, swine, poultry)
NO	0.01 kg kg^{-1} N	(sheep, goats, horses)
N_2	0.14 kg kg^{-1} N	(cattle, buffalo, swine, poultry)
N_2	0.07 kg kg^{-1} N	(sheep, goats, horses)

6.4.2.10 Indirect nitrous oxide emissions resulting from atmospheric deposition (4.D)

N_2O emissions from atmospheric deposition are calculated using the following equation (Tier 1a):

Equation 14: Determination of indirect N_2O emissions from soils resulting from deposition of reactive N species from agriculture

$$E_{N2O,ge} = \left[\left(m_{N,fert} \cdot x_{fert}\right) + \left(m_{N,ex} \cdot x_{ex}\right)\right] \cdot EF_4 \cdot \gamma_{N2O}$$

where:

$E_{N2O,ge}$	N_2O emissions from emissions of NO_x and NH_3 from fertiliser, and their subsequent atmospheric deposition [Gg a^{-1} N_2O]
$m_{N, fert}$	Amount of mineral fertiliser applied [Gg a^{-1} N]
x_{fert}	Fraction of mineral fertiliser that is emitted as NH_3 or NO_x [kg kg^{-1} N] (IPCC: $Frac_{GASF}$)
$m_{N,ex}$	Total amount of N in applied manure fertilisers [Gg a^{-1} N]
x_{ex}	Share of manure fertiliser that is emitted as NH_3, NO, N_2O or N_2 [kg kg^{-1} N] (IPCC: $Frac_{GASM}$)
EF_4	Emission factor for N_2O emissions from atmospheric deposition [EF_4 = 0.01 kg kg^{-1} N]
γ_{N2O}	Conversion factor for masses (γ_{N2O} = 44/28 g g^{-1} mol mol^{-1})

These indirect emissions comprise N_2O emissions from atmospheric deposition and from leaching and surface run-off. The pertinent NH_3 and NO emissions data are based on spreading of mineral fertilisers and on manure management. Data on mineral-fertiliser use and legume cultivation were obtained from official statistics. NH_3 losses are calculated in accordance with EMEP (2003) and are not estimated in accordance with IPCC (1996b). IPCC default emission factors are used (IPCC, 2006: Tab11.3).

6.4.2.11 Indirect nitrous oxide emissions resulting from leaching and surface run-off (4.D)

Under a simple Tier 1 procedure, N_2O emissions from leaching and surface run-off are considered to be proportional to N inputs into the soil. The CRF lists fugitive nitrogen emissions from mineral and farm fertilisers, crop residues and N discharges from degradation of organic soils as relevant sources. Figures for the last of these quantities are not available for Germany for the time being. In contrast to the assumption used in earlier procedures, N from nitrogen fixing is now considered to be not vulnerable to leaching. IPCC default values are used for the leachable fraction and for the emission factor (IPCC, 2006: Table 11.3).

The N_2O emissions are calculated pursuant to the following formula:

Equation 15: Determination of indirect N_2O emissions from soils resulting from leaching of nitrogen from agriculture soils

$$E_{\mathrm{N2O,l}} = \left(m_{\mathrm{man}} + m_{\mathrm{fert}} + m_{\mathrm{SS}}\right) \cdot x_{\mathrm{leach}} \cdot EF_5 \cdot \gamma\ \mathrm{N2O}$$

where:
- $E_{N2O,l}$ N_2O emissions from leaching and surface run-off [Gg a^{-1} N_2O]
- m_{man} N input via manure [Gg a^{-1} N]
- m_{fert} N input via manure fertilisers [Gg a^{-1} N]
- m_{SS} N input via sewage sludge [Gg a^{-1} N]
- m_{CR} N input via crop residues [Gg a^{-1} N]
- m_{MOS} N input from mineralisation of organic soils [Gg a^{-1} N]
- x_{leach} Leachable N fraction [kg kg^{-1} N][x_{leach} = 0.3 kg kg^{-1} N]
- EF_5 Emission factor for N_2O emissions from leaching [EF_5 = 0.0075 kg kg^{-1} N]
- γ_{N2O} Conversion factor for masses (γ_{N2O} = 44/28 g g^{-1} mol mol^{-1})

6.4.3 Uncertainties and time-series consistency (4.D)

The uncertainties are outlined in EMEP/CORINAIR (EMEP, 2003); they apply to Germany as well until further notice. The detailed discussion in this source indicates that the error for relevant areas is on the order of 10 % and that the error for emissions is on the order of 50 %. The time series is consistent.

6.4.4 Source-specific quality assurance / control and verification (4.D)

It was not possible to carry out general quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents, since the relevant staff unit was in the process of being restructured.

The data is reviewed for transcription errors made between the original data and the calculation tables, and it is checked for errors with regard to units and orders of magnitude. Future QA/QC procedures pre-suppose the further development of methods and a better breakdown of activity data (cf. Chapter 6.1.4).

At present, Germany does not have any numerical basis for better description of data quality and uncertainties.

6.4.5 Source-specific recalculations (4.D)

6.4.5.1 Methane consumption of agricultural soils (4.D)

No source-specific recalculations have been carried out.

6.4.5.2 Ammonia emissions from agricultural soils (4.D)

The grassland share of the total area in question has decreased, as a result of (first-time) inclusion of land under vegetable cultivation, and of addition of such land to cropland, for purposes of determination of NH_3 emissions from use of mineral fertilisers. Since the NH_3 emission factors for grassland are lower, in some cases, than those for cropland, the newly reported figures tend to be somewhat lower than the previous corresponding figures. Other procedural changes (larger area for legumes, via inclusion of vegetable cultivation (peas, beans); and use of other basic data for deriving mean spring temperatures) have also led to data changes (cf. Table 108).

Table 108: Comparison of figures in the NIR 2008 and NIR 2009 for NH_3 emissions from agricultural soils (not including NH_3 emissions from grazing).

[Gg a^{-1} NH_3]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	74.8	67.5	62.8	66.8	61.9	69.7	70.0	71.9	73.6	80.0
NIR 2009	74.6	67.0	62.0	66.9	62.2	69.8	70.0	71.5	73.6	79.4
[Gg a^{-1} NH_3]	2000	2001	2002	2003	2004	2005	2006	2007		
NIR 2008	84.1	87.3	86.7	86.1	90.0	82.7	82.7			
NIR 2009	82.1	86.1	85.5	84.8	88.5	81.3	87.3	84.2		

6.4.5.3 Nitrous oxide and nitrogen monoxide emissions from agricultural soils (4.D)

The time series for activities relative to sewage sludges was corrected and completed.

In calculation of N_2O emissions from soils, NH_3 and NO emissions prior to N_2O formation were taken into account. $FRAC_{GASF}$ is not a constant.

For the first time, N_2O from harvest residues was calculated as a function of yield, using the IPCC procedure.

Calculation of N excretions in animal husbandry, using detailed or improved methods (cattle, sows, laying hens, broilers, pullets), and updating of N excretions (for example, for ducks and turkey), resulted in changes in the pertinent direct emissions of NH_3 and NO. The indirect emissions have also changed as a result.

N flows with farm fertilisers were calculated with the emission factors for N_2O given in IPCC (2006). This led to changes in NH_3 flows and N inputs into soils.

IPCC (2006) listed changed emission factors for direct emissions from mineral fertilisers, etc. (EF_1 in Equation 9). In the area of emissions from farm fertilisers, a distinction was now made between inputs with a) sheep, goat and horse manure and b) manure of other animals. N inputs with N fixing were no longer taken into account.

A considerable lower emission factor was used for calculation of indirect emissions from leaching and surface runoff.

A considerably increased emission factor was used for calculation of NO emissions from mineral fertilisers, farm fertilisers and grazing.

Transfer errors in the figures for crop residues were corrected. The inventory now takes account of the fact that some of the straw in the system is removed for use as straw bedding in animal husbandry.

Table 109: Comparison of figures used in the NIR 2008 and NIR 2009 for direct N_2O emissions from agricultural soils (including grazing).

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	94.8	87.6	84.9	82.8	78.6	82.3	82.4	81.9	82.6	84.9
NIR 2009	79.3	74.7	72.5	71.5	67.9	71.1	71.6	71.7	72.3	74.2
[Gg a^{-1} N_2O]	2000	2001	2002	2003	2004	2005	2006	2007		
NIR 2008	86.3	84.3	82.1	81.5	82.6	81.9	81.9			
NIR 2009	75.5	74.4	72.2	71.3	73.7	72.5	71.8	69.4		

Table 110: Comparison of figures used in the NIR 2008 and NIR 2009 for indirect N_2O emissions from agricultural soils.

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	48.1	43.6	42.2	40.8	38.8	40.7	40.6	40.2	40.6	41.8
NIR 2009	21.5	19.5	18.8	18.6	17.8	18.6	18.7	18.7	18.9	19.3
[Gg a^{-1} N_2O]	2000	2001	2002	2003	2004	2005	2006	2007		
NIR 2008	42.7	41.6	40.6	40.6	40.7	40.2	40.2			
NIR 2009	19.5	19.5	18.9	18.7	19.1	18.9	18.7	18.2		

Table 111: Comparison of figures used in the NIR 2008 and NIR 2009 for NO emissions from agricultural soils.

[Gg a^{-1} NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	65.2	59.3	57.1	55.6	52.0	55.0	55.2	54.8	55.4	57.3
NIR 2009	96.6	89.2	86.0	84.0	78.2	83.0	83.6	83.4	84.5	87.4
[Gg a^{-1} NO]	2000	2001	2002	2003	2004	2005	2006	2007		
NIR 2008	58.3	56.5	54.6	54.1	55.1	54.4	54.4			
NIR 2009	89.6	86.5	83.5	82.7	85.1	83.6	82.8	78.7		

Table 112: Comparison of figures used in the NIR 2008 and NIR 2009 for NH_3 emissions from agricultural soils (including grazing).

[Tg a^{-1} NH_3]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2008	0.091	0.082	0.077	0.082	0.075	0.083	0.084	0.086	0.087	0.094
NIR 2009	0.094	0.085	0.080	0.085	0.079	0.087	0.087	0.088	0.090	0.096
[Tg a^{-1} NH_3]	2000	2001	2002	2003	2004	2005	2006			
NIR 2008	0.098	0.101	0.100	0.099	0.103	0.096	0.096			
NIR 2009	0.099	0.103	0.102	0.101	0.105	0.097	0.103	0.100		

6.4.6 Planned improvements (source-specific) (4.D)

6.4.6.1 Ammonia emissions from agricultural soils (4.D)

Improved calculations of N excretions will necessitate revision of emissions throughout the entire nitrogen chain.

6.5 Prescribed burning of savannas (clearance of land by prescribed burning) (4.E)

Land clearance by prescribed burning is not practiced in Germany (NO).

6.6 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)

CRF 5					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - contribution to total emissions**	**Trend**
Forest Land (5.A)	l / t	CO_2	5.56 %	7.22 %	rising
Cropland (5.B)	l / t	CO_2	2.23 %	3.20 %	stegend
Grassland (5.C)	l / t	CO_2	1.03 %	1.38 %	rising
Wetlands (5.D)	- / t	CO_2	0.18 %	0.28 %	rising
Settlements (5.E)	l / t	CO_2	0.16 %	1.16 %	rising

The source categories Forest land (5.A), Cropland (5.B), Grassland (5.C) and Settlements (5.E) are a key source of CO_2 emissions, in terms of both emissions level and trend; the source category Wetlands (5.D) is a key source only in terms of trend.

7.1 Forest land (5.A)

The basis for reporting consists of the definition of "forest" used by the Federal Forest Inventory (Bundeswaldinventur - BWI)[59]. The BWI's survey instructions differentiate between the following sub-categories of forest:

- Productive forest, wooded ground[60]
- Unproductive forest[61], wooded ground[60]
- Forest, openings[62]
- Forest, non-wooded ground[63]

In calculations for greenhouse-gas inventories, the categories "unproductive forest" and "openings" were included with forest, while "non-wooded ground", in keeping with the definition of "forest" used in decision 11/CP.7 of the 7th Conference of the Parties in Marrakesh (UNFCCC, 2002: p. 58) was excluded, as non-forest.

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

[59] "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. Areas with forest cover in open pasture land or in built-up areas of less than 1000 m²; coppices less than 10 m wide; cultivations of Christmas trees and ornamental brushwood; and parkland attached to country houses are not forest within the meaning of the FFI. Watercourses up to 5 m wide do not break the continuity of a forest area. Cultivations of Christmas trees and ornamental brushwood in the forest are forest within the meaning of the Federal Forest Inventory (BMELF, 1990).

[60] The wooded-ground area is that part of the forest that is covered with trees used in forestry and that is used for wood production.

[61] Unproductive forest areas are fields of dwarf pines and green alders, areas of shrubs (but not openings) and other forest areas which are sparsely covered or which have low productivity (≤1 m³ average total growth (dGZ) / hectare).

[62] Openings are areas of wooded ground temporarily without forest cover.

[63] Non-wooded ground includes forest tracks, rides and firebreaks over 5 m wide, landings, tree nurseries, seed and plant nurseries, wood-pastures and fields for game, the areas of yards and buildings used for forestry purposes, recreational facilities linked to the forest and rocks, boulders, gravel and water located in the forest. In addition, if they are not overgrown, swamps and moors located in the forest fall under “non-wooded ground”.

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). 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.

With existing data for Germany, new forest additions in the old German Länder can be traced back only to 1987; for the new German Länder, it has been possible only to derive the net new forest since 1993.

7.1.1 Forest land remaining forest land (5.A.1)

7.1.1.1 Source-category description (5.A.1)

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										
Method of EF determination	CS/T2 [64]									

The source category "Forest land remaining forest land" has not yet been subjected to key-source analysis.

7.1.1.1.1 Changes in biomass

For the old German Länder, relevant data are available from two federal forest inventories (key dates: 1 October 1987 and 1 October 2002) (BFH, 2004). Between the two forest inventories, C stocks in forests of the old German Länder underwent a net increase of 1.52 Mg/ha/a. 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 forest-establishment data, given the lack of an initial inventory comparable to BWI I. The comparison showed a marked net C-stock increase of 3.01 Mg/ha/a.

It seems clear that the forest-establishment data underestimates stocks. If the initial value for total stocks is assumed to be 10 % higher (and evenly distributed among all tree species), a marked net C-stock increase of 2.32 Mg/ha/a results.

Overall, the forests of the Federal Republic of Germany are thus a net sink for C.

7.1.1.1.2 Dead wood, debris and soils

For greenhouse-gas inventories, it was assumed that stocks under existing forest do not change (corresponds to "Tier 1").

7.1.1.1.3 Other greenhouse-gas emissions from forests

Figures for CO_2 emissions from liming of forest floors are provided in category 5.G. (Other). They range between 75 and 210 Gg CO_2 per year, and are tending to decrease.

[64] The entry "CS/T2" refers to determination of changes in biomass stocks. Under Tier 1, changes in dead wood, debris and soil were estimated to be 0.

Forests in Germany are not normally given nitrogen fertilisers. In CRF Table 5(I), therefore, this activity has been marked "NO". No reliable data is available for reporting on N_2O emissions from draining of forest soils (CRF 5(II)).

BUTTERBACH-BAHL (2003), using the PnET-N-DNDC model, estimated total nitrous oxide (N_2O) emissions from forest soils for the years 1990-1999 as amounting to about 14 Gg per year. This figure includes "indirect" N_2O emissions, however, which originate in sources outside of the forestry sector and thus are outside the scope of greenhouse-gas inventories for forest soils.

As a result of use of the "stock-change method", CO_2 from biomass combustion has already been taken into account in changes of biomass stocks; the entry for that category is thus "IE".

Emissions of other greenhouse gases from forest fires and from controlled biomass combustion have been classified as negligible and, in Table 5 (V) "Biomass burning", reported as "NO", since only small areas of Germany are affected by forest fires and since logging areas are burned only in exceptional cases – for example, in cases of bark-beetle infestation. Large-scale burn-offs of vegetation cover are prohibited in Germany.

7.1.1.2 Methodological issues (5.A.1)

7.1.1.2.1 Data sources

The basis for the biomass and area calculations consists of the data from the two Federal Forest Inventories. Pursuant to provisions of the GPG-LULUCF (IPCC 2003), those data are processed in keeping with requirements pertaining to international reporting obligations.

The Federal Forest Inventory (Bundeswaldinventur – BWI) is a terrestrial random-sampling inventory with permanently marked sampling points in a 4 x 4 km basic grid whose resolution, at the request of the Länder, can be increased on a regional basis[65].

The first Federal Forest Inventory, BWI I, covered only the territory of the Federal Republic of Germany in its pre-1990 boundaries and West Berlin. For the new German Länder, therefore, forest-establishment data have to be taken from another source. The available source is the publication "The Forest in the New German Länder" ("Der Wald in den neuen Bundesländern" (BML, 1994)).

Now, with the Federal Forest Inventory II (BWI II) and Soil-Condition Survey (Bodenzustandserhebung - BZE), first inventories are available for the categories of deadwood, debris and soils. While this makes it possible to estimate the C stocks in these categories, it does not made it possible to determine the relevant changes.

The deadwood stocks of 11.5 m^3/ha found by the BWI II correspond to C stocks of some 2.6 Mg C /ha.

Finer debris fractions are part of the humus layer, which was surveyed by the BZE. The first BZE, which was carried out from 1987 to 1993, estimated the carbon stocks in the humus layer, and in the first 30 cm of mineral soil lying beneath the humus layer, as amounting to about 0.858 Pg C (BMELF, 1997).

[65] Further information: http://www.bundeswaldinventur.de

The data on liming of forest soils were derived from the fertiliser statistics published by the Federal Statistical Office (DESTATIS, Fachserie 4, Reihe 8.2) and from statistics of the former GDR. Since 1993/94, the results have been collected and published for unified Germany.

Data on areas on which forest fires have occurred, since 1992, are available in official forest-fire statistics pursuant to Council Regulation (EEC) No. 2158/92 of 23 July 1992 on protection of the Community's forests against fire; excerpts from the forest-fire statistics are published in BML 1992ff.

7.1.1.2.2 Forest land remaining as forest land

Forest-area data are not required for calculation of biomass stocks pursuant to the stock-change method, but such data must be reported in the CRF. The area data for individual years are based on linear interpolation.

Pursuant to the results of the two Federal Forest Inventories, in the old German Länder, the total forest area (not including the non-timber area) increased by 54.12 kha, to 7,693.72 kha, between 1987 and 2002. Pursuant to IPCC GPG-LULUCF (2003), new forest must be classified as "new forest" for a period of 20 years, and thus each year the category "forest land remaining forest land" is reduced by that forest area converted to other land uses. The category "forest land remaining forest land" thus decreased from 7,626.14 kha (1990) to 7,572.27 kha (2002).

According to forest-establishment data, in the new German Länder, the forest area (not including non-wooded ground) in 1993 amounted to 2,852.5 kha; by BWI II it had increased to 3,027 kha. As a result, the first of these values can be assigned to the category "forest land remaining forest land".

7.1.1.2.3 Derivation of stock changes pursuant to the "stock-change method" (difference method)

The Federal Forest Inventories provide such good data for calculation – by measuring about 230,000 trees in key year 1987 (BWI I) and some 377,000 trees in key year 2002 (BWI II) – 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).

For use of the stock-change method, the relevant living biomass was divided into the following separate categories: "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. The basic equations (Equation 16 and Equation 17) for C-stock determination via the stock-change method were thus converted into the form exhibited by Equation 18. The first part of Equation 18 (standing timber, branch wood) was applied to each tree, while the second part was applied to stands. The total value was then extrapolated from the stand values.

Equation 16:

$$\Delta C = \left(C_{t_2} - C_{t_1}\right) / \left(t_2 - t_1\right)$$

Equation 17:

$$C = \left[V \bullet D \bullet BEF\right] \bullet \left(1 + R\right) \bullet CF$$

Equation 18:

$$C = [V \bullet D_D + V \bullet D_A \bullet (VEF - 1)] \bullet (1 + R) \bullet CF$$

Trunk Wood — branch wood — root wood

where:

C = carbon stock
V = standing-timber volume
D_D = basic density of standing timber
D_A = basic density of branches
BEF = biomass-expansion factor
VEF = volume-expansion factor[66]
R = root / sprout relationship
CF = carbon content

7.1.1.2.4 Procedure

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).

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. Volume-expansion factors were used to estimate the tree-wood volume from the standing-timber volume (cf. Chapter 7.1.1.2.7).

For the new German Länder, forest-establishment data are available in aggregated form. 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 C-stock determination.

7.1.1.2.5 Total stocks of forest land remaining forest land

The results described here refer, in connection with individual-tree calculations for BWI I and BWI II, to volume densities pursuant to KOLLMANN (1982), whereas branch volumes, with their greater densities, were extrapolated pursuant to HAKKILA (1972). Regression equations were used to estimate above-ground tree volumes (cf. Annex). Root biomass was calculated using default values from IPCC GPG-LULUCF (2003). In the extrapolation for the new German Länder for 1993, the biomass-expansion factors of BURSCHEL et al. (1993) were separated into above-ground and below-ground components, and the upper branch volume was estimated from the difference between above-ground volume and standing-timber volume. In the interest of comparability between the extrapolation of forest-establishment data and individual-tree calculation pursuant to BWI, the same volume densities were used throughout this process.

[66] 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".

Table 113: Total C stocks, forest land remaining as forest land, with estimate of the relative standard deviation

Gg C		1987 (BWI I)	1993 (BML)	2002 (BWI II)
Old German Länder	below-ground	174.670	-	212.849
	above-ground	604.474	-	740.481
	total	**779.144 (± 8%)**	**-**	**953.330 (± 7,55%)**
New German Länder	below-ground	-	34.723	63.690
	above-ground	-	161.766	218.667
	total	**-**	**196.489 (±12,71 %)**	**282.357 (± 10,02 %)**

7.1.1.2.6 Volume density of trunk wood and branches

The volume densities were derived from the figures provided by KOLLMANN (1982) for raw density and volume-loss measures (cf. Annex), using Equation 19:

Equation 19:

$$R = r_0 * \left(1 - \frac{\beta_V}{100}\right)$$

where:

R = basic density (g/cm^3)
r_0 = raw density (g/cm^3)
$ß_V$ = volume-loss measure

Pursuant to Equation 18, other basic densities are used for branches. Due to the stresses it is subject to, branch wood is denser than trunk wood. Separation into various categories makes it possible to use different densities. The relevant necessary data were derived by analogy to HAKKILA (1972).

Furthermore, figures for volume density of trunk wood vary widely. For this reason, calculations were carried out for a range of different scenarios (cf. Annex Chapter 14.5.1.1.1.2.7).

7.1.1.2.7 Volume-expansion factors

The volume-expansion factors (VEF) for conversion of standing timber into above-ground biomass were derived from a linear regression; they are based on the tables of GRUNDNER & SCHWAPPACH (1952) for standing timber and tree wood. These factors provide a functional relationship between standing timber and tree wood. This makes it possible to estimate tree-wood amounts from the size of standing timber, which itself depends on the measurements diameter at a height of 1.3 m, diameter at a height of 7 m (BHD, D_7) and height. In addition, the tables require that the tree species spruce, fir, beech and pine be separated into age classes, since for these trees it was found that, for trunks with the same dimensions, older trunks have a greater volume than younger trunks; the older trunks have a greater wood fraction (cf. Table 166 in the Annex). This separation was retained, since the tables are based on separate basic totalities.

The following relationship thus results for the various volume-expansion factors for specific species and tree ages:

Equation 20:

$$VEF = \frac{B}{D} = \frac{a + bD}{D}$$

where:

B	= tree wood volume
D	= standing-timber volume
a, b	= regression parameter
VEF	= volume-expansion factor

7.1.1.2.8 Root biomass

Dry root substance was estimated directly from above-ground mass, at the stand level, using the root/shoot ratio with values pursuant to IPCC 2003. To obtain stand 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.

A comparative calculation, in keeping with the function published by DIETER & ELSASSER (2002) for estimating root biomass, produced similar results (Annex, Chapter 14.5.1.1.1.2.10).

7.1.1.2.9 Derivation of CO_2 emissions from liming of forest soils

The liming data were derived from the total-fertilisers calculation. They describe producers' and importers' deliveries to wholesalers and end users (DESTATIS, Fachserie 4, Reihe 8.2). For the calculation, the amount of fertiliser spread 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).

7.1.1.3 Uncertainties and time-series consistency (5.A.1)

The uncertainties were calculated for aggregated stocks, for the two Federal Forest Inventories and broken down by old and new German Länder.

For the old German Länder, stratification was carried out in accordance with tree-species groups pursuant to BWI (ALH[67], ALN[68], beech, douglas fir, oak, spruce, pine, larch, fir). This is accomplished by estimating or calculating the relative standard deviation for each input item (standing-timber volume, volume density, above-ground biomass expansion, root biomass and carbon fraction). This relative standard deviation is then extrapolated using either additive error propagation or multiplicative error propagation. The calculation does not take account of every possible error source (divergence of allometry, model errors in standing-timber calculation, measurement errors). Errors are derived using practical approaches, and thus such derivation provides only an approximation of the actual errors at work. Correlations between individual terms were neglected.

As a result, one obtains an estimate of the relative standard deviation of the total stocks. The 95% confidence interval for this estimate corresponds to double the relative standard deviation.

For the new German Länder, errors for C stocks can be calculated only as estimates, based on aggregated values; this is accomplished pursuant to the publication "The forest in the new German Länder" ("Der Wald in den neuen Bundesländern" (BML 1994)).

[67] ALH = all other deciduous trees with high life expectancies

[68] ALN = all other deciduous trees with low life expectancies

Error propagation for the periods 1993 (BML, 1994: new German Länder), 1987 (BWI I: old German Länder) and 2002 (BWI II: new and old German Länder) is presented in the Annex (Table 175 in the Annex), while Table 113 presents an overview of relative standard deviation.

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

It was not possible to carry out general quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents, since the relevant staff unit was in the process of being restructured.

The carbon-stocks estimates for the various periods are based on ACCESS queries of the data from the Federal Forest Inventories; with regard to the quality assurance developed for those inventories, the reader's attention is called to the literature on the Federal Forest Inventory process.

First, an estimate was carried out using the BURSCHEL et. al. (1993) method, to provide an indication of the orders of magnitude of the carbon-stock extrapolation. This estimate, which is based on aggregated values (average stocks, by tree-species groups), was carried out by two different persons, using two different methods (published BWI results and ACCESS queries). The results obtained with the two methods agreed.

In the individual-tree calculations, a "Burschel" scenario (cf. Annex Chapter 14.5.1.1.1.2.5), using the same volume densities used for the estimate (using aggregated values), was calculated. The resulting values agreed with the calculations using the aggregated values. Consequently, it is clear that the ACCESS queries, in general, provide correct values; on the other hand, their results can deviate depending on what assumptions are made for volume densities and root-shoot ratios.

One systematic error persists, however: It was not possible to estimate rejuvenation below the standing-timber threshold, and the relevant figure is not found in the stock data, because the volume-expansion function is based on standing-timber volumes. The lack of rejuvenation stocks results in a systematic underestimation of total stocks.

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

Pursuant to the above-described recalculation, stock increases are twice as high as listed in previous inventories. The main reason for this is the wood-stock increase determined in BWI II, an increase that far exceeds existing yield-table estimates. Other factors include inclusion, for the first time, of underground biomass, improved methods of calculation and underestimation of the outset stocks in the new German Länder (BML, 1994).

7.1.1.6 Planned improvements (source-specific) (5.A.1)

No improvements are planned.

7.1.2 Land converted to forest land (5.A.2)

7.1.2.1 Source-category description (5.A.2)

Forest is created through succession, afforestation and reforestation; new forest areas begin storing C equivalents as soon as they are converted. In a rigorous approach, the C-stocks of previous land uses should be deducted. But no data are available on previous plant coverage (for example, individual trees, hedges or long-lived woody cultivations) and its

biomass. Overall, such stocks are considered negligible, especially since the total area of new forest land is very small in comparison to the total forest area (old German Länder 2002: 121 kha to 7,694 kha).

7.1.2.2 Methodological issues (5.A.2)

7.1.2.2.1 New forest land

Pursuant to IPCC GPG-LULUCF (2003), new forest lands must remain in the category "new forest lands" for 20 years. No land-use-change data that could support comparisons are available prior to BWI I.

For the old German Länder, direct comparison between BWI I and BWI II makes it possible to separate new forest land and deforested land since 1987. The new forest lands occurring between BWI I (key year 1987) and BWI II (key year 2002), and amounting to 121.45 kha (not including the non-wooded ground) can be categorised as follows in keeping with their existing uses:

Table 114: New forest lands, old German Länder

Outset category	Area [kha]	Annual increase in area [kha/a]
Cropland and long-lived cultivations	30.57	2.04
Permanent grassland	45.46	3.03
Wetlands	15.67	1.04
Settled areas	29.75	1.98

To derive area data for individual years, a linear increase in the new forest lands in BWI I and II was assumed and included in the CRF tables. In comparison to the total forest area of the old German Länder in 2002, 7,693.72 kha, these additional areas, totalling 1.58% in 15 years (both figures without non-wooded ground), are marginal.

For the new German Länder, only the net forest-land increase between 1993 and 2002 can be determined; it amounts to 174.56 kha. This difference is considered the new forest land. Its annual rate of increase is 17.46 kha/a; the data do not permit any allocation into outset categories. The area increases were assumed to progress linearly between 1993 and 2002.

7.1.2.2.2 Biomass stocks, new forest land

For the old German Länder, it was possible to carry out an individual-tree calculation for new forest land. First, the stocks were calculated for the entire new forest land. Then, the stocks were distributed throughout the entire new forest area and divided among the sub-categories in accordance with the relevant area shares (Table 115).

Table 115: Stocks, new forest lands, end of 2002

Outset category	Stocks [Gg C]
Cropland and long-lived cultivations	922
Permanent grassland	1,372
Wetlands	473
Settled areas	897

Since for the new German Länder wood stocks on new forest lands cannot be derived directly from comparison of two inventories, hectare values were derived from the standing-

timber stocks of tree-species groups in the 1st age class (0-20 years, BWI II new German Länder) and converted into C stocks. In light of the young age of of the new forests that have developed since 1993, this value was then cut in half. This produces a value of 18.01 Mg/ha, or total stocks of 3,144 Gg C, for these areas at the end of the 2002 vegetation period.

The biomass stocks at the end of the 2002 vegetation period correspond to the biomass stock increases throughout the entire period under consideration since 1987 (old German Länder) and 1993 (new German Länder), as long as any possible previous plant cover is ignored. These stock increases were weighted with the new forest area produced in the relevant report years, and then they were linearly interpolated throughout the entire period under consideration.

7.1.2.2.3 Stocks in dead wood, debris and soils in new forest areas

Since in our latitudes it takes decades for typical forest stocks to develop in these categories, the annual increase was considered negligible and not taken into account in the greenhouse-gas inventory.

7.1.2.3 Uncertainties and time-series consistency (5.A.2)

Studies are currently underway that are reviewing possibilities for more precise estimation of uncertainties and time-series consistency. The results of such studies will be included in the next inventory reports.

7.1.2.4 Source-specific quality assurance / control and verification (5.A.2)

It was not possible to carry out general quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents, since the relevant staff unit was in the process of being restructured.

7.1.2.5 Source-specific recalculations (5.A.2)

7.1.2.6 Planned improvements (source-specific) (5.A.2)

No improvements are planned.

7.2 Cropland (5.B)

The total CO_2 emissions from cropland management amounted to 30,551.8 Gg in 2007. Of that figure, a total of 23,562.8 Gg CO_2 were released from agriculturally used bogs. 5,738.8 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 1,250.3 Gg CO_2 came from biomass.

An additional 2,062 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 are calculated to amount to 2.14 Gg N_2O, or 445.37 Gg CO_2 equivalents.

7.2.1 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										
Method of EF determination	CS/M[69]					CS/T1				

The source category "Cropland" has been identified as a key source.

Pursuant to IPCC GPG LULUCF (2003), carbon-stock changes in soil and biomass stocks are reported under the category "cropland". 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 key 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 the "Nomenklatur der Bodenbedeckungen" ("groundcover nomenclature") of the CORINE LAND COVER project (DESTATIS, 1989).

7.2.2 Methodological issues (5.B)

7.2.2.1 Data sources

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 (for literature details, cf. Chapter 14.5.2.1/14.5.2.2 in the Annex):

1. Basic digital landscape model of ATKIS® (AdV)
2. CORINE LAND COVER (BMU)
3. Digital soil map of Germany, drawn to a scale of 1: 1,000,000 (BUEK 1000)
4. Data from the following official German statistics:
   - Main soil-use survey (Bodennutzungshaupterhebung) 1991, 1999, 2003
   - Harvest survey, 1989 - 2005
   - Data from the district reform of 1998
   - Data from the Federal Forest Inventory (Bundeswaldinventur)

[69] The entry "CS/M" refers to determination of changes in biomass and soil stocks. Under Tier 1, changes in dead wood and debris were estimated to be 0.

For determination of emission factors

Soil:

- Literature

Biomass:

- Main soil-use survey (Bodennutzungshaupterhebung) 1991, 1999, 2003
- Harvest survey, 1989 – 2005
- Data from the district reform of 1998
- Statistical Yearbook (Statistisches Jahrbuch) (BMVEL 2003)
- Data from Federal Forest Inventories I and II
- Literature

In recent years, a "wall-to-wall" approach has been developed for identification of land-use categories and land-use changes in Germany. This approach was used for the first time for the present report. 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 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 14.5.2.1/14.5.2.2. 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 blending with digital map data, soil data and biomass data were then allocated to the georeferenced land-use-change areas that had been obtained via intersection (cf. also Chapter 14.5.2.3 in the Annex).

7.2.2.2 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:

Δ C:	Change in the carbon stock as a result of use change in t / district * 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. Chap. 14.5.2.3.1, 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.

7.2.2.3 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.

7.2.2.4 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}*observation 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 14.5.2.3.2 in the Annex). In a first for such reports, the present report had access to biomass-emissions factors for each of the years since 1989. For 2006 and 2007, the values for 2005 were used, since the data for those years were not available to reporters at the time the report was prepared. Specially developed programmes (cf. Chap. 14.5.2, in the Annex) were used for combination, category-oriented summation and output of the data in keeping with the CRF categories.

7.2.3 Uncertainties and time-series consistency (5.B)

The uncertainties for determination of land-use changes via ATKIS® are very small (cf. Chap. 14.5.2.6, 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 0.02 % - 2 % (median of 0.03 %) 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.

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 variation (cf. Chapter 14.5.2.5.2).

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.

7.2.4 Source-specific quality assurance / control and verification (5.B)

It was not possible to carry out general quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents, since the relevant staff unit was in the process of being restructured.

With the exception of "Institutionalisierung der Datenbereitstellung" ("Institutionalisation of Data Provision"), the data sources used to prepare this inventory fulfil the checking criteria of the QSE manual for data sources (and yet are still inadequate; cf. Chapter 14.5.2.7). Internally, the possibility of determining uncertainties via data manipulation with cross-sum checking 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.

7.2.5 Source-specific recalculations (5.B)

This year's report is able to provide revised tables for all years since 1990, as a result of this year's first-time use of the "wall-to-wall" approach for categorising and allocating activity data. In addition, annually based biomass emission factors were determined, and those factors were used, for the first time, to estimate biomass carbon-stock changes. As a result of data correction, the tables for the periods 1990 – 2000 and 2000 – 2007 are consistent (with a discontinuity in 2000; cf. Chap. 14.5.2.6.1, in the Annex) and nearly complete.

7.2.6 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 in the coming years:

- GIS-based use of InVeKoS data, for identification of management and biomass
- Use of an improved soil map, for both organic and mineral soils (and with a target scale of at least: 1: 200,000)
- Improvement in the emission factors used for soils:
  - For organic soils: via complete-coverage measurements, carried out in a preliminary study;
  - For mineral soils: via evaluation of the results for all German long-term soil-monitoring sites, as well as of the results of a soil-carbon inventory of non-forest soils.
- Parametrisation, validation (on the basis of the findings from the preliminary studies) and use of mathematical models for calculating carbon-stock changes and N_2O flows in mineral and organic soils
- Determination and use of more precise values for carbon stocks in perennial plants (preliminary study for fruit trees and grapevines)
- Use of yearly specific biomass data
- Norming of CORINE data, and harmonisation with ATKIS® data, to ensure the consistency of the time series

For further remarks, cf. Chapter 14.5.2.7 in the Annex.

7.3 Grassland (5.C)

The anthropogenic CO_2 emissions from grassland were placed at 14102.58 Gg for the year 2007. A total of 13,000.4 Gg CO_2 were released via draining of organic grassland soils, while 5,224.3 Gg CO_2 were released via changes in biomass. During the same period, 4122.2 Gg were stored in mineral soils.

With regard to the relevant uncertainties and liming, cf. Chapter 7.2 (CRF 5.B) and Chapters 14.5.2.4 and 14.5.2.6 in the Annex.

7.3.1 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										
Method of EF determination	CS/M[70]									

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.

[70] The entry "CS/M" refers to determination of changes in biomass and soil stocks. Under Tier 1, changes in dead wood and debris were estimated to be 0.

The basis for reporting under "cropland" consists of the definitions in the ATKIS® object-type key for the basic digital landscape model (Basis-DLM); the use-type key 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 the "Nomenklatur der Bodenbedeckungen" ("groundcover nomenclature") of the CORINE LAND COVER project (DESTATIS, 1989).

7.3.2 Methodological issues (5.C)

Cf. Chapter 7.2.2

7.3.3 Uncertainties and time-series consistency (5.C)

Cf. Chapter 7.2.3

7.3.4 Source-specific quality assurance / control and verification (5.C)

Cf. Chapter 7.2.4

7.3.5 Source-specific recalculations (5.C)

Cf. Chapter 7.2.5

7.3.6 Planned improvements (source-specific) (5.C)

Cf. Chapter 7.2.6

7.4 Wetland (5.D)

In 2007, a total of 2,823.1 Gg CO_2 were released from wetlands. This sum comprises 2,147.9 Gg CO_2 of emissions from peat extraction and use; 823.4 Gg of CO_2 emissions from biomass; and CO_2 additions of 148.3 Gg to mineral soils.

7.4.1 Source-category description (5. D)

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 remaining 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.

7.4.2 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 estimates are based were obtained from official German statistics (DESTATIS, Fachserie 4, Reihe 3.1) as well as from figures of the Federal association of the peat and humus industry (Bundesvereinigung der Torf- und Humuswirtschaft; organised within the German Garden Industry Association (Industrieverband Garten; IVG), Gothaer Str. 27, D-40880 Ratingen.

Carbon-stock changes in soils, and in biomass as a result of land-use changes, were calculated using the procedures and methods described in Chap. 14.5.2. 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 2006) 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.

7.4.3 Uncertainties and time-series consistency (5.D)

The statements made in Chapter 7.2.3 and Chapter 14.5.2.6 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 ± 2.1 %. The largest uncertainties in this category occur via use of emission factors with error > 100 % (IPCC 2006).

7.4.4 Source-specific quality assurance / control and verification (5.D)

Cf. Chapter 7.2.4

7.4.5 Source-specific recalculations (5.D)

Since previous reports did not cover greenhouse-gas emissions from wetlands, the present report includes the first revised tables, for all years since 1990, for this land-use category.

With regard to estimation of emissions from land-use changes, the statements made in Chapter 7.2.5 apply.

For the period 2000 through 2007, figures for emissions from peat extraction are based on the official German statistics for the relevant years. The estimates for the years 1990 to 2000 are based on the very stable average values for subsequent years.

7.4.6 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 a preliminary study, "Organic Soils", that cover all phases of this form of land use (cf. Chapter 14.5.2.7). 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.

An 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.

7.5 Settlements (5.E)

In 2007, CO_2 emissions from Germany's settlement and transport-infrastructure areas, as a result of land-use changes, amounted to 11,881.4 Gg. That figure represents the sum of loss of forest biomass (10,076.6 Gg) and stock losses in organic soils (1,804.8 Gg).

7.5.1 Source-category description (5.E)

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.

7.5.2 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, areas 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, it was assumed, in the underlying approach, 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 116 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 14.5.2. 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 116: 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 infrastructure**		
3100 – 3205	Roads and railways		
3301	Airports		50 %
3302	Airfields		70 %
3400 – 3543	Ship-transport infrastructure and related facilities		

7.5.3 Uncertainties and time-series consistency (5.E)

The statements made in Chapter 7.2.3 apply here as well, with regard to the quality of activity data for the categories of land use and land-use changes. 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.

7.5.4 Source-specific quality assurance / control and verification (5.E)

Cf. Chapter 7.2.4

7.5.5 Source-specific recalculations (5.E)

Since previous reports did not cover greenhouse-gas emissions from settlements, the present report includes the first revised tables, for all years since 1990, for this land-use category. With regard to estimation of emissions from land-use changes, the statements made in Chapter 7.2.5 apply. The calculations for the years 2000 – 2007 are based on ATKIS® data. Those for the years 1990 – 2000 are based on CORINE data, which were normed for this purpose via the ATKIS® data.

7.5.6 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. That project will seek to determine carbon stocks in urban and transport-infrastructure vegetation, as well as carbon flows in such vegetated areas, for the purpose of deriving country-specific emission factors (cf. Chapter 14.5.2.7).

In an additional preliminary study, the pertinent activity data parameters are to be improved. That study will be aimed at developing a system for differentiated categorisation of vegetation cover in settlements.

Yet another preliminary study will aim to derive emission factors for soils in settlements, as a basis for estimation of the emissions related to conversion.

7.6 Other land (5.F)

The total CO_2 emissions from "other land" amounted to 485.7 Gg in 2007. That figure comprises 491.7 Gg of CO_2 emissions from biomass and storage of 6.04 Gg of CO_2 in mineral soils. Pertinent emissions from biomass come primarily from deforestation.

7.6.1 Source-category description (5.F)

Reporting for the category "Other land" has to cover the 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. Since, as a rule, glacier areas, scree, sand banks, etc. are not managed by humans, emissions from such areas do not fall under reporting obligations. For purposes of emissions calculation, conversions to "Other Land" can be significant, however, especially in cases of deforestation.

7.6.2 Methodological issues (5.F)

The following object types defined in ATKIS® are assigned to the "Other land" category within the German LULUCF report system: "area currently not classifiable" (object number 4199), "vegetation-free areas" (object number 4120), and "waste land" (4110). Areas are identified and classified in keeping with the algorithms described in Chapter 14.5.2.

For emissions from mineral soils, the principles described in Chapter 14.5.2.3.

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.

7.6.3 Uncertainties and time-series consistency (5.F)

Cf. Chapter 7.2.3

7.6.4 Source-specific quality assurance / control and verification (5.F)

Cf. Chapter 7.2.4.

7.6.5 Source-specific recalculations (5.F)

For the category "Other land", all values until 1990 were recalculated, since they are being reported for the first time, in keeping with the IPCC definitions, as a result of introduction of the ATKIS® system. The calculations for the years 2000 – 2006 are based on ATKIS® data.

Those for the years 1990 – 2000 are based on CORINE data, which were normed for this purpose via the ATKIS® data. The calculation procedures are similar to those for 2006.

7.6.6 Planned improvements (source-specific) (5.F)

For waste land and woods/shrubbery, the newly determined emission factors from the aforementioned preliminary study will be used. No additional improvements are planned at present.

7.7 Other areas (5.G)

Emissions from this source category are currently not being reported.

8 WASTE AND WASTE WATER (CRF SECTOR 6)

8.1 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**	**2007 - contribution to total emissions**	**Trend**
6.A.1 Solid waste disposal on land	l / t	CH_4	2.85 %	0.80 %	falling

Gas	CO_2	CH_4	HFC	PFC	SF_6	N_2O	NO_X	CO	NMVOC	SO_2
Emission factor (EF)		CS/D								
EF uncertainties in %										
Distribution of uncertainties										
Method of EF determination		T2								

The source category "Solid waste disposal on land" is a key source of CO_2 emissions in terms of emissions level and trend.

Only managed disposal in landfills (6.A.1) is relevant for purposes of German emissions reporting under CRF 6.A. "Wild" or illegal dumping of solid waste (CRF 6.A.2) is prohibited by law in Germany.

In light of the growing importance of other methods for treating biodegradable waste fractions, emissions from composting and from mechanical-biological waste treatment have been reported since 2004. These emissions are reported under category 6.D Other.

In the CSE, source category 6.A Solid waste disposal on land includes landfilled household waste and sewage sludge.

8.1.1 Managed disposal in landfills – landfilling of municipal waste (6.A.1)

8.1.1.1 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 26). 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 (DESTATIS Fachserie 19, Reihe 1 Abfallentsorgung 2006 ("Waste management, 2006") of 1 August 2008) are available for the period until 2006. Those figures were carried over 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. Consequently, 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.

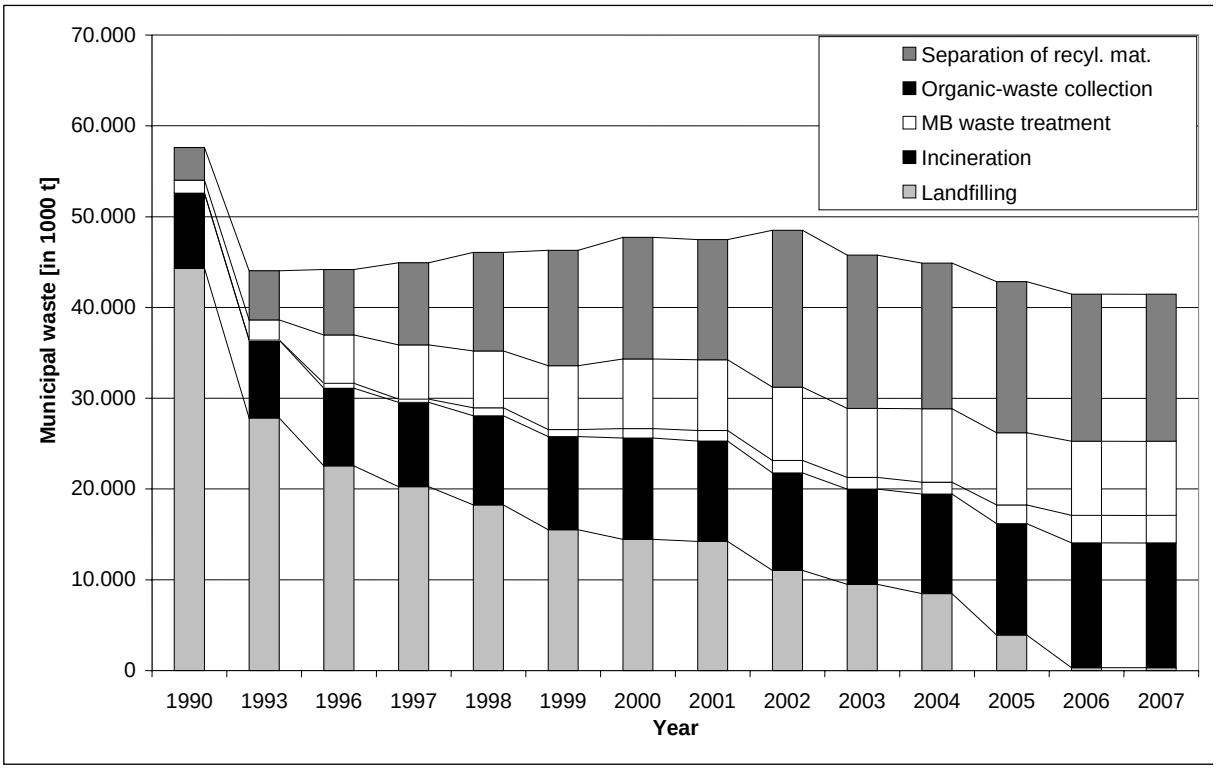


Figure 26: Changes in pathways for management of household waste, 1990 to 2007, with intermediate years

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.

8.1.1.2 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 21[71]:

Equation 21 *(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 to CH_4*

A multi-phase model was used that calculates with a range of different half-lives for the various waste fractions involved.

71 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).

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 22:

Equation 22 *(IPCC Guidelines, Equation 5.1)*:

$$CH_4 \text{ emitted in year t (Gg/year)} = (CH_4 \text{ produced in year t} - R(t)) \bullet (1- OX)$$

Where

R(t) = CH_4 collection in year t
OX = Oxidation factor (fraction)

For both Tier 1 and Tier 2, the relevant quantities of municipal waste (MSW_T), and the proportion of municipal waste that is landfilled (MSW_F), must be determined; for Tier 2, production of municipal waste over the previous decades must also be determined. Pursuant to IPCC Good Practice Guidance (2000), landfilled 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.

8.1.1.2.1 Quantities of landfilled waste

The FOD model calculates emissions from municipal waste, industrial waste and landfilled sewage sludge.

Pertinent quantities of landifilled municipal waste (household and commercial waste) are taken from relevant statistics of the Federal Statistical Office, which are based on annual surveys of waste types, origins and final destinations, as well as on surveys taken of waste-storage facilities, every two years, that focus on specific equipment of the facilities. 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.

8.1.1.2.2 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 27 and Figure 28). Such evaluation of existing studies was carried out for household waste, household-like commercial waste and for bulky waste, categories that are listed separately in national statistics. As to waste composition in the new German Länder, the figures provided by LALE (2000) for the 1980s in the former GDR were adopted (composition of household waste: 28 % vegetable waste, 14 % paper/cardboard, 2.3 % wood, rubber, composites, 3 % textiles; household waste accounted for only 16 % of total landfilled waste quantities, however). Quantities of municipal waste landfilled in the former GDR contain smaller fractions of biodegradable materials and large inorganic fractions (primarily ash from household combustion systems). Food waste was collected and used as feed; feeds tended to be scarce during certain periods of time. Paper was collected; it was also a scarce resource. Wood and paper were often burned in ovens for purposes of heating

and cooking. The "SERO" recycling system efficiently collected the country's relatively small fractions of plastic packaging. Deposit systems were operated for glass, and glass was also collected. All in all, the former GDR's economy was subject to scarcities of resources, and this led to efficient waste recycling. Ash from household combustion systems accounted for large fractions of landfilled quantities of household waste.

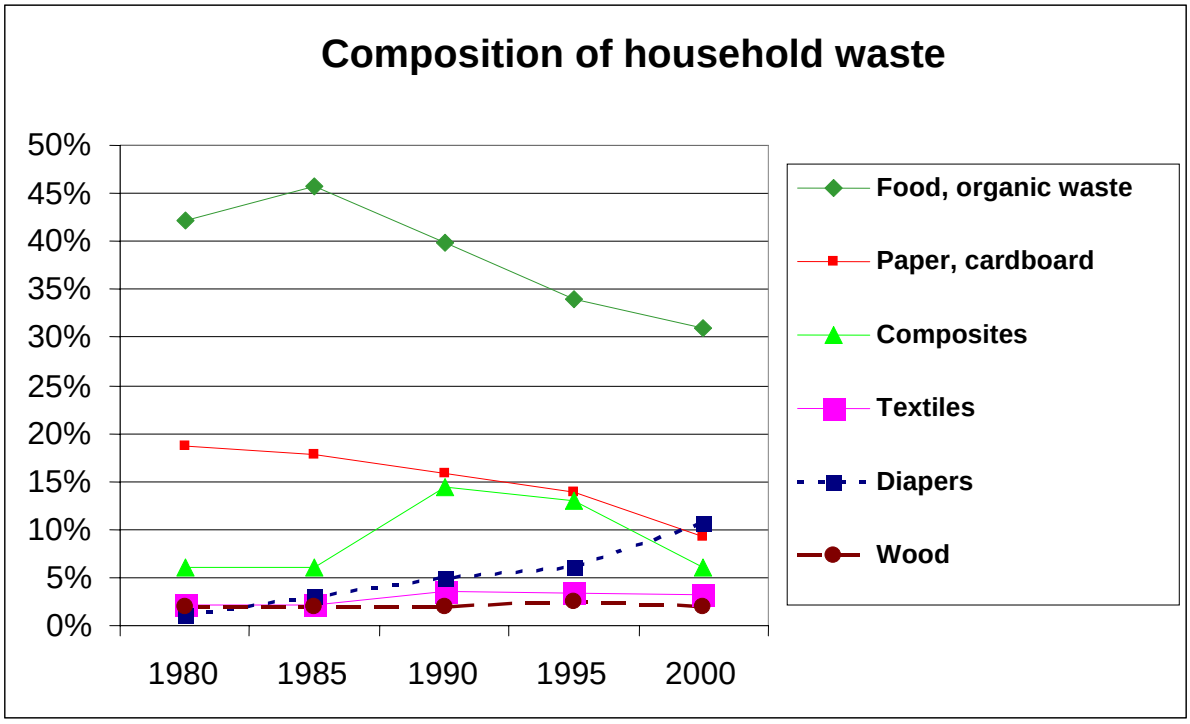


Figure 27: Trends in waste composition (old German Länder) between 1980 and 2000

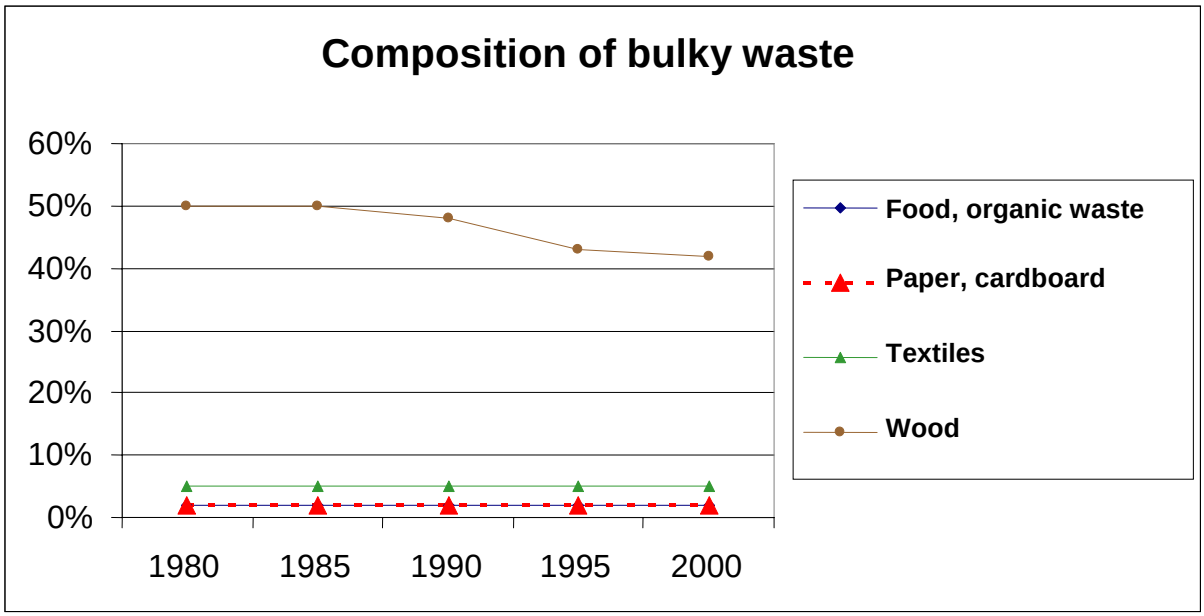


Figure 28: Trends in bulky-waste composition (old German Länder) between 1980 and 2000

8.1.1.2.3 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.

8.1.1.2.4 DOC

Until 2005, both national data and IPCC default factors were used for DOC, the proportion of degradable organic carbon in waste. Table 117 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 117: 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

8.1.1.2.5 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.

8.1.1.2.6 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).

8.1.1.2.7 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 118 shows the half-lives used for the pertinent waste fractions.

Table 118: 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

8.1.1.2.8 Landfill-gas use

The "TA Siedlungsabfall" of 1993[72] 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.

8.1.1.2.9 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

[72] Technical instructions on recycling, treatment and other management of municipal waste (Third general administrative provision on the Waste Act (Abfallgesetz)) of 14 May 1993

landfills of the former GDR, and thus the factor 0.1 was also used for that period (BMBF, 1997).

8.1.1.3 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 14.6.1.1.

Over the long, 30-year period covered by the activity data, inconsistencies in the time series are unavoidable, since the pertinent waste categories and survey methods changed several times as a result of improvements in legislation and waste statistics. In Germany, special problems arise especially via German reunification and the resulting merging of two different economic and statistical systems. For this reason, considerable effort has to be invested in reviewing data consistency and allocations to the reported categories, in the interest of making time series as consistent as possible.

8.1.1.4 Source-specific quality assurance / control and verification (6.A.1)

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 been carried out completely.

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 the FOD model. The same result was obtained.

8.1.1.5 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.

8.1.1.6 Planned improvements (6.A.1)

An experts' assessment (assessment period: September-November 2008) has quantified the low residual gas emissions from landfilling of mechanically and biologically treated waste. If such residual gas emissions prove to be non-negligible with regard to total landfill gas emissions, they will be taken into account in future inventory reports.

8.2 Wastewater handling (6.B)

CRF 6.B					
Key source by level (l) / trend (t)		**Gas (key source)**	**1990 - contribution to total emissions**	**2007 - 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.

8.2.1 Methane emissions from industrial wastewater and sludge treatment (6.B.1)

8.2.1.1 Source-category description (6.B.1)

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

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.

Industrial sludge treatment and stabilisation, like industrial wastewater treatment, is carried out either aerobically or anaerobically with methane-gas use.

8.2.2 Municipal wastewater treatment (6.B.2)

8.2.2.1 Methane emissions from municipal wastewater treatment (6.B.2)

8.2.2.1.1 Source-category description (6.B.2)

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 %		+/- 50				+/- 50				
Distribution of uncertainties		N				N				
Method of EF determination		D/CS				D				

The source category "Municipal wastewater treatment" is a key source via the aggregated source category Wastewater handling (6.B).

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.

8.2.2.1.2 Methodological issues (6.B.2)

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 119. 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 119: 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**		
Cesspools and septic tanks	*27.74*	24.42	*23.20*	*21.98*	20.76	*19.54*	*18.32*	*17.10*		

Numbers in italics: Interpolated and extrapolated figures
(DESTATIS, 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 14.6.2). 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 120: Methane emissions from cesspools and septic tanks

Methane emissions: [kt CH_4]	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 CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
Cesspools and septic tanks	8.32	7.33	6.96	6.59	6.23	5.86	5.50	5.13		

8.2.2.1.3 Uncertainties and time-series consistency (6.B.2)

The method's uncertainties have not yet been estimated.

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 (DESTATIS, 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 2007 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.

8.2.2.1.4 Source-specific quality assurance / control and verification (6.B.2)

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 been carried out completely.

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 14.6.2). 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).

8.2.2.1.5 Source-specific recalculations (6.B.2)

No recalculations have been carried out.

8.2.2.1.6 Planned improvements (6.B.2)

No improvements are planned at present.

8.2.2.2 Methane emissions from municipal wastewater treatment (6.B.2)

8.2.2.2.1 Source-category description (6.B.2)

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). 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.

In Germany, sewage sludge from kitchen 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.

8.2.2.2.2 Methodological issues (6.B.2)

Table 121 lists the emission factors for open sludge digestion and the methane emissions determined for that process.

Table 121: 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)[73]. 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. On the basis of this assumption, the Federal Environment Agency used the same activity rates – i.e. quantities of sewage sludge produced – for the years 1993 to 1994.

8.2.2.2.3 Uncertainties and time-series consistency (6.B.2)

The activity rates between 1990 and 1992 are based on a personal communication; those for 1993 and 1994 are based on estimates of the Federal Environment Agency. As a result, a high degree of time-series consistency is not assured.

8.2.2.2.4 Source-specific quality assurance / control and verification (6.B.2)

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 been carried out completely.

8.2.2.2.5 Source-specific recalculations (6.B.2)

No recalculations were carried out for the present report.

8.2.2.2.6 Planned improvements (6.B.2)

At present, improvements seem neither necessary nor possible, since no further activity data can be obtained.

73 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.

8.2.2.3 Nitrous oxide emissions from municipal wastewater (6.B.2)

8.2.2.3.1 Source-category description (6.B.2)

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.).

8.2.2.3.2 Methodological issues (6.B.2)

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.

Average protein intake per person and day:

- 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)[74] used estimated food-consumption data for 1993 to estimate average daily protein intake (among other figures). From this data, an average value of about 76.5 g protein / person and day[75] was derived.
- The FAO determined the average protein intake in Germany, per person and day, to be between 98g (1989-91) and 100g (2001-03) (cf. Table 122) .[76]

The FAO database is used for determination of the N_2O emissions from wastewater, since that database is a consistent, internationally comparable time series. 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.

Table 122: Daily protein intake per person in Germany

	[g/inhabitant and day]									
Protein intake	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	98	99	*99*	*99*	*99*	*99*	*99*	*99*	*99*	*99*
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
	99	100	100	100	*100*	*100*	*100*	*100*		

Numbers in italics: Extrapolated or automatically extended values
(FAO, no year)

74 The nutrition report is published every four years.

75 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).

76 FAO Statistical Yearbook 2004 Vol.1/1 http://www.fao.org/statistics/yearbook/vol_1_1/index.asp; September 2007

Table 123: Population in Germany

	[in 1000]									
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**		
	82,260	82,440	82,537	82,532	82,501	82,438	82,315	82,218		

(DESTATIS, 1991-2006)

The nitrous oxide emissions can be determined with the aid of Table 122 and Table 123 and the IPCC method; cf. Table 124.

$$N_2O_{(s)} = \mathrm{Pr}\,otein\ x\ Frac_{NPR}\ x\ NR_{PEOPLE}\ x\ EF_6$$

where:

$N_2O_{(s)} = N_2O\ emissions\ \ from\ \ human\ \ wastewater\ \ (kg\ N_2O - N/a)$

$\mathrm{Pr}\,otein = annual\ \ protein\ intake\ \ (kg/person/a)$

$NR_{PEOPLE} = Population\ \ of\ \ the\ country$

$EF_6 = emission\ \ factor\ \ (default\ \ 0.01\ \ (0.002 - 0.12)\ \ kg\ N_2O - N/kg\ \ produced\ \ \ wastewater - N)$

$Frac_{NPR} = Nitrogen\ \ \ fraction\ in\ protein\ \ (default = 0.16\ kg\ N/kg\ \ protein\ )$

Table 124: Nitrous oxide emissions in Germany pursuant to IPCC method

	[t N_2O]									
N_2O emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	7,173	7,220	7,357	7,390	7,408	7,433	7,451	7,455	7,453	7,465
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
	7,474	7,566	7,575	7,574	7,571	7,565	7,554			

8.2.2.3.3 Uncertainties and time-series consistency (6.B.2)

The uncertainties in emissions determination have not yet been estimated. The activity rates for 1992 through 2000 were linearly interpolated from the FAO's published data for 1991 and 2001, and the activity rates as of 2004 were obtained by carrying over the FAO's published data for 2003. Relevant interpolated and extrapolated values are thus subject to increased uncertainty. Since the inhabitant-specific activity rates increased by only 2 % over a space of 10 years (1991-2001: 2 g/inhabitant and day), however, the error in such carryover as of 2004 cannot have a higher order of magnitude than that figure.

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.

8.2.2.3.4 Source-category-specific quality assurance / control and verification (6.B.2)

Quality control and quality assurance, in conformance with the requirements of the QSE manual and its associated applicable documents, have been carried out.

Analysis of the national inventory reports of other countries shows that most Annex I countries, like Germany, use the IPCC method for determining N_2O emissions. 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.

8.2.2.3.5 Source-specific recalculations (6.B.2)

No recalculations were carried out for the present report.

8.2.2.3.6 Planned improvements (6.B.2)

No improvements are planned at present.

8.3 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.

8.4 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.

8.4.1 Other areas – composting facilities (6.D.1)

8.4.1.1 Source-category description (6.D.1)

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.

8.4.1.2 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 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.

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.

For kitchen waste from households, the following emission factors resulted:

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.

8.4.1.3 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 an uncertainty of 60% for CH_4 and of at least 100 % for N_2O are assumed.

8.4.1.4 Source-specific quality assurance / control and verification (6.D.1)

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

8.4.1.5 Source-specific recalculations (6.D.1)

No recalculations are required.

8.4.1.6 Planned improvements (6.D.1)

Currently, a research project is underway, under commission to the Federal Environment Agency, with the aim of improveing 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 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.

8.4.2 Other areas – mechanical-biological waste treatment (MBT) (6.D.2)

8.4.2.1 Source-category description (6.D.2)

As of 1 June 2005, landfilling of organic and biodegradable waste is no longer permitted in Germany. Miscellaneous municipal waste, and other waste of similar composition, may thus be landfilled only following pre-treatment. In addition to thermal waste-treatment processes (waste incineration), mechanical-biological processes are increasingly being used for this purpose.

Since the 1990s, mechanical-biological processes have been used extensively in Germany for managing miscellaneous waste. Initially, relevant plants had relatively simple designs and were not fitted for waste-gas collection and treatment. As processes have improved, however, closed systems, with "biofilters" for waste-gas scrubbing, have gradually become the norm. While the waste-gas-scrubbing processes used by such plants have significantly reduced the plants' smell emissions, they have not reduced greenhouse-gas emissions.

In 2005, when all landfilling of untreated waste was terminated, capacities for mechanical-biological waste treatment were considerably expanded. Pursuant to the 30th Ordinance on the Execution of the Federal Immission Control Act (30th BImSchV), as of 1 March 2001, new plants for mechanical-biological waste treatment must fulfil strict technical requirements and conform to demanding standards for maximum permitted emissions. The transitional provisions for old plants call for such plants to be retroffited by no later than 1 March 2006.

Nearly all recently constructed new facilities were commissioned in 2005. 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.

8.4.2.2 Methodological issues (6.D.2)

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 mechanical-biological treatment (MBT) systems. For this reason, a national method has been developed in which composted waste quantities are multiplied by emission factors from a national study.

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:

$EF\text{-}N_2O$ = 190 g N_2O/Mg waste
$EF\text{-}CH_4$ = 150 g CH_4/Mg waste

For closed mechanical-biological waste-treatment facilities with biofilters, the same study obtained the following emission factors:

$EF\text{-}N_2O$ = 375 g N_2O/Mg waste
$EF\text{-}CH_4$ = 150 g CH_4/Mg waste

For the period as of 2006, the emissions-load limitations imposed by the 30th BImSchV will be used as the applicable emission factors:

$EF\text{-}N_2O$ = 100 g N_2O/Mg waste
$EF\text{-}CH_4$ = 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.

8.4.2.3 Uncertainties and time-series consistency (6.D.2)

The uncertainties for the mechanically-biologically treated 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. 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 are lower than the standards.

8.4.2.4 Source-specific quality assurance / control and verification (6.D.2)

General quality control (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out completely.

8.4.2.5 Source-specific recalculations (6.D.2)

No recalculations are required.

8.4.2.6 Planned improvements (6.D.2)

No improvements are planned at present.

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

The following section lists recalculations based on quantitatively effective inventory improvements that occurred between the inventory calculations for the 2008 report year and those for the 2009 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 various specialised factors can necessitate recalculations (cf. Chapter 10.1.1).

10.1 Explanation and justification of the recalculations

10.1.1 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.
- Recommendation 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.

10.1.2 Recalculations in the 2009 inventory, by source categories

The recalculations this year resulted largely from revision – extensive, in part – of the inventories in certain report categories (agriculture, LULUCF). In addition, a number of methods were adjusted, and this led to changes in affected source categories (such as air transport). Some of the changes were major, while others involved improvements of details.

The inventories contain improvements in the following areas:

Energy:

- Updating of activity data for fuel inputs for the period 2003 through 2006 (1.A.1)
- Improvement of the method for calculating emissions from flue-gas desulphurisation (1.A.1.a)
- Updating of activity data for fuel inputs from household waste / settlement waste, for 2006 (1.A.1.a)
- Correction of N2O emission factors for the period 1990 through 1994 (1.A.1.a)
- Updating of activity data for coal dust and fluidised-bed coal as of 2000 (1.A.1.c)
- Updating of activity data for fuel inputs for the period 2003 through 2006 (1.A.2.a)
- Updating of activity data for fuel inputs for 2005 and 2006 (1.A.2.b, e, f)
- Correction of activity data for lignite inputs as of 1996 (1.A.2.a)
- Use of a new calculation algorithm for liquid fuels as of 1995 (1.A.2.f cement/lime/other)
- Correction of fuel inputs in the glass industry as of 2003 (1.A.2.f Glass)
- Revision of methods for N2O emission factors for the period 1990 through 1994 (1.A.2.f Other)
- Adjustment of activity data as of 2003 (1.A.2.f Other)
- Introduction of an annually specific split factor for differentiating national and international air transports (1.A.3.a, 1.BU.1)
- Updating of activity data for the period 2000 through 2006 (1.A.3.b)
- First-time inclusion of data for bioethanol in road transports as of 2004 (1.A.3.b)
- Updating of activity data for 2005 and 2006 (1.A.3.c)
- Updating of activity data for the period as of 1996 (1.A.3.d, 1.BU.2)
- Updating of activity data for construction-sector transports as of 1996, and for natural gas inputs in natural gas compressor stations as of 2003 (1.A.3.e)
- Use of new N2O and CH4 emission factors for the period as of 1996 (1.A.4, 1.A.5.a), and use of updated activity data for the period as of 2003 (1.A.4)
- Updating of activity data for military transports for the period as of 1996 (1.A.5.b)
- Use of current data of the Association of the German hard-coal mining industry (Gesamtverband Steinkohle; GVSt), and first-time consideration of energy recovery from methane for the period as of 1998 (1.B.1.c)
- First-time reporting for 1.B.2.a.i
- Correction of double-counting of 1.B.2.a.ii and iii; application of adjustments in 1.B.2.a.iii
- Correction of an interface error in 1.B.2.a.v and 1.B.2.b.iv

Industrial processes:

- Revision of cullet inputs for the period as of 1990 (2.A.7 Glass)
- Use of the default EF for CO2 from carbon-black production for the period as of 1990 (2.B.5).

- Deletion of N2O emissions from nitrous-oxide production, to take account of the fact that 100% of those emissions are reported under 3.D (narcotic uses) (2.B.5)
- Revision of activity data for magnesium foundries for the period as of 1996 (2.C.4)
- Use of current SO2 emission factors for sulphite pulp production for the period as of 1991 (2.D.1)
- Updating of the entire source category (2.D.2)
- First-time consideration of disposal of refrigerants (2.F.1.d & e)
- Revision of the calculation procedure for automobiles (2.F.1.f)
- Comprehensive recalculation of emissions from mobile air-conditioning systems (2.F.1.f)
- Adjustment of EF and activity data for one-component foams (2.F.2)
- Correction of activity data for hard foams, for 2006 (2.F.2)
- Adjustment of the activity data for 2006 for R227ea in fire extinguishers (2.F.3)
- Updating of consumption data for medicinal sprays, for 2006 (2.F.4)
- Correction of the activity data for insulating glass windows, for 2006 (2.F.8)
- First-time reporting on welding (2.F.8.f), optical glass fibre (2.F.8.g) and photovoltaics (2.F.8.h)

Solvent and other product use:

- First-time reporting of the indirect CO_2 emissions from NMVOC for the areas of degreasing, painting and lacquering, production and use of chemical products and other solvent use (3.A. through 3.D)

Agriculture (selection)**:**

- Thorough revision of the inventory – comprehensive updating of existing activity data, and introduction of new activity data (4.A through 4.D)
- Use of final animal-population figures for 2006 (4.A, 4.B)
- Completion and correction of the animal-population figures for buffalo husbandry (4.A, 4.B)
- Recalculation of fodder digestibility for dairy cows (4.A, 4.B)
- Updating of feed composition for fattening bulls (4.A, 4.B)
- Recalculation of NMVOC emissions on the basis of changed NH3 emissions (4.B)
- Updating of the frequency distribution of husbandry methods for farm animals, of grazing periods and of methods for storing and spreading farm manure (4.B)
- Use of new NO and N2 emission factors (4.B)
- Partial recalculation of emissions in keeping with Tier 2 methods (4.B)
- Correction of a data-transfer error in connection with grazing of sheep (4.B)
- Reassessment of quantities of imported poultry excrement (4.B)
- First-time inclusion of vegetable-cultivation areas as cropland (4.D)
- Correction of activity data for sewage sludge (4.D)
- Recalculation of N2O, NO and NH3 emissions (4.D)

Land use, land-use changes and forestry (selection)**:**

- Correction of activity data and inclusion of some new activity data; revision of calculation methods (5.A.1)
- Change of methods for identifying and allocating activity data; use of annually specific emission factors (5.B)
- First-time reporting on the category "Wetlands" (5.D)

- First-time reporting on the category of "Settlements" (5.E)
- Recalculation of all emissions data on the basis of ATKIS® (5.F)

Waste and wastewater:

- Correction of activity data for 2006 (6.D)

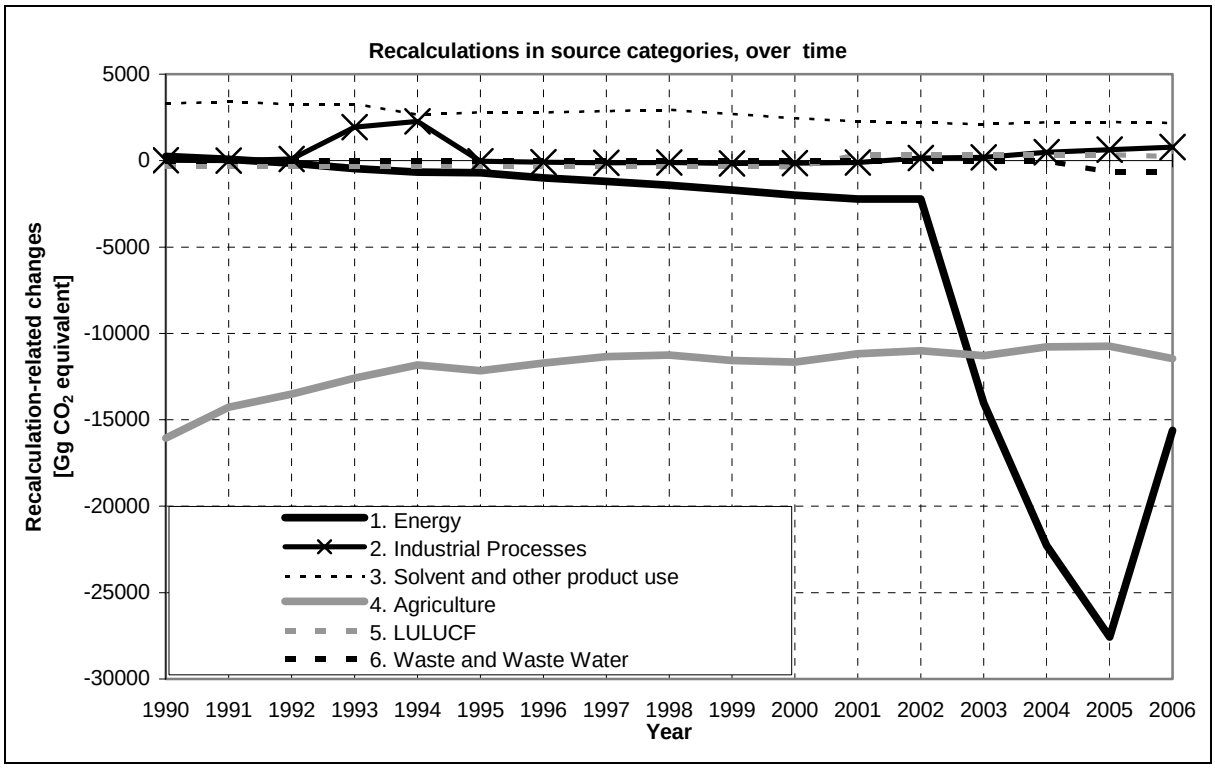


Figure 29: Change in total emissions, for all categories, and for the entire time series, in comparison to the relevant figures in the 2008 report

10.1.3 Recalculations in the 2009 inventory, by gases

CO_2: Recalculations were carried out in the following source categories:

- Cf. the "energy" list in 10.1.2
- Cf. the "industrial processes" list in 10.1.2
- Cf. the listings for solvent and other product use in 10.1.2

N_2O/CH_4 recalculations were carried out in the following source categories:

- Cf. the "energy" list in 10.1.2
- Cf. the "agriculture" list in 10.1.2
- Cf. the "LULUCF" list in 10.1.2

F-gas recalculations were carried out in the following source categories:

- Cf. the "industrial processes" list in 10.1.2

Table 125: Inventory recalculations with respect to last year's report

	Base year (1990/ 1995)	2006
	Change in [%]	
Total (CO_2 equiv.)	**- 1.04 %**	**+ 2.44 %**
CO_2	+ 0.33 %	- 1.50 %
CH_4	- 1.47 %	- 3.87 %
N_2O	- 17.39 %	- 16.42 %
HFC, PFC, SF_6	- 0.05 %	+ 5.21 %

Source: own calculations; emissions do not include LULUCF

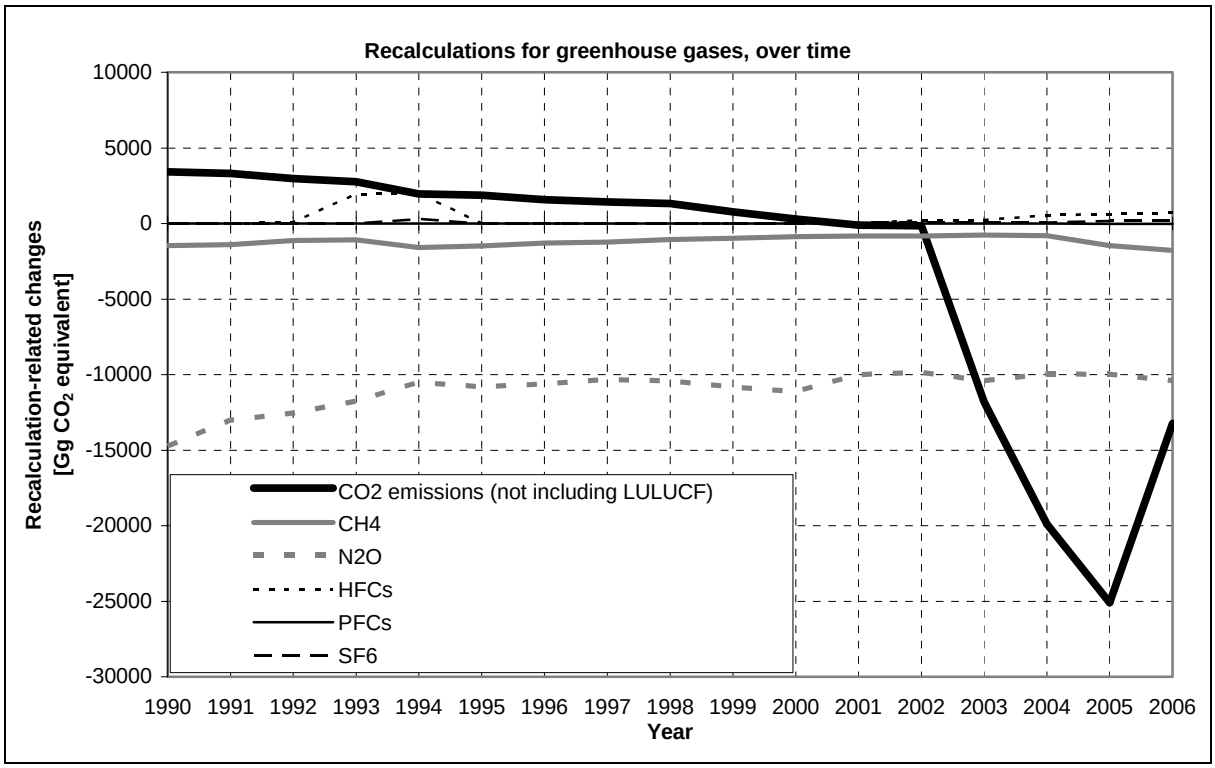


Figure 30: Recalculation-related change in pollutant-specific total emissions, for all source categories, and for the entire time series, in comparison to the relevant figures in the 2008 report

10.1.4 Recalculations to implement results of the review process

A few recalculations have been made in direct response to requirements identified in past reviews:

- Revision of the methods for the N2O emission factors used in 1.A.1 and 1.A.2, for the years 1990 through 1994

10.2 Impact on emissions levels

The inventory has been considerably improved with regard to completeness and accuracy.

The emissions reductions have resulted from use of more current Energy Balances and from calculations based on those Energy Balances. The mild winters of 2005/06 and 2006/07 had an especially positive effect on emissions.

Table 126: Inventory recalculations, in time series, with respect to last year's report

	Total national emissions of greenhouse gases, not including carbon dioxide from LULUCF		
	2008 submission	2009 submission	Recalculation / difference
	[Gg CO_2 equivalent]	[Gg CO_2 equivalent]	[%]
1990	1,228,063.02	1,215,265.05	-1.04
1991	1,179,969.14	1,168,855.95	-0.94
1992	1,129,336.49	1,118,728.22	-0.94
1993	1,116,347.71	1,108,200.85	-0.73
1994	1,098,124.32	1,090,246.29	-0.72
1995	1,095,385.40	1,084,953.65	-0.95
1996	1,115,055.27	1,104,723.17	-0.93
1997	1,077,745.91	1,067,626.79	-0.94
1998	1,052,680.36	1,042,512.99	-0.97
1999	1,020,986.54	1,009,933.80	-1.08
2000	1,019,915.63	1,008,220.19	-1.15
2001	1,036,756.03	1,025,859.27	-1.05
2002	1,017,691.90	1,007,147.48	-1.04
2003	1,030,520.65	1,007,847.46	-2.20
2004	1,028,005.47	997,973.44	-2.92
2005	1,005,422.04	969,644.74	-3.56
2006	1,005,215.42	980,667.20	-2.44

Source: own calculations; does not include carbon dioxide from LULUCF

The areas of agriculture and LULUCF were comprehensively revised and extensively recalculated.

In the area of communications provided for information only, recalculations, affecting all relevant years, were carried out for international air transports. CO_2 emissions from biomass changed as a result of adjustments in use of biomass for heat production and in use of biofuels in road transports.

Table 127: Rückrechnungen nachrichtlicher Inventardaten gegenüber der vorjährigen Berichterstattung

	1990	2006
	Change in [%]	
Emissions from international transports	**- 0.32 %**	**+ 9.85 %**
Air transports	**- 0.54 %**	**+ 15.09 %**
Marine transports	**± 0.00 %**	**± 3.05 %**
Multilateral missions	**NE**	**NE**
CO_2 emissions from biomass	**0.00 %**	**- 7.99 %**

Source: Own calculations

The changes in the figures for international air transports result from first-time use of an annually specific split factor for differentiation of national and international air transports (cf. Chapters 3.1.5.1 and 3.1.9).

10.2.1 Impacts on 1990 emissions levels

Emissions of CO_2, CH_4 and N_2O changed slightly for 1990. Total emissions for 1990 changed only slightly – by a total of 1.02 % – as a result of corrections in methods.

Most such changes occurred in the sectors *Solvent and other product use* and *Agriculture*.

The increase in the emissions reported in the solvents category is the result of first-time determination of figures for indirect CO_2 releases from emitted NMVOC. Inclusion of such figures led to an over-2.5-fold emissions increase in this category (+158.31 %).

Basic revision of the *Agriculture* category, on the other hand, led to a reduction in the emissions reported for 1990 that, in terms of actual quantities, more than offset the increase seen in the solvents category.

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 128: Recalculation of source-category-specific total emissions, for all gases in 1990

	Reported 2008 [Gg]	Reported 2009 [Gg]	Change, in CO_2 equivalents [Gg]	Change [%]
Total national emissions (not including LULUCF)	**1,227,688**	**1,215,209**	**-12,479**	**-1.02**
1. Energy	987,692	987,938	246	0.02
2. Industrial processes	119,799	119,820	21	0.02
3. Solvent and other product use	2,089	5,396	3,307	158.31
4. Agriculture	77,685	61,631	-16,054	-20.67
5. Land-use changes and forestry	-28,241	-28,250	-9.2	-0.03
- N_2O (emissions)	375	57	-318	-84.93
- CO_2 (storage)	-28,615	-28,306	309	1.08
6. Waste	40,423	40,424	0	0.00

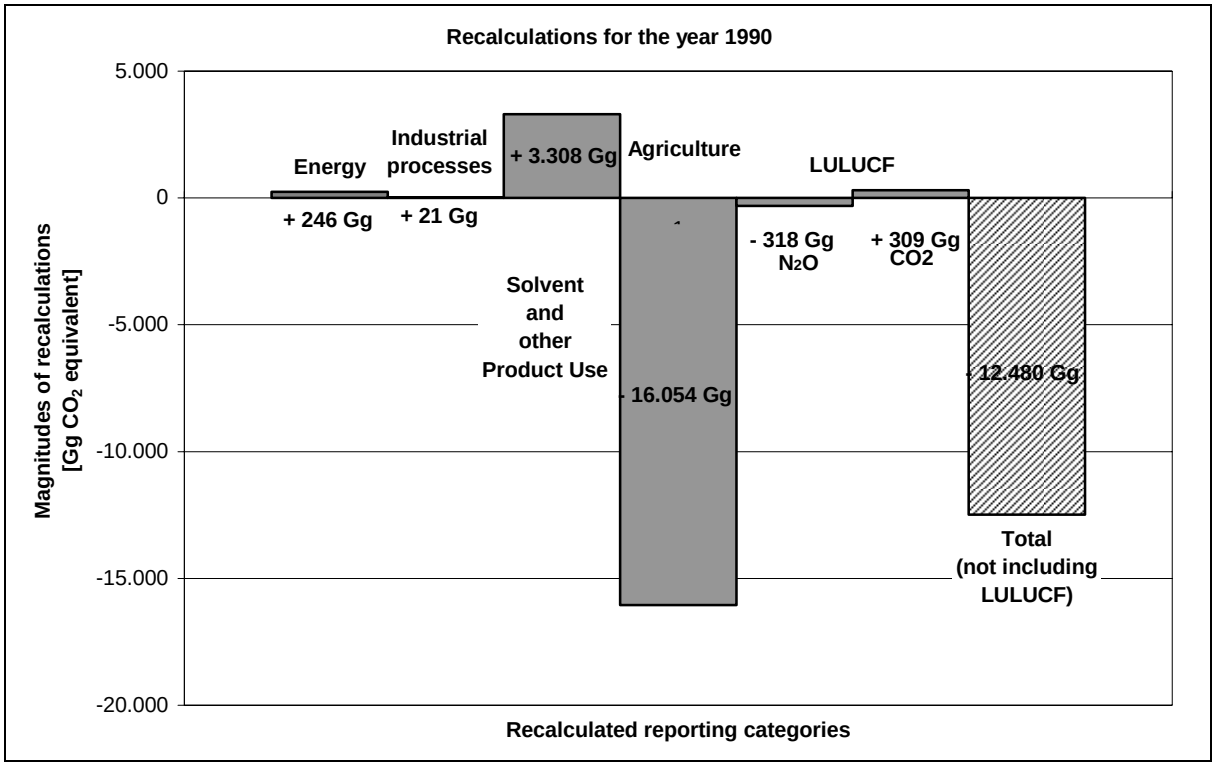


Figure 31: Recalculations of all greenhouse gases for 1990

10.2.2 Impacts on 2006 emissions levels

In comparison to the 2008 submission, total emissions for 2006, not including LULUCF, decreased by 2.47 %.

The pertinent changes occurred primarily in the sectors *Energy* and *Agriculture*, in which emissions, as a result of the recalculations, are considerably lower than the corresponding figures in the previous submission, and *LULUCF*, in which emissions increased.

Recalculation of emissions from *Energy Production*, on the basis of revised Energy Balances, led to an emissions reduction of somewhat more than 1.9 %. As a result of that category's large contribution to total emissions, it accounts for over 62 % (-15.616 Gg) of the total emissions reductions (-24.789 Gg, not including LULUCF).

Extensive revision of the "Agriculture" category led to a more than 18 % reduction of reported emissions, accounting for about 45 % of the total reductions (not including LULUCF).

In the LULUCF sector, CO_2 storage decreased considerably (decrease of about 56 %). In addition, the pertinent reported N_2O emissions increased sharply (+57.1 %). Overall, these shifts resulted in a change of +57.2 %.

Additional information about recalculations is provided in CRF tables 8(a)s1, 8(a)s2 and 8(b) and in the table below.

Table 129: Recalculation of source-category-specific total emissions, for all gases in 2006

	Reported 2008 [Gg]	Reported 2009 [Gg]	Change, in CO_2 equivalents [Gg]	Change [%]
Total national emissions (not including LULUCF)	**1,004,794**	**980,005**	**-24,789**	**-2.47**
1. Energy	818,905	803,289	-15,616	-1.91
2. Industrial processes	108,178	108,967	789	0.73
3. Solvent and other product use	1,174	3.345	2,171	184.96
4. Agriculture	63,542	52,098	-11,445	-18.01
5. Land-use changes and forestry (LULUCF)	-36,399	-15,572	20,828	57.22
- N_2O (emissions)	421	662	241	57.06
- CO_2 (storage)	-36,821	-16,234	20,588	55.91
6. Waste	12,995	12,306	-688	-5.30

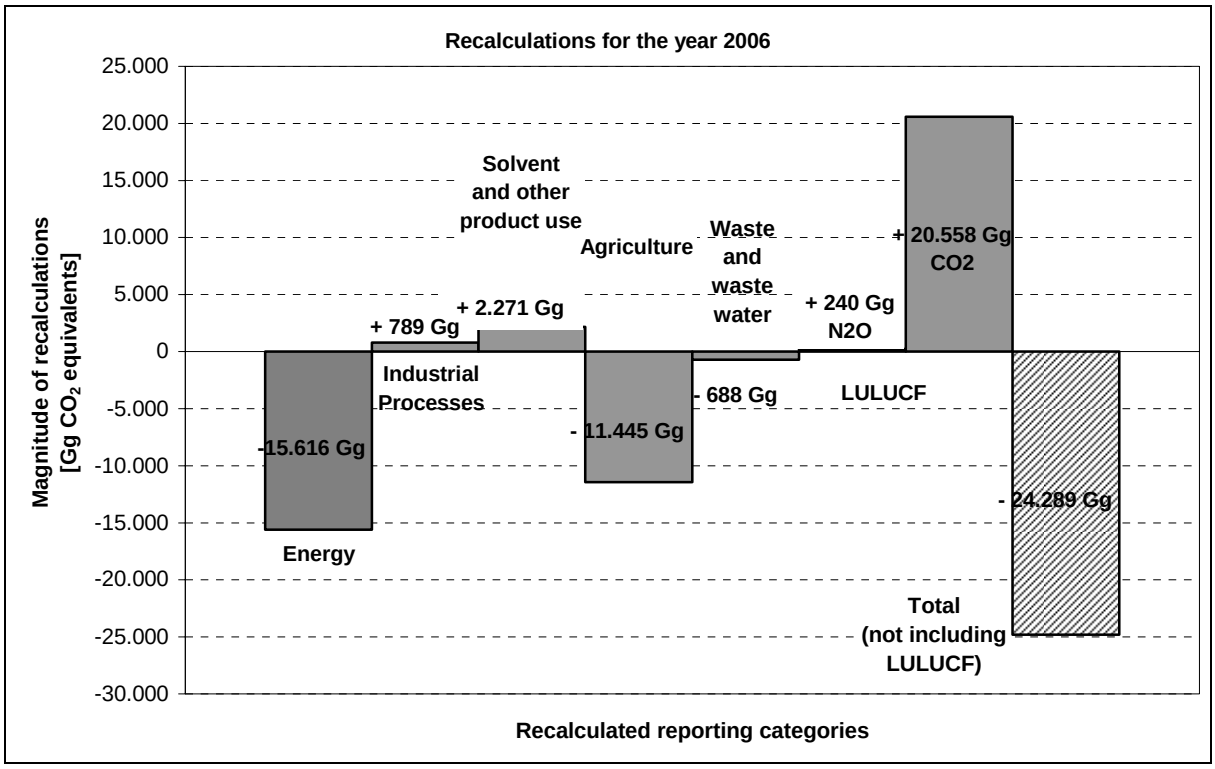


Figure 32: Recalculations of all greenhouse gases for 2006

10.3 Impacts on emissions trends and on time-series consistency

The time-series consistency has improved as a result of the recalculations. While trends for specific source categories changed, even markedly, trends at higher levels of aggregation hardly changed at all. One exception was the trend for the LULUCF category, which was more strongly influenced by pertinent specific trends.

In the sum result, the overall trend, with respect to the base year, shows a reduction of 21.5 %. CO_2 and CH_4 emissions decreased with respect to the previous year. N_2O emissions decreased considerably. HFC and SF_6 emissions show especially marked increases, while PFC emissions have decreased.

10.4 Inventory improvements

The following table summarises the improvements made in greenhouse-emissions reporting on the basis of references and remarks in the ERT from Initial Review under the Kyoto

Protocol and for the 2006 Inventory. The table lists only aspects that were not already addressed during the Review.

Table 130: 1.1 Compilation of improvements documented in the NIR 2009

CRF	Comment	Improvement / Germany's response	Chapter in NIR
National System	IRR 2007, §11: ERT recommended Germany to implement the policy paper on the national system, including the establishment of a coordination committee.	The coordination committee was established in 2008 and consists of representatives of relevant ministries (BMU, BMELV, BMWi, BMI/Destatis, BMVBS). It meets twice a year.	Section 1.2.1 and 17.1.2
National System	IRR 2007, §16/§88: ERT recommended Germany to ensure clarity of roles and responsibilities.	The German federal research institutes under the auspices of the German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) were restructured in 2008. A new working group, entitled "Emissions Reporting", was established in the recently founded "Johann Heinrich von Thünen Institute", which in future will handle all emissions reporting issues relative to CRF 4 and 5.	Section 1.2.4.6 and 1.4.1.5
National System	ARR 2008/§10/§62: ERT expressed concerns about the implementation status of the national system for reporting of Art. 3.3/3.4 KP and strongly recommended that high priority be given to improving the LULUCF reporting.	After restructuring of the research institutes under the auspices of the BMELV, Johann Heinrich von Thünen-Institut was commissioned to implement reporting of Art. 3.3 and 3.4 KP.	Section 1.2.4.6
National System	ARR 2008/§10/§21: ERT recommended that Germany reports on the progress it is making in the completion and strengthening of the National System: full implementation of the QA/QC plan, achieving agreement with DESTATIS and FAL regarding confidentiality issues and availability of agricultural statistics, reaching agreement with EUROCONTROL, development of an integrated concept for land-use monitoring in the LULUCF sector.	Progress in the further completion of the National System was achieved by conclusion of an agreement with FAL (vTI) and DESTATIS on the availability of agricultural statistics.	Section 17.1.2
QA/QC	IRR 2007, §18/ARR 2006, §19: ERT recommended that Germany continue its current QA/QC practices, enhance them where possible and clearly document the QA/QC systems of external data providers (implementation of the policy paper on the national system).	Minimum requirements pertaining to data documentation, a system for QA/QC and archiving for external data providers have been established and approved by the coordination committee. The implementation of the requirements is ongoing.	Section 1.2.3 and 1.2.6
QA/QC	IRR 2007, §19/ARR 2006, §20: ERT recommended that a more formal, annual external peer review process be established as a means of improving the inventory.	A workshop on the National System of Emission Inventories along with a review of the inventory by independent organisations is planned for spring 2009.	Section 1.2.4.8

CRF	Comment	Improvement / Germany's response	Chapter in NIR
Implementation of review recommendations	ARR 2008 § 19: ERT noted that Germany has not followed up some of the recommendations from previous ERTs, such as to improve the timeliness of the national energy balance.	The schedule for the delivery of data derived from the national energy balance was adjusted to the requirements of the national GHG inventory.	Section 1.2.5
Key categories	IRR 2007, §24/ARR 2006, §7: ERT recommended that Germany continues its work in further developing a tier 2 key category analysis.	Expanded determination of key categories according IPCC's Tier 2 method is being carried out for the German greenhouse-gas inventory at three-year intervals. Such work was carried out for the first time in 2007.	Section 1.3.1.3
Completeness	IRR 2007, §27 ARR 2006, §9: ERT noted, that to date no detailed information is available on the assessment of potentially excluded categories.	A methodical assessment of the completeness of the categories is currently undertaken in a research project. First results could already be included in the inventory 2009 (indirect CO_2 emissions, CRF 3.A-3.D).	E.g. section 5.1.2
1	IRR 2007, §49/§64/ARR 2006, §30/35: ERT recommended that Germany continue to improve on the separation of fossil fuels used for feedstocks and non-energy use and combustion emissions.	Relevant methodological assumptions and process considerations for the non-energy-related use of fuels are currently being revised.	Section 13.9
1	IRR 2007, §54/ARR 2006, §40: ERT strongly recommended the assumption of 100 per cent oxidation to be used consistently in future submissions.	Germany further assumes a complete oxidation of the carbon contained in fuels.	Section 3
1	ARR 2008, §18: ERT recommended that Germany explore the use of the EU ETS data as a means to improve QA/QC in inventory preparation and reduce uncertainties.	A direct use of the EU ETS data would result in lower transparency due to confidentiality of plant-specific data. Therefore the EU ETS data are used for quality assurance purposes. Furthermore consistency of the EU ETS data with public national statistics is checked. In terms of emission factors ETS data are directly used (basic emission factors for CO_2).	Section 1.2.4.3, section 1.2.6.7, section 3.1.4.1.2, section 4.1.2.4, section 4.1.8.4, section 4.3.1.2, section 13.7.1 (emission factors)
1.A.1.a	IRR 2007, §55/ARR 2006, §42: ERT highlighted Germany's intention to improve the estimates of N_2O (different emission factors for 1990-1994 and 1995-2004) in its 2009 submission.	Consistency of the N_2O emission factors was checked for the years 1994/1995 and appropriate corrections and recalculations were performed for the 2009 submission.	Section 3.1.1.3.4
1.A.2.f	IRR 2007, §55: Emissions of N_2O from energy and manufacturing industry have been recalculated. During the review the ERT was provided with the results but identified that the recalculated data were not part of the original submission.	Corrections of N_2O emission factors were performed (see 1.A.1.a). The recalculated data was included in the submission 2009.	Section 3.1.4.11.5
1.A.2.c/d	IRR 2007, §56/ARR 2006, §43: ERT recommended that emissions from chemicals and pulp, paper and print be reported separately or that the use of the notation keys be changed from „NO" to „IE".	Change of notation keys was already implemented in the 2008 submission.	

CRF	Comment	Improvement / Germany's response	Chapter in NIR
1.A.3.b	IRR 2007, §58/ ARR 2006, §46: ERT invited Germany to explain the effect of its fuel consumption of fuel purchased abroad in its next NIR and to verify the fuel sold – fuel consumed discrepancy with independent data in the fuel trade with neighbouring countries if possible.	Germany provided an explanation in its NIR2009. A quantitative assessment and verification is currently not possible.	Section 3.1.5.2.2
1.A.3.b	ARR 2008, §12: ERT identified that the inventory is not fully complete in terms of categories, with many reported as not estimated (NE) and that many of the NE categories are marked for checking.	Due to the improvement of data availability emissions from the use of bioethanol could be estimated for the first time and included in the GHG inventory. The categories reported as NE are considered to be negligible. Nevertheless the continuous process of inventory improvement will continue to periodically re-evaluate this assumption.	Section 3.1.5.2.5
1.BU	ARR 2008, §28: ERT recommended that Germany carry out a research project to improve estimates of emissions from the consumption of international aviation fuels for the years after 1995.	Specific annual split factors for international and domestic aviation were used. In order to improve the Tier methodologies (Tier 3) a research project was initialized.	Section 3.1.9.1.1, section 3.1.5.1.6
1.BU.1	IRR 2007, §50/ARR 2006, §45 ERT identified the need of improvements in emission estimates based on the assumption of a 20:80 split for domestic to international aviation.	Split factor for domestic and international aviation was completely revised and adjusted for the submission 2009.	Section 3.1.9.1.1, section 3.1.5.1.2
2	IRR 2007, §63: ERT encouraged Germany to provide details on the methodological issues affecting the reporting of actual F-gas emissions for the years 1990-1994.	Details about the calculation methods and the methods of data collection have been included in the NIR 2009.	Section 4.5.1.2, section 4.6.1.2.1, section 4.6.6.2, section 4.6.8.1.2
2.A.5	IRR 2007, §18 ERT recommended that Germany further implement the policy paper, in particular in respect of the specific roles and responsibilities of data developers and suppliers in institutions outside the UBA and clearly document the QA/QC systems of external data providers.	Negotiations on an agreement on the provision of data by the "Industrieverband Bitumen Dach- und Dichtungsbahnen" (vdd) are currently ongoing.	Section 1.2.4.7
2.B.1 **2.B.2** **2.B.3**	IRR 2007, §18, see 2.A.5	Discussions about an agreement on the provision of data by the Association of chemical industry (Verband der Chemischen Industrie, VCI) are currently ongoing.	Section 1.2.4.7
2.B.3	IRR 2007, §70/ARR 2006, §65: ERT criticized inconsistency in the use of notation keys for the AD.	Corrections of notation keys have already been implemented for 2008 submission.	

CRF	Comment	Improvement / Germany's response	Chapter in NIR
2.B.5	IRR 2007, §71/ARR 2006, §66: ERT identified that emissions from 2.B.5 are reported as a non-key category in the body of the NIR, whereas they are included in the key category table in the introduction and recommends Germany to address this discrepancy.	The discrepancy identified by the ERT has been deleted.	
2.F	IRR 2007, §73/ARR 2006, §68: ERT recommended that Germany complete the recalculation and fully document the changes in the next NIR.	Descriptions of the sector-specific recalculations have been completed in the NIR 2009.	Section 4.6
3.A-3.D	ARR 2008, §34: ERT encouraged Germany to estimate emissions of other gases and the other categories in order to improve the completeness of the inventory.	The submission 2009 includes estimates of indirect CO_2-emissions from solvent and other product use for the first time.	Section 5.1.2
4	FCCC/SBSTA/2007/4, §56: SBSTA encouraged parties to gain experience with the 2006 IPCC Guidelines.	The 2006 IPCC Guidelines were used for the estimation of emissions from German agriculture.	Section 6
4	ARR 2008 §8: ERT identified the need for improvements in reporting for the agriculture sector.	The submission 2009 includes considerable recalculations of the emissions from agriculture.	Section 6.1.5, section 6.2.5.1, section 6.2.5.2, section 6.2.5.3
4.D	IRR 2007, § 80/ARR 2006, § 77: ERT recommended Germany to check the consistency of the AD for imported manure and sewage sludge.	The time series for sewage sludge have been revised completely for the submission 2009.	Section 6.4.5.3
4.B	IRR 2007, § 82/ARR 2006, §76/ARR 2008, §51: ERT recommended Germany to use the latest scientific literature available regarding the methane conversion factor (MCF) and to update the emissions estimates.	The MCFs from 2006 IPCC Guidelines were used for the estimation of emissions from 4.B in the inventory 2009.	Section 6.2.2.1
4.B	ARR 2008, §52: ERT recommended that Germany check the nitrogen excretion by sheep and verify the calculations.	Nitrogen excretion by sheep was corrected for the current inventory.	Section 6.2.5.3
4.D	ARR 2008, §54: ERT recommended that Germany include $Frac_{NCRBF}$, $Frac_{NCRO}$ and $Frac_{R}$ in the CRF table 4Ds2.	In the 2009 inventory fractions $Frac_{NCRBF}$, $Frac_{NCRO}$ and $Frac_{R}$ have been included in the relevant CRF table.	CRF 4Ds2
5	IRR 2007, §85/ARR 2006, §81/ARR 2008, §57: ERT identified that not all categories, pools and gases for the LULUF sector have been estimated and recommended that Germany report a complete set of information for the LULUCF sector. ARR 2008 §8, 9: ERT identified a need for improvements in reporting for the LULUCF sector.	In the 2009 inventory several categories, pools and gases (consideration of all land use categories) were completed and improved.	Section 7.4, section 7.5
5.A.1		Below-ground biomass was included in the estimates of emissions/removals from LULUCF and relevant calculation methods have been improved.	Section 7.1.1.5

CRF	Comment	Improvement / Germany's response	Chapter in NIR
5	IRR 2007, §86/ARR 2006, §82/ARR 2008, §59: ERT criticised missing information on land-use definitions and classification systems used for the LULUCF categories. It recommended that Germany improve the transparency by providing all the necessary documentation and information.	The current inventory considers all land use categories and provides information on definitions of the newly reported categories.	Section 7.2.2.1, section 7.4, section 7.5
5.B/ 5.C	IRR 2007, §94/§95/§96/§97/ARR 2006, §90/§91/§92/§93/ARR 2008, §60/§61: ERT encouraged Germany to report a consistent representation for its land-use definition in accordance with the IPCC GPG and a complete time series of AD for each land use and land-use change.	The submission 2009 includes a complete definition and consideration of all land-use categories. Consistent identification of land is achieved by wall-to-wall approach.	Section 7.2.2.1

All measures are aimed at achieving complete consistency with the UNFCCC report guidelines and the IPCC Guidelines and at preventing any adjustments under the Kyoto Protocol.

Details on planned improvements are described in the chapters for the relevant source categories.

11 REFERENCES

AGEB, 2003: Arbeitsgemeinschaft Energiebilanzen (ed.): Energiebilanzen der Bundesrepublik Deutschland - Jahre 1990-1999, Verlags- und Wirtschaftsgesellschaft der Elekrizitätswerke, Frankfurt a. M.AGEB, 2002: Arbeitsgemeinschaft Energiebilanzen (ed.): Sonderauswertung für das UBA zur Darstellung von ausgewählten Energieverbräuchen in der Struktur der Energiebilanz vor 1995 für Zeitreihen von 1995 bis 1999 (unpublished)

AGEB, 2006: Arbeitsgemeinschaft Energiebilanzen (ed.): Energiebilanz für die Bundesrepublik Deutschland, URL: www.ag-energiebilanzen.de (Aufruf: 07.11.2005), Köln, Berlin.

AGEB, 2008: Arbeitsgemeinschaft Energiebilanzen (ed.): Energiebilanz für die Bundesrepublik Deutschland, URL: www.ag-energiebilanzen.de (Aufruf: 02.10.2008), Köln, Berlin.

AGFW 2006 / 2007: Arbeitgemeinschaft für Wärme und Heizkraftwirtschaft_AGFW_e.V. 2007 Vorabinformation zum Hauptbericht der Fernwärmeversorgung (still unpublished; publication tentatively planned for 12-2007)

AMD, 2002/2003**:** Amd Saxony LLC&Co. KG, Dresden, Umweltbericht. P. 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 pages; Bergisch Gladbach, 2007

BASt, 2008: Bundesanstalt für Straßenwesen: V 166: "Verkehrsentwicklung auf Bundesfernstraßen 2006" Arnd Fitschen, Ingo Koßmann ; 239 pages; Bergisch Gladbach, 2008

BATZ, 1995: Kokereien und Produktemissionen. Oral communication. Federal Environment Agency.

BENNDORF, R., 1999: Situation in Deutschland, ACCC-Workshop „N_2O und das Kyoto-Ziel“, Umweltbundesamt (Berlin), Wien

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

BMELV, 2007: Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten der Bundesrepublik Deutschland. Landwirtschaftsverlag GmbH, Münster-Hiltrup

BMVg, 2008: Bundesministerium der Verteidigung: Energieeinsatz zur Wärmeversorgung der Bundeswehr (unpublished).

BMWA, o.J.: Bundesministerium für Wirtschaft und Arbeit: Der Bergbau in der Bundesrepublik Deutschland. Regular series.

BOECKX u. CLEEMPUT, 2001: Boeckx, P. ,Van Cleemput, O.: Estimates of N_2O and CH_4 fluxes from agricultural lands in various regions in Europe. Nutr. Cycl. Agroecosyst. 60, 35-47

BPB, 2002: Bundeszentrale für politische Bildung. Projektgruppe Zukunft der Wirtschaft, Die Zukunft der Wirtschaft, Landwirtschaft und Ernährung, edited by Margarete Wohlan

BUND, 2006: Pressehintergrund PKW-Vignette vom 10.08.2006, Berlin, 2006

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, 2008: Jahresbericht des Bundesverband Glasindustrie e.V., with statistical annex

BVKalk, 2008 (Bundesverband der deutschen Kalkindustrie e.V.): Kalk Daten nationaler Inventarbericht; e-mailed to the Federal Environment Agency on 14 August 2008.

BVE, 2007: Bundesvereinigung der Deutschen Ernährungsindustrie e.V. Internetseiten, URL: www.bve-online.de, Recherchedatum September 2007.

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.

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 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, 19-42.

DÄMMGEN et al, 2006: Dämmgen, U.; Lüttich, M.; Döhler, H.; Eurich-Menden, B.; Osterburg, B.: Calculations of Emissions from German Agriculture - National Emission Inventory Report (NIR) 2006 for 2004. Part 3: Methods and Data (GAS-EM). Landbauforschung Völkenrode, special issue 291, 47-221

DÄMMGEN et al, 2007: Dämmgen, U.; Lüttich, M.; Haenel, H.-D.; Döhler, H.; Eurich-Menden, B.; Osterburg, B.: Calculations of Emissions from German Agriculture - National Emission Inventory Report (NIR) 2007 for 2005. Part 3: Methods and Data (GAS-EM). Landbauforschung Völkenrode, special issue 304

DÄMMGEN et al, 2008: 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. In publication.

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, 2008: Deutscher Asphaltverband e.V., Schieffelingsweg 6, 53123 Bonn,
Pressemitteilung vom 26.02. 08,
http://www.asphalt.de/site/startseite/aktuelles/pressemitteilungen/

DBU, 2002: Vogt, R., Knappe, F., Giegrich, J., Detzel, A., ifeu-Institut für Energie und Umweltforschung Heidelberg (ed.): 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.

DESTATIS, 1989: CORINE Land Cover - Nomenklatur der Bodenbedeckungen. URL: http://www.destatis.de/stbis/oc_1110/f20/d/nomenkla.htm

DESTATIS, 1991-2005: Statistisches Bundesamt: Fachserien (Zeitschrift), cf. individual sources

DESTATIS, 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

DESTATIS, 2002c: Statistisches Bundesamt, Klassifikation der Wirtschaftszweige, Ausgabe 1993 (WZ93), Wiesbaden 2002.

DESTATIS 2006a: Statistisches Bundesamt, „Monatsberichte über die Elektrizitätsversorgung / Dezember 2006“ _ Tab. 3.2 und Tab. 5b.

DESTATIS, 2006b: 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“

DESTATIS, 2006c: 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“

DESTATIS 2006d: Statistisches Bundesamt, „Stromerzeugungsanlagen der Betriebe im Bergbau und Verarbeitenden Gewerbe“.

DESTATIS, Fachserie 3 Reihe 3.2.1, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 3.2.1: Wachstum und Ernte

DESTATIS, Fachserie 3 Reihe 4, versch. Jahrgänge: Statistisches Bundesamt, Fachserie 3, Reihe 4: Viehbestand und tierische Erzeugung.

DESTATIS, Fachserie 4 Reihe 3.1, Jg. ab 1991: Statistisches Bundesamt, Fachserie 4, Reihe 3.1: Produzierendes Gewerbe - Produktion im produzierenden Gewerbe, Wiesbaden

DESTATIS, Fachserie 4 Reihe 8.1, versch. Jahrgänge: Statistisches Bundesamt; Fachserie 4, Reihe 8.1; Eisen und Stahl, Poeschel-Verlag

DESTATIS, Fachserie 4 Reihe 8.2, Jg. ab 1990: Statistisches Bundesamt, Fachserie 4, Reihe 8.2: Produzierendes Gewerbe, Düngemittelversorgung, Wiesbaden.

DESTATIS, Fachserie 8 Reihe 4, Jg. ab 1991: Statistisches Bundesamt, Fachserie 8, Reihe 4: Binnenschifffahrt (für die Jahre 1990-2003), Wiesbaden.

DESTATIS, Fachserie 19 Reihe 1, Jg ab 1990: Statisisches Bundesamt, Fachserie 19, Reihe 1: Umwelt, Abfallentsorgung.

DESTATIS, 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

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, page II-89

DIE VERBRAUCHER INITIATIVE e.V., 2005: Distickstoffmonoxid, (Online Dokument) http://www.zusatzstoffe-online.de/html/zusatz.php3?nr=942, accessed May 2005

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“

DLR, 1999: Deutsches Zentrum für Luft- und Raumfahrt (ed.), 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, 2000: Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook. 2nd ed., EEA, Copenhagen, 2000

EMEP, 2002b: Atmospheric Emission Inventory Guidebook, Chapter 1090 Manure Management Regarding Nitrogen Compounds. EEA, Copenhagen.

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.

FAO, 1998: World Reference Base for Soil Resources. Rome, Italy.

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, p. 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.

GDA, 2008: Gesamtverband der Aluminiumindustrie – Fachverband Primäraluminium: Monitoringbericht über die Fortschritte bei der Reduktion der CF4/C2F6 Emissionen der deutschen Primäraluminiumindustrie für das Jahr 2007, including background tables, e-mail communication of 19 August 2008 from Mr Rainer Buchholz (Wirtschaftsvereinigung Metalle e.V.), via Herrn Salomon (BMU).

HAENEL & DÄMMGEN, 2007a: Haenel, H.-D.; Dämmgen, U.: Consistent time series of data to model volatile solids and nitrogen excretions of poultry. 1. General considerations and pullets. Landbauforschung Völkenrode 57, 349-362.

HAENEL & DÄMMGEN, 2007b: Haenel, H.-D.; Dämmgen, U.: Consistent time series of data to model volatile solids and nitrogen excretions of poultry. 2. Laying hens. Landbauforschung Völkenrode 57, 363-390.

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

HORTIGATE, 2005: Freilandgemüse-Düngung nach Durchschnittswerten. URL: http://www.hortigate.de/scripts/WebObjects.dll/Hortigate.woa/2/wo/idbb6dt87xLy8HiXAzJ5zw/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, 2002: International Civil Aviation Organisation: Engine Exhaust Emissions Data Bank, 3rd edition, Doc. 9646-AN/943, 2002

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: Aktualisierung des Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen aus dem motorisierten Verkehr in Deutschland 1980 bis 2020; and TREMOD 3.0; under commission to the Federal Environment Agency, FKZ 201 45 112; Berlin 2002

IFEU 2003a: Detzel, A., Vogt, R., Fehrenbach, H., Knappe, F., Gromke, U., ifeu-Institut Heidelberg: 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 Heidelberg: Entwicklung eines Modells zur Berechnung der Luftschadstoffemissionen und des Kraftstoffverbrauchs von Verbrennungsmotoren in mobilen Geräten und Maschinen, under commission to the Federal Environment Agency, FKZ 299 45 113, Heidelberg.

IFEU, 2005: Knörr,W. et al, IFEU-Institut Heidelberg: Fortschreibung Daten- und Rechenmodells: Energieverbrauch und Schadstoffemissionen des motorisierten Verkehrs in Deutschland 1960-2030, sowie TREMOD 4.0, under commission to the Federal Environment Agency, FKZ 204 45 139, Berlin 2005

IKP, 1996: Institut für Kunststoffprüfung und Kunststoffkunde (IKP), Universität Stuttgart: Ganzheitliche Bilanzierung von Dachbahnen aus Bitumen, 1996

INFRAS, 2004: Handbuch Emissionsfaktoren des Straßenverkehrs 2.1- Dokumentation, Bern, 188.8.2004

IPCC, 1996a: Intergovernmental Panel on Climate Change: Greenhouse Gas Inventory, Workbook, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, 1996

IPCC, 1996b: Intergovernmental Panel on Climate Change: Guidelines for National Greenhouse Gas Inventories, Reference Manual, Volume 3, 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, Kap. 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, 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.

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

KOLLMANN, F. 1982: Technologie des Holzes und der Holzwerkstoffe. Springer-Verlag, Berlin, Heidelberg, New York

KTBL, 2004: Kuratorium für Technik und Bauwesen in der Landwirtschaft (ed.) (2004) Betriebsplanung Landwirtschaft 2004/05. KTBL-Datensammlung. 19. Ausgabe Darmstadt: KTBL, 573 pp.

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%. Unpublished.

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. Unpublished.

LENK et al., 2005: Auswirkungen des Tanktourismus auf das deutsche Steueraufkommen – eine finanzwissenschaftliche Bestandsaufnahme; Leipzig, 2005

LINDE GAS GMBH, 2005: Aufschäumen von Molkereiprodukten; URL: http://www.lindegas.at/international/web/lg/at/likelgatn.nsf/PrintView/63ED15ADE8FCF595C1256B7B004C6250; accessed May 2005

LÜTTICH et al, 2007: Lüttich M, Dämmgen U, Haenel H-D, Eurich-Menden B, Döhler H, Osterburg B: Calculations of Emissions from German Agriculture – National Inventory Report (NIR) 2007 for the Year 2005. Part 2: Tables. Landbauforsch Völkenrode special issue 304A, 1-347

LWK-NI, 2007: Landwirtschaftskammer Niedersachsen: Empfehlungen zur Stickstoffdüngung nach der N_{min}-Methode. URL: http://www.lwk-niedersachsen.de/index.cfm/portal/pflanze/nav/341/article/8200.html

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, p. 56

Müller-Westermeier et al, 2008: Die Witterung in Deutschland.

MWV, 2006: Mineralölwirtschaftsverband, „Mineralölzahlen 2005“.

MWV, 2008: Mineralölwirtschaftsverband, „Mineralölzahlen 2007“. URL: http://www.mwv.de/cms/front_content.php?idart=43&idcat=26

OECD/IEA, 2008: CO_2-Emissions from fuel combustion 2008 Edition, OECD & IEA, Paris, ISBN 9789264042384

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 (unpublished)

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 (unpublished)

ÖKO-INSTITUT, 2004c: CO_2 Emisssionsfaktoren für die Erstellung der nationalen CO_2-Inventare. Sub-report for the 2004 national inventory report.

ÖKO-INSTITUT, 2007: Emissionsberichterstattung im Luftverkehr, vorläufiger Endbericht zum F+E-Vorhaben 201 42 258, Berlin, 30.11.2007.

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, 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

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 under commission to the Federal Environment Agency, FKZ 201 45 108/ 01, Berlin, 2003

REIDY et al., 2008: Reidy, B.; Dämmgen, U.; Döhler, H.; Eurich-Menden, B.; Hutchings, N.J.; Luesink, H.H.; Menzi, H.; Misselbrook, T.H.; Monteny, G.-J.; Webb, J.: Comparison of models used for the calculation of national NH_3 emission inventories from agriculture: liquid manure systems. Atmospheric Environment, in print.

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 under commission to the Federal Environment Agency.

RETTENBERGER et al, 1997: RETTENBERGER, STEGMANN: Neue Aspekte der Deponiegasnutzung. Trierer Berichte zur Abfallwirtschaft Band 11. Economia-Verlag Bonn 1997. Pages 268, 319 (inter alia)

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

SAUVANT D, GIGER-REVERDIN S, 2007: Empirical modelling by meta-analysis of digestive interactions and CH4 productions in ruminants. In: Ortigues-Maty I (ed.) Energy and Protein Metabolism and Nutrition. Wageningen: Wageningen Academic Publishers. Pages 561-562

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.

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.

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.

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, of 27 February 1986, Gemeinsames Ministerialblatt p. 95, report p. 202)

TA LUFT, 2002: Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz, TA Luft - Technische Anleitung zur Reinhaltung der Luft, vom 24. Juli 2002, Gemeinsames Ministerialblatt (GMBl). No. 25 - 29 of 30 July 2002, p. 511ff.

UBA, 1983: Greiner, B., Barghoorn, M. Dobberstein, J., Eder, G., Fuchs, J., Gössele, P.: Chemisch-physikalische Analyse von Hausmüll. Research report 83-033 under commission to the Federal Environment Agency, Berlin.

UBA, 1986: Barghoorn, M., Gössele, P., Kaworski, W.: Bundesweite Hausmüllanalyse 1983-85, Forschungsbericht 10303508 under commission to the Federal Environment Agency, Berlin.

UBA, 1989: Umweltbundesamt: UBA-Text 6/89: Ermittlung der Abgasemissionen aus dem Flugverkehr über der Bundesrepublik Deutschland, UBA-Bericht 6/89, FKZ 104 05 961

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, Berlin, Schmidt, E-Verlag.

UBA, 1993: Umweltbundesamt: UBA-Text 9/93Emissionen der Treibhausgase Distickstoffoxid und Methan in Deutschland. Auftragnehmer: Schön, M. et al. Fhg-ISI

UBA, 1994: Daten zur Umwelt 1992/1993, p. 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, Edited: Federal Environment Agency, 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, 2002a: Umweltbundesamt: UBA-Text 05/02: Döhler H., Eurich-Menden B., Dämmgen U., Osterburg B., Lüttich M., Bergschmidt A., Berg W., Brunsch R.: BMVEL/UBA-Ammoniak-Emissionsinventar der deutschen Landwirtschaft und Minderungsszenarien bis zum Jahr 2010. Research report FKZ 299 42 256/02, Berlin 2002

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“ (unpublished)

UBA, 2004b: Dr. R. Joas; A. Potrykus; R. Schott; S. Wenzel: VOC-Minderungspotenzial beim Transport und Umschlag von Mineralölprodukten mittels Kesselwagen, FKZ 202 44 372, UBA-Texte 12/2004, Dessau.
URL: http://www.umweltdaten.de/publikationen/fpdf-l/2637.pdf

UBA 2005b, FKZ 20442203/02: Endbericht zum Forschungsprojekt „Einsatz von Sekundärbrennstoffen“

UBA 2005c, FKZ 20541115: unveröffentlichter Zwischenbericht zum Forschungsprojekt „Bereitstellung der Energiedaten für stationäre Feuerungsanlagen zur Erfüllung der Berichtspflichten im Rahmen des Nationalen Treibhausgasinventars (NIR 2006) und des Berichtes zur Festlegung der zugewiesenen Mengen nach Kyoto-Protokoll“

UBA 2005d: Umweltbundesamt: Qualitätssystem Emissionsinventare. Handbuch zur Qualitätskontrolle und Qualitätssicherung bei der Erstellung von Emissionsinventaren und der Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen sowie der EU-Entscheidung 280/2004/EG, Dessau. Last revised 24 August 2005

UBA, 2006: Umweltbundesamt: UBA-Text 29/06,: Lechtenböhmer, Nanning, Buttermann, Hillebrand: Bilanzierung der Gewinnung und Verwendung von Kalkstein und Ausweisung der CO_2-Emissionen, Forschungsbericht FKZ 20541217/02, Dessau 2006

UBA, 2007: Dr. Matthias Kühle-Weidemeier, Wasteconsult International: Endbericht des UFOPlan-Projekts „Anlagen zur mechanisch-biologischen Restabfallbehandlung, FKZ 206 33 301. June 2007

UMEG 2004: Umweltmessungen, Umwelterhebungen und Gerätesicherheit 2004: Emissionsfaktoren-Handbuch, Emissionserklärung 2004 Baden-Württemberg

UNFCCC, 2002: FCCC/SBSTA/2002/1: Guidelines for the Preparation of National Communications By Parties included in Annex 3 to the Convention, Part I: UNFCCC Reporting Guidelines on annual Inventories, Tables of the Common Reporting Format, unter URL: http://unfccc.int/resource/webdocs/sbsta/2002/01.pdf

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, 2006: Internetseiten: National Reports, GHG Inventories (Annex I), National Inventory Submissions, National Inventory Submissions 2005, URL: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/2761.php. Bonn. Accessed 7 March 2006.

UNFCCC, 2008: United Nations Framework Convention on Climate Change: National Inventory Submissions 2008 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 2008: Presseerklärung des Verbandes vom 12.03.08 zum Absatz im Jahre 2007, http://www.derdichtebau.de/trend-zur-qualitaets-dachabdichtung.45781.htm, Frankfurt a.M. 2008,

VDP, versch. JG: Verband Deutscher Papierfabriken e.V.: Ein Leistungsbericht, Bonn, various years since 1990

VDP, 2004: Verband Deutscher Papierfabriken e.V.: Ein Leistungsbericht, Bonn

VDZ, 2008 (Verein Deutscher Zementwerke e.V.): Zement – Produktionsdaten der deutschen Zementindustrie; am 15.8.2008 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

VOLK, F., 1997: Recherches sur les Fumees Produits par la Detonation de divers Explosifs, Explosifs,

WEG, 2000: Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V.: ERDGAS - ERDÖL. Entstehung, Suche, Förderung. Hannover. URL: http://www.erdoel-erdgas.de/Publikationen-68a.html

WEG, 2006: WEG Wirtschaftsverband Erdöl und Erdgasgewinnung e.V.: Jahresbericht 2006, Zahlen und Fakten. Hannover. URL: http://www.erdoel-erdgas.de/Publikationen-68a.html

WEG, 2007: WEG Wirtschaftsverband Erdöl und Erdgasgewinnung e.V.: Jahresbericht 2007, Zahlen und Fakten. Hannover. URL: http://www.erdoel-erdgas.de/Publikationen-68a.html

WEILBACHER, 1987: Ausgasung von Zellgasen, interner Laborbericht vom 17.08.87 (überreicht von der BASF AG, Ludwigshafen).

WEISS, SCHIELER, SCHADAUER, RADUNSKY, ENGLISCH, 2000: Die Kohlenstoffbilanz des Österreichischen Waldes und Betrachtungen zum Kyoto-Protokoll. Umweltbundesamt GmbH, Wien.

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

WEG, 2005: Wirtschaftsverband Erdöl- und Erdgasgewinnung e.V., 2005: Jahresbericht, Zahlen & Fakten 2004. Hannover.

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“, final report for the EUROSTAT project of the Federal Environment Agency, 24 April 2003, updated to include the "Energiebilanz 1999" of 20 September 2003

ZIESING 2008: Ziesing, Hans Joachim: CO2-Emissionen in Deutschland 2007: Milde Temperaturen und hohe Energiepreise lassen Emissionen sinken. In: Energiewirtschaftliche Tagesfragen Jg. 58, Heft 4, May 2008

12 ANNEX 1: GERMAN GREENHOUSE GAS INVENTORY - KEY SOURCES

In accordance with the "*IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*"[77] (*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 with 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 for 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.

12.1 Description of the method for identifying key sources

The results of the key-sources analysis based on the two Tier 1 techniques (Level and Trend) are outlined below. We refer the reader to the description of the underlying methods in the

77 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.
Work was carried out with the aim of supporting governments in the preparation of their 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

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.

12.1.1 Tier 1 Level Approach

As a result of this approach, 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.

Tier 1 Level analysis, using source-category structuring as described, identified a total of 28 key sources in 2007 (cf. Table 131).

Table 131: Key sources for Germany (2007), pursuant to the Tier 1 Level Approach (without sinks)

IPCC Source Categories	Activity	Emissions Of	2007 [Gg CO_2 Eqiv.][#]	Level Assesment	Key Source Decision
1A1a Public electricity and Heat production	all fuels	CO2	345672.7	33.89	•
1A3b. Transport Road Transportation	all fuels	CO2	144114.2	14.13	•
1A4b. Other Sectors Residential	all fuels	CO2	85949.8	8.43	•
1A2f. Manufacturing Industries and Construction Other	all fuels	CO2	80446.8	7.89	•
2C1. Metal Production Iron and Steel Production	Steel (integrated production)	CO2	46243.6	4.53	•
1A4a. Other Sectors Commercial/Institutional	all fuels	CO2	35850.3	3.51	•
5.B Cropland		CO2	32613.9	3.20	•
1A1b. Petroleum Refining	all fuels	CO2	22003.8	2.16	•
4D1. Agricultural Soils	Direct Soil Emissions	N2O	20087.5	1.97	•
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CO2	17851.6	1.75	•
2A1. Mineral Products Cement Production		CO2	14306.0	1.40	•
5.C Grassland		CO2	14102.6	1.38	•
5.E Settlements		CO2	11881.4	1.16	•
2E. Production of Halocarbons and SF6		PFC´s	10892.1	1.07	•
2B5 Chemical Industry	Other	CO2	10338.1	1.01	•
2B2 Chemical Industry	Nitric Acid Production	N2O	9555.2	0.94	•
6 A1 Managed Waste Disposal on Land		CH4	8211.0	0.80	•
4A.1. Enteric Fermentation	Dairy Cattle	CH4	7904.4	0.77	•
4A.1. Enteric Fermentation	Non-Dairy Cattle	CH4	7676.8	0.75	•
1.B.2.b. (all) Fugitive Emissions from Fuels, Natural Gas	Natural Gas	CH4	6581.2	0.65	•
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CO2	5863.1	0.57	•
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CO2	5727.8	0.56	•
4D3. Agricultural Soils	Indirect Emissions	N2O	5676.3	0.56	•
2A2. Mineral Products Lime Production		CO2	5670.9	0.56	•
2B3 Chemical Industry	Adipic Acid Production	N2O	5623.5	0.55	•
2B1. Chemical Industry	Ammonia production	CO2	5200.5	0.51	•
1B1a. Fugitive Emissions from Fuels Coal Mining and Handling	Solid Fuels	CH4	3982.3	0.39	•
1A1a Public electricity and Heat production	all fuels	N2O	3742.9	0.37	
1A3e. Transport Other Transportation	all fuels	CO2	3632.3	0.36	
2F. Industrial Processes	Consumption of Halocarbons and SF6	PFC´s	2894.8	0.28	

IPCC Source Categories	Activity	Emissions Of	2007 [Gg CO_2 Eqiv.]#	Level Assesment	Key Source Decision
5.D Wetlands		CO2	2823.1	0.28	
4B8. Manure Management	Swine	CH4	2593.5	0.25	
2C4. SF6 Used in Aluminium and Magnesium Foundries		SF6	2355.4	0.23	
6B Wastewater Handling	Domestic and Commercial Wastewater	N2O	2339.0	0.23	
1A3a. Transport Civil Aviation	Aviation Gasoline	CO2	2329.6	0.23	
3 Total Solvent and Other Product Use		CO2	2142.4	0.21	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CO2	2114.9	0.21	
4B1. Manure Management	Dairy Cattle	CH4	1677.3	0.16	
4D2. Agricultural Soils	Animal Production	N2O	1475.5	0.14	
4A.2. Enteric Fermentation	other animals	CH4	1413.3	0.14	
1A5 Other Include Military fuel use under this category	all fuels	CO2	1285.1	0.13	
1A3c. Transport Railways	all fuels	CO2	1278.0	0.13	
3D.Total Solvent and Other Product Use		N2O	1174.0	0.12	
1A3b. Transport Road Transportation	all fuels	N2O	1077.4	0.11	
4B1. Manure Management	Non-Dairy Cattle	CH4	1026.9	0.10	
4B13. Manure Management Other	Other Cattle	N2O	912.5	0.09	
4B13. Manure Management Other	Dairy Cows	N2O	881.5	0.09	
2A7. Glass Production		CO2	759.3	0.07	
2C3. Aluminium Production		CO2	757.2	0.07	
1A2f. Manufacturing Industries and Construction Other	all fuels	N2O	726.0	0.07	
5.G Other (please specify)		CO2	718.2	0.07	
5, Land-Use Change and Forestry		N2O	662.2	0.06	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	CO2	653.6	0.06	
6 A3 Other - Composting		CH4	542.1	0.05	
1A3d. Transport Navigation	Diesel Oil	CO2	531.1	0.05	
1A4b. Other Sectors Residential	all fuels	CH4	522.3	0.05	
5.F Other Land		CO2	485.7	0.05	
4B13. Manure Management Other	Swine	N2O	456.4	0.04	
2A7. Bricks and Tiles Production	limesto-input	CO2	391.6	0.04	
2F. Industrial Processes	Consumption of Halocarbons and SF6	HFC´s	334.8	0.03	
1A4b. Other Sectors Residential	all fuels	N2O	321.6	0.03	
6 A3 Other - Composting		N2O	318.8	0.03	
2F. Industrial Processes	Consumption of Halocarbons and SF6	SF6	316.4	0.03	
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	N2O	240.8	0.02	
2E. Production of Halocarbons and SF6	production of HCFC-22	HFC´s	198.7	0.02	
2C3. Aluminium Production		PFC´s	193.3	0.02	
1.B.2.a. (all) Fugitive Emissions from Fuels, Oil	Oil	CH4	186.4	0.02	
4B2. Manure Management	other animals	CH4	179.8	0.02	
1A3b. Transport Road Transportation	all fuels	CH4	146.0	0.01	
1A1a Public electricity and Heat production	all fuels	CH4	119.7	0.01	
6B Wastewater Handling	Domestic and Commercial Wastewater	CH4	107.8	0.01	
4B13. Manure Management Other	other animals	N2O	106.5	0.01	
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	N2O	102.2	0.01	
1A4a. Other Sectors Commercial/Institutional	all fuels	N2O	98.5	0.01	
1B1c. Fugitive Emissions from Fuels Other (Abandoned Mines)	Solid Fuels	CH4	73.8	0.01	
1A1b. Petroleum Refining	all fuels	N2O	69.0	0.01	
1A4a. Other Sectors Commercial/Institutional	all fuels	CH4	62.9	0.01	

IPCC Source Categories	Activity	Emissions Of	2007 [Gg CO_2 Eqiv.]#	Level Assesment	Key Source Decision
2B5 Chemical Industry	other	N2O	62.0	0.01	
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CH4	57.8	0.01	
1A2f. Manufacturing Industries and Construction Other	all fuels	CH4	55.4	0.01	
4B13. Manure Management Other	Poultry	N2O	44.7	0.00	
1A3a. Transport Civil Aviation	Aviation Gasoline	N2O	34.4	0.00	
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	N2O	32.9	0.00	
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CH4	25.8	0.00	
1A3e. Transport Other Transportation	all fuels	N2O	19.2	0.00	
2B4 Chemical Industry	Carbide Production	CO2	17.5	0.00	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CO2	17.5	0.00	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	N2O	13.4	0.00	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	N2O	9.7	0.00	
1B1b. Fugitive Emissions from Fuels Solid Fuel Transformation	Solid Fuels	CH4	8.7	0.00	
1A5 Other Include Military fuel use under this category	all fuels	N2O	8.6	0.00	
1A1b. Petroleum Refining	all fuels	CH4	8.3	0.00	
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CH4	7.5	0.00	
2C5. Other		HFC 134a	7.1	0.00	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	N2O	6.4	0.00	
1A3c. Transport Railways	all fuels	N2O	5.4	0.00	
1A3e. Transport Other Transportation	all fuels	CH4	4.2	0.00	
1A5 Other Include Military fuel use under this category	all fuels	CH4	4.1	0.00	
2C2. Ferroalloys Production	Ferroalloys	CO2	2.8	0.00	
1A3d. Transport Navigation	Diesel Oil	N2O	2.2	0.00	
2C1. Metal Production Iron and Steel Production	other	CH4	2.0	0.00	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CH4	1.8	0.00	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CH4	1.7	0.00	
1A3a. Transport Civil Aviation	Aviation Gasoline	CH4	0.6	0.00	
1A3c. Transport Railways	all fuels	CH4	0.6	0.00	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	CH4	0.5	0.00	
2B5 Chemical Industry	other	CH4	0.4	0.00	
1A3d. Transport Navigation	Diesel Oil	CH4	0.4	0.00	
1.B.2.a. (all) Fugitive Emissions from Fuels, Oil	Oil	CO2	0.0	0.00	
1.B.2.d. Other	Stadtgas	CH4	0.0	0.00	
1B2c. Fugitive Emissions from Fuels Venting and Flaring	Venting and Flaring	CH4	0.0	0.00	
2A4. Soda Ash		CO2	0.0	0.00	
4G. Other	Other	N2O	0.0	0.00	
2E. Production of Halocarbons and SF6	Fugitive emissions	SF6	0.0	0.00	

without sinks

12.1.2 Tier 1 Trend Approach

As a result of this 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 33 key sources (cf. Table 132).

Table 132: Key sources for Germany (base year & 2007), pursuant to the Tier 1 Trend approach (not including sinks)

IPCC Source Categories	Activity	Emissions Of	Base Year [Gg CO_2 Equi.]#	2007 [Gg CO_2 Equi.]#	Percent Absolute	Key Source Decision
1A1a Public electricity and Heat production	all fuels	CO2	335781.5	345,672.725	21.81891	●
1A2f. Manufacturing Industries and Construction Other	all fuels	CO2	138312.0	80,446.786	9.02139	●
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CO2	59066.1	17,851.621	8.65085	●
1A3b. Transport Road Transportation	all fuels	CO2	150358.3	144,114.206	6.66697	●
6 A1 Managed Waste Disposal on Land		CH4	35910.0	8,211.000	6.02759	●
1A4b. Other Sectors Residential	all fuels	CO2	129474.0	85,949.841	5.35034	●
1A4a. Other Sectors Commercial/Institutional	all fuels	CO2	63949.6	35,850.273	4.56215	●
1B1a. Fugitive Emissions from Fuels Coal Mining and Handling	Solid Fuels	CH4	18415.2	3,982.346	3.15744	●
5.E Settlements		CO2	1965.6	11,881.374	2.99389	●
5.B Cropland		CO2	28174.0	32,613.882	2.88032	●
2B3 Chemical Industry	Adipic Acid Production	N2O	18804.6	5,623.503	2.77153	●
2E. Production of Halocarbons and SF6		PFC´s	2244.6	10,892.073	2.64088	●
1A5 Other Include Military fuel use under this category	all fuels	CO2	11797.8	1,285.090	2.39098	●
2C1. Metal Production Iron and Steel Production	Steel (integrated production)	CO2	48326.0	46,243.621	2.12085	●
1A1b. Petroleum Refining	all fuels	CO2	20005.9	22,003.788	1.70952	●
2B2 Chemical Industry	Nitric Acid Production	N2O	4673.4	9,555.167	1.68302	●
2B5 Chemical Industry	Other	CO2	6869.8	10,338.090	1.39596	●
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CO2	12577.9	5,863.055	1.24275	●
5.C Grassland		CO2	13057.0	14,102.583	1.04060	●
2E. Production of Halocarbons and SF6	production of HCFC-22	HFC´s	4218.5	198.660	0.93078	●
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CO2	10917.1	5,727.802	0.89290	●
2F. Industrial Processes	Consumption of Halocarbons and SF6	PFC´s	6413.8	2,894.754	0.66134	●
2C4. SF6 Used in Aluminium and Magnesium Foundries		SF6	197.1	2,355.393	0.63864	●
2A1. Mineral Products Cement Production		CO2	15145.8	14,306.014	0.61028	●
6B Wastewater Handling	Domestic and Commercial Wastewater	CH4	2226.2	107.755	0.49035	●
4D1. Agricultural Soils	Direct Soil Emissions	N2O	22889.3	20,087.493	0.47668	●
2B1. Chemical Industry	Ammonia production	CO2	4596.4	5,200.451	0.43494	●
1B1c. Fugitive Emissions from Fuels Other (Abandoned Mines)	Solid Fuels	CH4	1806.8	73.779	0.40195	●
1A3d. Transport Navigation	Diesel Oil	CO2	2049.8	531.098	0.32592	●
1.B.2.b. (all) Fugitive Emissions from Fuels, Natural Gas	Natural Gas	CH4	6781.5	6,581.173	0.32433	●
2C3. Aluminium Production		PFC´s	1551.7	193.273	0.30742	●
1A3c. Transport Railways	all fuels	CO2	2879.3	1,277.980	0.30314	●
5.D Wetlands		CO2	2230.2	2,823.090	0.29821	●

IPCC Source Categories	Activity	Emissions Of	Base Year [Gg CO_2 Equi.]#	2007 [Gg CO_2 Equi.]#	Percent Absolute	Key Source Decision
4A.1. Enteric Fermentation	Non-Dairy Cattle	CH4	10755.3	7,676.804	0.28831	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	CO2	1989.2	653.559	0.27612	
1A4a. Other Sectors Commercial/Institutional	all fuels	CH4	1216.1	62.871	0.26669	
1A3b. Transport Road Transportation	all fuels	CH4	1271.1	145.965	0.25542	
1A1a Public electricity and Heat production	all fuels	N2O	3610.0	3,742.873	0.24228	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CO2	1599.7	2,114.916	0.24005	
2A2. Mineral Products Lime Production		CO2	6135.0	5,670.919	0.21117	
5, Land-Use Change and Forestry		N2O	56.5	662.185	0.17929	
1A3b. Transport Road Transportation	all fuels	N2O	608.4	1,077.415	0.17070	
6B Wastewater Handling	Domestic and Commercial Wastewater	N2O	2223.5	2,339.032	0.15902	
3 Total Solvent and Other Product Use		CO2	3307.5	2,142.401	0.15216	
3D.Total Solvent and Other Product Use		N2O	2088.5	1,174.007	0.14808	
6 A3 Other - Composting		CH4	49.8	542.119	0.14596	
5.F Other Land		CO2	23.2	485.687	0.13578	
1A4b. Other Sectors Residential	all fuels	CH4	1200.4	522.335	0.12943	
4B8. Manure Management	Swine	CH4	2727.0	2,593.472	0.11503	
1.B.2.a. (all) Fugitive Emissions from Fuels, Oil	Oil	CH4	700.4	186.388	0.10994	
2C2. Ferroalloys Production	Ferroalloys	CO2	429.0	2.750	0.09973	
2B4 Chemical Industry	Carbide Production	CO2	443.2	17.526	0.09875	
1A4b. Other Sectors Residential	all fuels	N2O	801.9	321.613	0.09440	
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	N2O	684.2	240.785	0.09032	
6 A3 Other - Composting		N2O	14.0	318.775	0.08941	
4D3. Agricultural Soils	Indirect Emissions	N2O	6693.4	5,676.336	0.08190	
1A2f. Manufacturing Industries and Construction Other	all fuels	N2O	1242.7	726.046	0.08011	
4A.2. Enteric Fermentation	other animals	CH4	1444.1	1,413.339	0.07252	
4B1. Manure Management	Non-Dairy Cattle	CH4	1530.9	1,026.860	0.06018	
5.G Other (please specify)		CO2	643.1	718.192	0.05811	
2A7. Glass Production		CO2	695.6	759.347	0.05777	
4B1. Manure Management	Dairy Cattle	CH4	1841.7	1,677.297	0.05610	
1A5 Other Include Military fuel use under this category	all fuels	CH4	236.8	4.131	0.05429	
2F. Industrial Processes	Consumption of Halocarbons and SF6	HFC´s	197.9	334.754	0.05095	
2F. Industrial Processes	Consumption of Halocarbons and SF6	SF6	609.5	316.388	0.05083	
2B5 Chemical Industry	other	N2O	292.7	62.000	0.05056	
1A3e. Transport Other Transportation	all fuels	CO2	4302.3	3,632.291	0.04792	
4A.1. Enteric Fermentation	Dairy Cattle	CH4	9603.9	7,904.367	0.04767	
4B13. Manure Management Other	Other Cattle	N2O	1284.4	912.511	0.03566	

IPCC Source Categories	Activity	Emissions Of	Base Year [Gg CO_2 Equi.]#	2007 [Gg CO_2 Equi.]#	Percent Absolute	Key Source Decision
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CH4	176.9	25.809	0.03395	
1A3a. Transport Civil Aviation	Aviation Gasoline	CO2	3024.9	2,329.623	0.03151	
4B13. Manure Management Other	Swine	N2O	435.3	456.400	0.03068	
1A2f. Manufacturing Industries and Construction Other	all fuels	CH4	180.9	55.435	0.02628	
4B2. Manure Management	other animals	CH4	128.7	179.787	0.02211	
2C3. Aluminium Production		CO2	1011.9	757.228	0.01696	
4B13. Manure Management Other	other animals	N2O	72.0	106.516	0.01409	
1A5 Other Include Military fuel use under this category	all fuels	N2O	64.4	8.570	0.01260	
4B13. Manure Management Other	Dairy Cows	N2O	1040.3	881.537	0.01253	
2A7. Bricks and Tiles Production	limesto-input	CO2	531.1	391.604	0.01060	
1A1b. Petroleum Refining	all fuels	N2O	121.9	68.951	0.00851	
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	N2O	158.3	102.195	0.00737	
1A4a. Other Sectors Commercial/Institutional	all fuels	N2O	144.2	98.465	0.00517	
1A3a. Transport Civil Aviation	Aviation Gasoline	N2O	20.8	34.437	0.00514	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CO2	3.6	17.520	0.00424	
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CH4	27.1	7.482	0.00418	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	N2O	25.6	6.371	0.00416	
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CH4	54.6	57.826	0.00401	
4B13. Manure Management Other	Poultry	N2O	38.4	44.661	0.00399	
1A1a Public electricity and Heat production	all fuels	CH4	138.2	119.715	0.00242	
4D2. Agricultural Soils	Animal Production	N2O	1821.1	1,475.463	0.00224	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	N2O	2.9	9.725	0.00214	
1B1b. Fugitive Emissions from Fuels Solid Fuel Transformation	Solid Fuels	CH4	18.1	8.686	0.00171	
1A3c. Transport Railways	all fuels	N2O	12.6	5.354	0.00140	
1A3d. Transport Navigation	Diesel Oil	N2O	8.6	2.225	0.00137	
1A3e. Transport Other Transportation	all fuels	CH4	9.8	4.215	0.00107	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	CH4	3.8	0.453	0.00075	
1A1b. Petroleum Refining	all fuels	CH4	13.3	8.347	0.00069	
1A3e. Transport Other Transportation	all fuels	N2O	26.5	19.159	0.00064	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CH4	0.5	1.830	0.00040	
1A3c. Transport Railways	all fuels	CH4	2.3	0.580	0.00037	
2C1. Metal Production Iron and Steel Production	other	CH4	3.9	2.034	0.00033	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	N2O	17.8	13.365	0.00029	
1A3d. Transport Navigation	Diesel Oil	CH4	1.7	0.362	0.00029	

IPCC Source Categories	Activity	Emissions Of	Base Year [Gg CO_2 Equi.]#	2007 [Gg CO_2 Equi.]#	Percent Absolute	Key Source Decision
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CH4	1.2	1.700	0.00022	
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	N2O	40.5	32.938	0.00008	
2B5 Chemical Industry	other	CH4	0.3	0.419	0.00006	
1A3a. Transport Civil Aviation	Aviation Gasoline	CH4	0.9	0.622	0.00002	
1.B.2.a. (all) Fugitive Emissions from Fuels, Oil	Oil	CO2	0.0	0.004	0.00000	

without sinks

12.1.3 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 will be carried out in connection with the 2010 report.

13 ANNEX 2: DETAILED DISCUSSION OF THE METHODOLOGY AND DATA FOR CALCULATING CO_2 EMISSIONS FROM COMBUSTION OF FUELS

13.1 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. In an effort to overcome such discrepancies, in the early 1970s, associations of the Germany energy industry, along with economic research institutions, formed the Working Group on Energy Balances (AGEB), charging it with evaluating statistics from all areas of the energy industry on the basis of uniform criteria, combining the data into a coherent whole and making the relevant figures available to the general public in the form of Energy Balances. The Energy Balances of the Federal Republic of Germany command a pivotal position in the energy data system by virtue of their structure and conclusiveness. They therefore form the basis for determination of energy-related emissions and for development of scenarios and forecasts of the effects 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). The Mineralölwirtschaftsverband e.V. petroleum-industry association provides petroleum data, and the other associations respresented in the Working Group of Energy Balances (AGEB) review data relative to "their" fuels. 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 133. 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 133: Data sources for the Energy Balances

All energy resources	**Federal Ministry of Economics and Technology** 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)

13.2 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 33). 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 33: 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 33 shows the structure of the production and consumption balances in the energy balances until 1994 and as of 1995.

Energy resource structure in energy balances ...

Through 1994

Hard coal	HC coal HC coke HC briquettes HC raw tar HC pitch HC other Crude benzene
Lignite	L coal L briquettes L coke L coal dust Hard lignite
Other solid fuels	Firewood Peat Sewage sludge
Petroleum	Oil Gasoline Raw gasoline Avgas Jet kerosene Diesel Heating oil, light. Heating oil, heavy Petrol coke Other petroleum products
Gases	LP gas Refinery gas Coke-oven gas Blast-furnace gas Natural gas Petroleum gas Pit gas Landfill gas
Electricity and other energy resources	Electricity Hydropower Nuclear power District heat Other energy resources
Total energy resources	Primary energy resources Secondary energy resources Total

As of 1995

Hard coal	HC coal HC briquettes HC coke Other HC products
Lignite	L coal L briquettes Other L products Hard lignite
Petroleum	Oil Gasoline Raw gasoline Jet kerosine Diesel fuel Heating oil, light Heating oil, heavy Petrol coke LP gas Refinery gas Other petroleum products
Gases	Coke-oven and city gas Blast-furn. & converter gas Natural gas, petroleum gas Pit gas
Renewable energies	Hydropower Wind and photovol. systems Waste and other biomass Other renewable energies
Electricity and other energy resources	Electricity Nuclear power District heat
Total energy resources	Primary energy resources Secondary energy resources Total

Source: ZIESING et al, 2003

Figure 34: 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 may 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

The main group structure (until 1994 and as of 1995) is shown in Figure 34. Via the "Renewable energies" satellite balance, renewable energies can be 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, energy resources are first listed with their specific units. The so-called *natural units* used are tonnes (t) for solid and liquid fuels, cubic metres (m^3) for gases, kilowatt hours (kWh) for electrical power, and joules (J) for waste, renewable energy sources, nuclear power and district heating. In order to render the data comparable and suitable for addition, all values are converted into joules (J) using calorific value tables and conversion factors. Unlike gas statistics or international Energy Balances, the Energy Balance lists even gases in terms of calorific value.

13.3 Preparation of preliminary energy balances, by the Federal Environment Agency

To date, Energy Balances through 2006 have been published. To a large extent, these Energy Balances have entered into the 2009 report. 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,
- Commerce, trade and services and military agencies,
- Use of energy resources for power generation.

This information is used to prepare preliminary Energy Balances.

13.4 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). In the following areas, the activity rates determined via the Energy Balance are substantiated with other sources:

Firewood consumption

The Energy Balance is the source for data on residential firewood consumption. Firewood consumption in the source categories commercial, trade and services 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.

Household and industrial waste

The Energy Balance data for total inputs of household waste in waste incineration facilities were supplemented with figures of the Federal Statistical Office (DESTATIS, Fachserie 19, Reihe 1). The difference between the a) thus-obtained total sum for household-waste inputs in the public electricity and district-heat supply and b) the pertinent Energy Balance data was distributed proportionally among the relevant categories of Energy Balance data (electricity generation in public thermal power stations, heat generation in public thermal power stations and heat generation in public district-heating stations).

A similar procedure is adopted for waste incineration in industrial thermal power stations. In this case, the difference between a) the sum of the Energy Balance data and the data for substitute fuels (obtained by research project FKZ 204 42 203/02) and b) the pertinent waste statistics of the Federal Statistical Office (DESTATIS, Fachserie 19 Reihe 1) is divided proportionally among the pertinent Energy Balance figures (electricity generation in waste-incineration plants of other industrial power stations, and heat production in waste-incineration plants of industrial power stations of the manufacturing and other mining sectors).

Such cross-checking of the difference between Energy Balance data and pertinent waste statistics of the Federal Statistical Office is carried out in the described manner only for the old German Länder and for Germany. For the new German Länder, for which the Energy Balance shows higher values for the 1990-1994 period than the waste statistics do in both the public and industrial sectors, the Energy Balance data are not adjusted to the level of waste statistics. In this area, the Energy Balance values are likely to be more realistic than those of the waste statistics, since the latter underestimate use of industrial waste for energy recovery, as was confirmed by the results of the research project "Base year and updating" ("Basisjahr und Aktualisierung"; FKZ 20541115). The activity rates for the new German Länder for the 1990-1994 period, then, are higher than those given by waste statistics. This approach is in line with the aim of including all emissions.

Waste incineration in other facilities of the transformation sector must also be considered. From 1993 to 1994, the Energy Balances for the old *Länder* include data on the use of sewage sludge and waste under "energy consumption in the transformation sector for coke ovens" (line 38 of the Energy Balance; in the CSE, this input is interpreted as "plastic waste"); from 1995 onwards, the corresponding data for Germany are listed under "consumption in energy production and in the transformation sectors for other energy producers" (line 39 of the Energy Balance).

Natural gas inputs in compressors

The Energy Balance values were also supplemented in the area of natural gas inputs in compressors in the natural gas network in the 1990-1994 period. These inputs are determined via the factor 0.005, which is the factor used for relevant domestic natural gas consumption. The corresponding activity rates until 1994 – for the inventory data analysed in detail to date – are not deducted from the energy consumption data in the transformation sector listed in line 42 or 44 (until 1994). In other words, these are included as additional emissions. For Germany as a whole, in the first half of the 1990s, this produced annual emissions of approximately 700,000 tonnes of CO_2.

From reporting years 1995 to 2004, natural gas inputs in natural-gas compressor stations were reported in the context of the Energy Balance and in a manner consistent with it. The relevant fuel inputs were listed, along with natural gas inputs in coking plants, in Energy Balance line 33 (energy consumption in coking plants).

Since reporting year 2005, it has no longer been possible to list fuel inputs in natural-gas compressor stations separately in the Energy Balance. For this reason, they are again being calculated separately, in keeping with the aforementioned method.

13.5 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 the past few years (ZIESING et al, 2003). By contrast, the Energy Statistics Act (Energiestatistikgesetz), which entered into force in 2003, is having a positive effect.

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 (edition 1993, WZ 93), since 1995 only Energy Balances for Germany as a whole (in the territorial delimitation of 3 October 1990) have been submitted.

The structures of energy balances until 1994, and as of 1995, are shown in Figure 33 and Figure 34.

13.5.1 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 (DESTATIS, 2002c).

In the view of DIW Berlin, these Energy Balances may be considered the standard energy-statistical basis for determining energy-relevant 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 13.6.1.

13.6 Uncertainties in the activity rates for stationary combustion systems

See NIR 2007, Chapter 13.6.

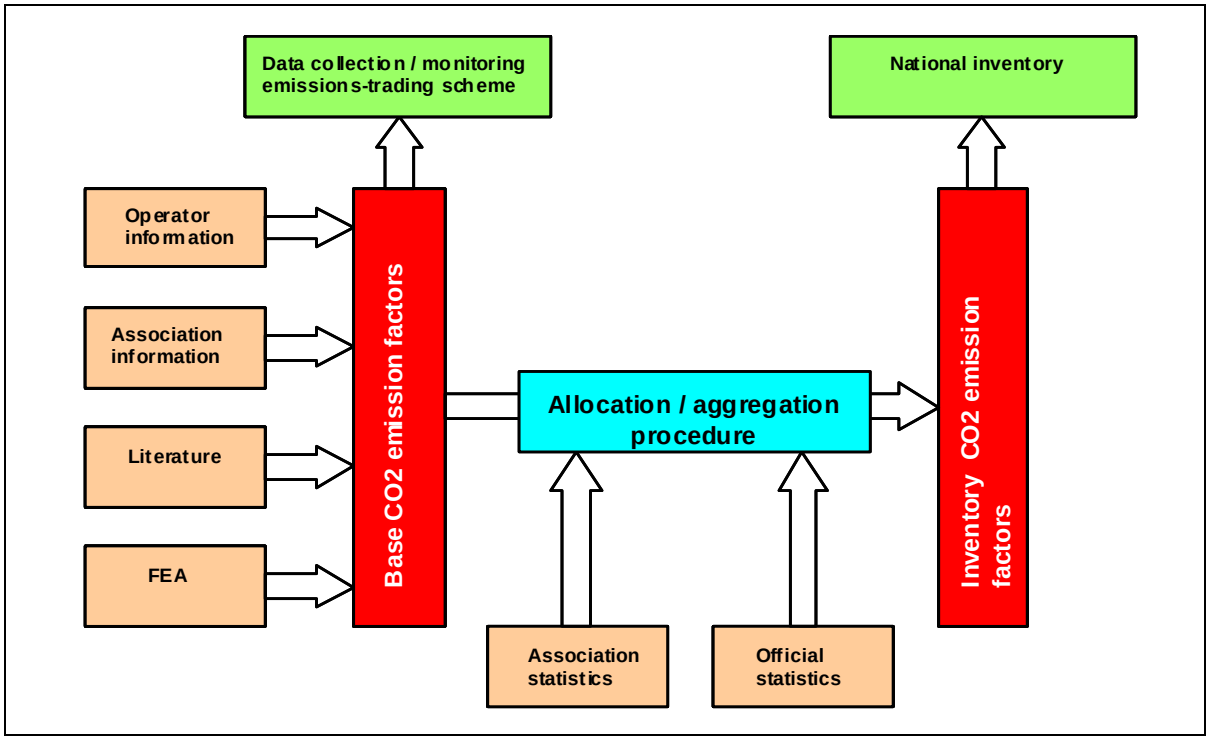
13.7 CO_2 emission factors

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).

13.7.1 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.



Source: Öko-Institut

Figure 35: Base and inventory emission factors for CO_2

With this in mind, a consistent concept for CO_2 emission factors was developed (Figure 35).

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.

13.7.2 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

13.7.3 Determination of inventory emission factors for CO_2

With the basic emission factors for CO_2 (not including the area of secondary fuels), and 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 134).

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) 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.

DEBRIV 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 134 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 134: Aggregation and allocation of basic emission factors for CO_2, as of 1990 - 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
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	94.1	94.0
Hard-coal briquettes	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	93.0	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
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
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
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
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
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
Hessen	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
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
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
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	99.7
Old German Länder	99.0	99.0	99.0	99.0	99.0													
New German Länder	99.7	100.0	100.0	100.0	100.3													
Lignite tar *New German Länder*	97.0	97.0	97.0	97.0	97.0													
Lignite dust and fluidised bed coal *Germany*						97.8	97.7	97.7	97.8	97.9	98.0	98.0	97.9	97.9	97.9	98.0	98.0	97.9
Old German Länder	98.0	98.0	98.0	98.0	98.0													
New German Länder	96.7	96.6	96.8	97.5	97.1													
Lignite coke	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	108.0	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	NO	NO	NO	NO

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
Petroleum																		
Crude oil	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
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
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													
Aircraft fuel	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0	73.3	73.3	73.3	73.3	73.3	73.3	73.3	73.3
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
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
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
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
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
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
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
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
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
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
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
Flammable gas *New German Länder*	49.0	49.0	49.0	49.0	49.0													
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
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
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

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
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
Industrial waste [2] *Germany*						74.5	74.8	74.0	74.0	74.1	73.4	73.3	73.2	72.9	72.1	72.0	71.9	71.8
Old German Länder	73.9	73.9	74.0	74.1	74.3													
New German Länder	74.9	74.8	74.7	74.6	74.6													
Special fuels [1]																		
Recycled 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
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
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
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
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
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
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
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
Sewage sludge	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	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
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
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
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
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
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
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
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
Waste wood (wood scraps)	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
Bark	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 meals and fats	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
Animal fat	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
Firewood [5]	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0	112.0
Landfill gas, sewage-treatment gas [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
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
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

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 1990-94, 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 for informational purposes, 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

Table 135: Aggregation and allocation of basic emission factors for CO_2, as of 1990 - industrial processes

Industrial processes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	[kg CO_2/ t (raw material or product)]																	
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
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
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
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
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
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
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
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
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
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
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
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
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
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
2.B Production of ammonia	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00	1815.00
2.B Production of calcium carbide	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)	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.00
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
2.C.1 Production of electrical steel	8.50	8.00	7.50	7.00	7.00	6.50	6.50	6.00	5.50	5.00	5.00	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
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
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
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
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

* Factor for the ideal blast-furnace process (Scholz factor) pursuant to the Allocation Ordinance in connection with the National Allocation Plan

13.8 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).

13.9 Analysis of CO_2 emissions from non-energy-related use of fuels

This information is provided in Annex 2, Chapter 13.9 of the 2007 inventory report (NIR 2007). Currently, the relevant methodological assumptions and process considerations are being revised, on the basis of recommendations and results of the 2007 Initial Review.

14 ANNEX 3: OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR INDIVIDUAL SOURCE OR SINK CATEGORIES (WHERE RELEVANT)

14.1 Other detailed methodological descriptions for the source category "Energy" (1)

14.1.1 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)

14.1.1.1 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.

14.1.1.2 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.[78] 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.

[78] 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.

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 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.

14.1.1.3 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 136: 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 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 137: 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 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 138: 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 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**
		↓ **EBL 18**	↓ **EBL 18**	↓ **EBL 18**	↓ **EBL 18**		↓ **EBL 18**		↓ **EBL 18**	

Table 139: 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 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 140: 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	District-heat production in TA-Luft systems of industrial power stations of the manufacturing sector and other mining	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-temp.coke	TJ		*64*	*0*	*0*	*165*	*11*	*0*			
> Lignite hi-temp.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	TJ		0	0	0	0	0	0	0	0	0
> Coke-oven / city gas		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
- Special fuels	TJ	896	391	0	136	167	11	190	0	0	0
> Other petrol. 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 141: Fuel inputs in the transformation sector (auxiliary energy / Energy Balance line 45) (new German Länder, 1990)

1	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	TJ	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	TJ	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	TJ	13,901	0	0	11,619	11,619	2,282
Lignite tar	TJ	0	0	0	0	0	0
> Industrial waste	TJ	2,509	2,509	0	0	2,509	0

Table 142: 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	TJ	2,803		0	0	0	0	0	0	0	0	0	0	0	0
> Coke-oven / city gas		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
- 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 143: 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	TJ	2,803	0	0	0	1,988	0		0	0	815
> Coke-oven / city gas		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	TJ	301	0	0	0	0	0		0	0	301
Lignite tar		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

14.1.1.4 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.

14.1.1.4.1 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.
5. 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.
6. 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.

14.1.1.5 Results (activity rates, 1991-1994)

14.1.1.5.1 Lignite

A by-district breakdown of lignite consumption had to be obtained, as was accomplished for the year 1990. Table 144 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 144 shows inputs, for coal briquetting, in lignite plants in the Lausitz and Mitteldeutschland districts, while Table 145 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 144: 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 (energy company)	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 145 provides an overview of fuel inputs for drying coal briquettes and coal dust, in the Lausitz and Mitteldeutschland mining districts.

Table 145: 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 plans 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.

14.1.1.5.2 Energy-intensive industrial processes

The following tables (Table 146 through Table 153) 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 146: 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 147: 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 148: 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 149: 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 150: 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 151: 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 152: 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 153: 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.

14.1.2 Energy Industries (1.A.1)

14.1.2.1 Methodological aspects of determination of emission factors (Chap. 3.1.1.2*)*

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 13.7).

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 3.1) – 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.

5. 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.

6. The chosen methods for deriving emission factors for a given reference year are shown in Figure 36 below.

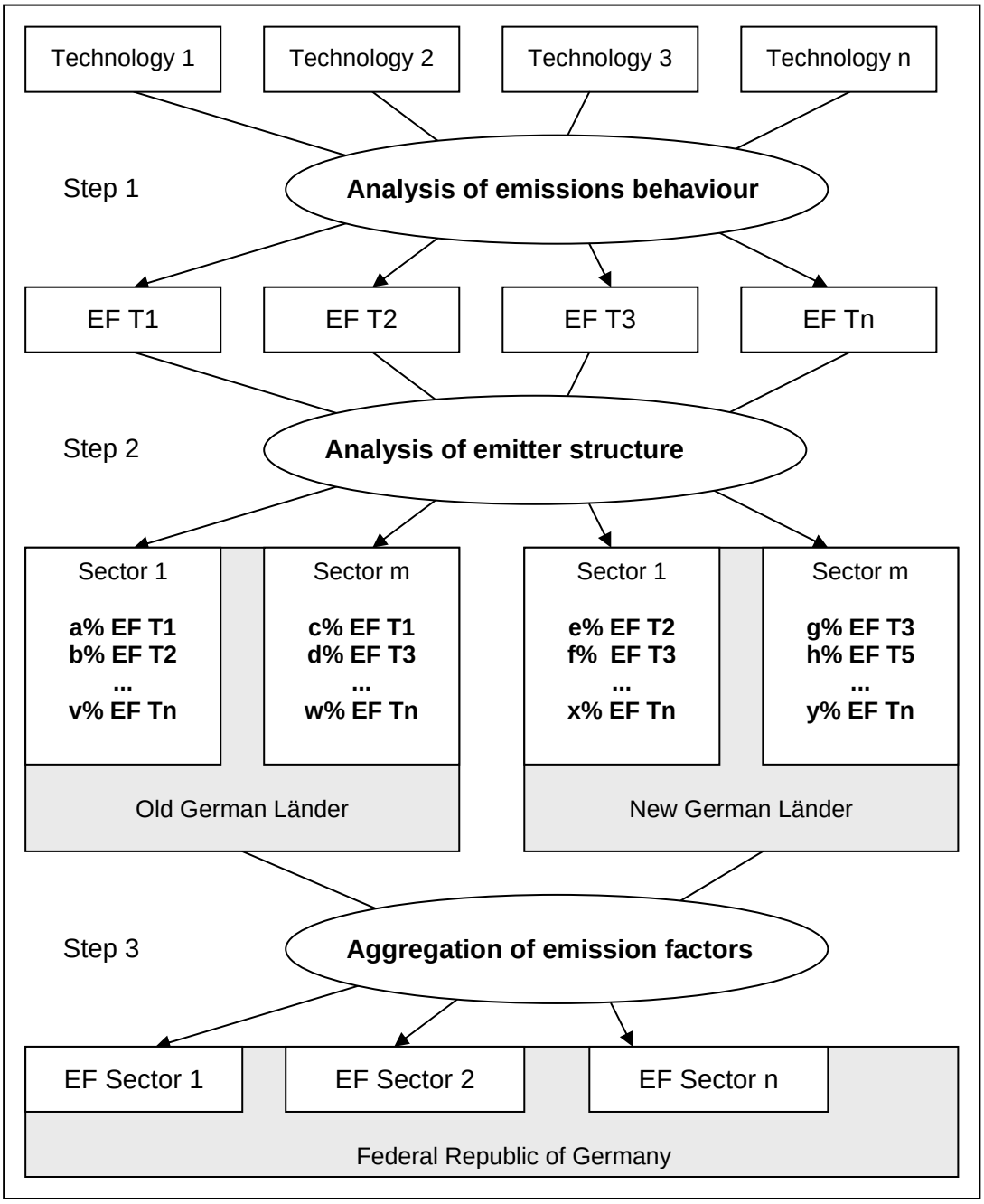


Figure 36: Methods for calculating emission factors

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 %[79]. 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 154 provides an overview of the facility types in question and lists the relevant classification numbers under the 4th BimSchV and the relevant type of declaration required.

Table 154: 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 155 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.

79 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 155: 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

14.1.2.2 Methods for determining uncertainties of emission factors

This section of the Annex describes the main steps carried out in the research project RENTZ et al (2002) for determining the uncertainties of emission factors (except for those of CO_2 emission factors).

The guide on describing uncertainties in measurements (Leitfaden zur Angabe der Unsicherheit beim Messen; DIN, 1995: DIN 1319) recommends the following systematic approach for cases in which not enough observations have been carried out to yield a meaningful result, via calculation of averages and standard deviation:

On the basis of the available information, limits (upper and lower limit a_+ and a_-) are defined for the value to be determined, X_i. If no special findings regarding possible values of X_i within this range are available, then it must be assumed that all possible values have the same probability, an assumption that corresponds to a uniform or square distribution of possible values. Then, the expected value x_i lies in the middle of the estimated range. The following relationship holds for the pertinent variation:

$$u^2(x_i) = (a_+ - a_-)^2 / 12 \qquad (A1)$$

In keeping with physical realities, values in the vicinity of the middle of the range often have a higher probability than values near the limits. This leads to the assumption of a symmetric trapezoidal distribution, with a base line of length a+ - a- (= 2a) and a top line of length 2aβ with $0 < \beta < 1$. For $\beta = 0$, a triangular distribution results. The following relationship holds for the pertinent variation:

$$u^2(x_i) = a^2 (1 + \beta^2) / 6$$

The estimated standard deviation u is thus calculated as the positive square root of u^2.

The standard deviation of approximated, normally distributed values can also be roughly estimated via the interdecile range (Sachs 1992). The following approximation holds:

$u \approx 0{,}39\ (DZ_9 - DZ_1)$, (A2)

where DZ_9 and DZ_1 stand for the 90th and 10th percentiles, respectively.

The IPCC guidelines recommend that the uncertainty be given via the 95% confidence interval, which can be approximated as double the value of the standard deviation. To obtain a relative error, one determines the share of 2u in the value X_i. Via multiplicative linking of various independent values that are subject to uncertainties, one can calculate the *combined standard deviation* as the positive square root of the sum of variations. This approximation holds, pursuant to IPCC-GPG (2000), as long as the relative standard deviation of any component does not exceed a value of 30 %.

$$u_{total} = \sqrt{u_1^2 + u_2^2 + ... + u_n^2} \qquad \text{(A3)}$$

Quantification of the uncertainties of emission factors for combustion systems

For derivation of emission factors, various sets of data, of varying extensiveness depending on pollutant and source category, are available for Germany; this data can be used as a basis for determining the pertinent uncertainties. The data is classified in keeping with the main groups defined for the report – large combustion systems, combustion systems under the TA Luft and gas turbines. First, the uncertainty of the relevant technology-specific factors is evaluated. Then, the uncertainty must be taken into account that results from aggregation of these factors for the various source categories used for the emissions calculation. Finally, the uncertainty resulting from extrapolation of the emission factors for 2000 and 2010 must be taken into account.

The relationships A1 and A2 above, for determination of the standard deviation and 2u, respectively, were reviewed via examples for which a comparatively large number of individual data items is available (30 – 70) and thus the standard deviation of the relevant random sample can be calculated.

Example: NO_X emissions from large combustion systems (lignite)

a) New German Länder

Random sample: n = 77;

DZ_1: 68.4 g/GJ; quartile 25%: 113.5 g/GJ; median: 134 g/GJ; mean value: 135.6 g/GJ;

quartile 75%: 154.5 g/GJ; DZ_9: 187.7 g/GJ;

Calculated standard deviation u = 45.3 g/GJ (relative error of 67.6 %)

Estimation of u pursuant to A1: 46.9 g/GJ (69.9 %)

Estimation of u pursuant to A2: 46.4 g/GJ (69.2 %)

b) Old German Länder

Random sample: n = 30;

DZ_1: 67.5 g/GJ; quartile 25%: 70.6 g/GJ; median: 74 g/GJ; mean value: 72.6 g/GJ;

quartile 75%: 75.9 g/GJ; DZ_9: 77.7 g/GJ;

Calculated standard deviation u = 6.1 g/GJ (relative error of 16.6 %)

Estimation of u pursuant to A1: 5.3 g/GJ (14.3 %)

Estimation of u pursuant to A2: 4 g/GJ (10.8 %)

The examples considered show that, especially for smaller random samples, estimation with A1 yields better agreement with the calculated standard deviation than does estimation with A2. The quantiles, the upper and lower limits, were set at 5 % and 95 %. With even smaller random samples, conventional calculation methods produce larger standard deviations. Determination of emission factors, in contrast to determination of the correctness of measurements, involves assessing the robustness of results. In actual emissions calculation, some compensation can occur through simultaneous overestimation and underestimation within the totality of all sources. For example, in example a) the individual factors are widely scattered, while the higher emission factors account for smaller shares of the relevant activities. If the random sample is considered as a complete survey, then a factor of 119 g/GJ results for the observed emission, which corresponds to a 15 g/GJ deviation from the median.

The robustness of the emissions calculation can be characterised by noting that consideration of the entire range of factors is likely to lead to overestimation of the actual uncertainty. The upper and lower boundaries of the range are thus estimated with the upper and lower quartiles. In the case of a), this produces a relative error of 18 %. This also corresponds to the order of magnitude estimated, in other studies, for the uncertainty of NO_X emission factors from energy transformation.

To evaluate the uncertainty of the proposed emission factors, the upper (a_+) and lower (a_-) quartiles are determined, on the basis of the surveyed individual data, and then the standard deviation is estimated in accordance with equation (A1). Similarly, the relative uncertainty is calculated as $2u/X_i$. This procedure is used first to determine the uncertainties of the technology-specific factors. Then, these uncertainties are linked with the uncertainty resulting from aggregation to form source-category-specific factors.

In aggregation of technology-specific factors to form source-category-specific factors, the former are weighted and added in accordance with their relative contributions to the source-category structure. As a simplification, such weighting is also carried out in linking of the relative errors.

14.1.2.3 Methane emission factors in the research project RENTZ et al, 2002

The following Table 156 summarises the emission factors shown in Tables 3, 4 and 5 of Annex E of the research project RENTZ et al (2002):

Table 156: Methane emission factors for combustion systems < 50 MW thermal output and for gas turbines, pursuant to RENTZ et al, 2002

Facility type	Fuel	Federal *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

14.1.2.4 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. 4.1.3). Flue-gas desulphurisation systems have the task of converting sulphur dioxide in combustion gases, via chemical and physical processes, into substances that are less harmful. Limestone is commonly used as a reagent in flue-gas desulphurisation. Desulphurisation systems are tailored to the applicable requirements under immissions-control law and to the economic value of the resulting residual substances (plaster). The predominant process used in electricity generating plants is limestone scrubbing. 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. We improved the calculation steps for determination of the actual limestone-input quantities from these figures; then, we recalulated the limestone-input quantities for the years 1990 to 2006. 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 in 2007, we have used the 2006 plaster-production figure as a preliminary input figure. As a result of the new calculation, the CO_2 emissions differ slightly form the values reported in the NIR 2008.

Table 157: 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**		
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		

Source: Calculation, updated in 2008, on the basis of the "Limestone balance sheet" ("Kalksteinbilanz") project (UBA 2006, FKZ 20541217/02)

In the inventory, these CO_2 emissions were assigned to emissions from use of solid fuels, because such use is the reason for operation of the flue-gas desulphurisation systems and for the systems' CO_2 emissions. Pursuant to expert estimates of the group carrying out the

pertinent research, the uncertainty for limestone use and, thus, the uncertainty for related CO_2 emissions, is +/- 10 %.

14.1.3 Transport (1.A.3)

14.1.3.1 Transport – Civil aviation (1.A.3.a)

14.1.3.2 Derivation of activity rates for road transport (1.A.3.b)

14.1.3.2.1 Cross-check with 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 is shown in Table 158 below.

Table 158: Energy balances, 1990-2005

Year	Land (state)	Line	Petrol	Petroleum	Diesel fuel	Liquid gas	Biofuels
Energy consumption in road transports, pursuant to energy balances 1990-2004 (last revision: 08/2008), in TJ							
1990	ABL	75	1,159,942	0	657,443	138	0
1990	NBL	75	170,537	0	78,477	0	0
1991	ABL	75	1,156,589	0	700,405	137	0
1991	NBL	75	175,696	0	84,769	0	0
1992	ABL	75	1,157,939	0	740,248	229	0
1992	NBL	75	186,190	0	113,254	0	0
1993	ABL	75	1,158,636	473	777,146	184	0
1993	NBL	75	191,981	0	130,641	0	0
1994	ABL	75	1,082,653	559	787,800	184	0
1994	NBL	75	193,984	0	144,260	0	0
1995	D	62	1,299,982	610	964,013	138	1,504
1996	D	62	1,299,879	638	964,580	115	2,046
1997	D	62	1,297,487	357	979,586	106	3,652
1998	D	62	1,300,463	637	1,022,794	106	4,081
1999	D	62	1,300,602	637	1,097,036	100	5,370
2000	D	62	1,237,055	600	1,108,105	94	12,276
2001	D	62	1,199,318	600	1,097,416	98	16,740
2002	D	62	1,166,381	600	1,105,842	607	20,460
2003	D	62	1,108,989	600	1,078,352	694	30,132
2004	D	62	1,072,720	600	1,110,931	1,887	39,060
Preliminary figures pursuant to Mineralölzahlen 2007 (fossil; “2007 Petroleum Data”) and Amtliche Mineralöldaten 12/2007 (bio; “Official Petroleum Data 12/2007”)							
2005	D	62	991,518	600	1,073,067	2,357	73,586
2006	D	62	929,086	600	1,077,729	4,605	106,343
2007	D	62	889,901	600	1,073,056	7,058	165,574
Sources: Evaluation tables of the energy balances,"Mineralöl-Zahlen 2007" ("2007 Petroleum Data") of the Association of the German Petroleum Industry (MWV) (MWV, 2008) and "Amtliche Mineralöldaten" ("Official Petroleum Data").							

The Energy Balance is also used to model transport-quantity structures in TREMOD. For example, the German Economic Institute (DIW) carries out a fuel-consumption calculation in order to derive total mileage travelled (DIW, 2002). Some of the results of the calculation, for

automobile transports, are entered into TREMOD. The DIW uses a fuel-consumption calculation in order to determine total domestic mileage; TREMOD uses some other sources and assumptions to estimate total domestic mileage – especially for goods transports (cf. the detailed description in IFEU, 2002). This estimate also takes the basic figures of the Energy Balance into account.

On the other hand, due to the many dependencies and uncertainties in the model, and to the basic data that must be taken into account, no feasible means is available for comparing mileage and energy consumption, for each year and each vehicle layer, in such a manner that the results yield the Energy Balance sum and the mileage and 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 159).

Table 159: Net calorific values for petrol and diesel fuel

Year	Petrol	Diesel fuel
1990-1992	43,543 MJ/kg	42,704 MJ/kg
since 1993	43,543 MJ/kg	42,960 MJ/kg

Source: Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen)

The correction factors are derived in TREMOD separately for the various vehicle categories, as follows:

- Firstly, a correction factor for petrol is derived from the calculated petrol consumption for all vehicle categories and from petrol sales pursuant to the Energy Balance.
- The correction factor for petrol is then also used to bring fuel consumption of vehicles with diesel engines, among automobiles and other vehicles ≤ 3.5 t (light duty vehicles (LNF), and of motor homes and motorcycles (MZR)), in line with the Energy Balance.
- The difference between the corrected diesel-fuel consumption of automobiles and of other vehicles ≤ 3.5 t and the Energy Balance is then allocated to heavy duty vehicles and busses.
- The correction factor for heavy duty vehicles and busses is then calculated from their energy consumption, as calculated in accordance with the domestic principle, and the pertinent difference, as calculated for this group, from the Energy Balance.

Table 160 below summarises the correction factors used.

Table 160: Correction factors for adjustment to the Energy Balance

Year	Land (state)	**Petrol** (including bioethanol)	**Diesel fuel** (including biodiesel)	
		Automobiles, light duty vehicles, motorcycles	**Autos, light duty vehicles**	**Heavy duty vehicles, busses**
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	0.985	1.201
1996	D	0.988	0.990	1.181
1997	D	0.990	0.994	1.183
1998	D	0.988	0.992	1.244
1999	D	0.996	1.001	1.303
2000	D	0.971	0.982	1.325
2001	D	0.964	0.978	1.235
2002	D	0.962	0.980	1.184
2003	D	0.952	0.979	1.107
2004	D	0.969	1.001	1.038
2005	D	0.966	1.019	0.980
2006	D	0.952	1.019	0.924
2007	D	0.953	1.074	0.853

Remark: 1994 correction factors for old German Länder (ABL) and new German Länder (NBL) as for Germany (D) as a whole

14.1.3.2.2 Allocation of biofuels, petroleum and LP gas to the structural elements

The Energy Balance lists data for biofuels, petroleum and LP gas for the transport sector. 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).

14.1.3.2.3 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 for the Energy Balance are used.

14.1.3.3 Derivation of emission factors

14.1.3.3.1 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 159) 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).

14.1.3.3.2 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 161: Emission factors for automobiles that run on LP gas

Gas	Type of vehicle	Structural element	EB line	Units	1995-2007
CH_4	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	3
CO	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	350
CO_2	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	65,000.00
N_2O	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	1.7
NH_3	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	0.5
NMVOC	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	157
NO_X	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	975
SO_2	PKW	SV PKWO KOIO	EBZ 62	kg/TJ	1.7

14.1.3.4 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:
- The emission factors for old and new German Länder are set, for all structural elements, to the relevant values for all of Germany in 1994.
- The structural elements' percentage shares of the activity rates, for each fuel, are considered to be the same in each case for the old and new German Länder, and they are the same as the relevant values for all of Germany in 1994.

With these assumptions, the aforementioned conditions are fulfilled. A third condition is not fulfilled, however: the plausibility of emissions results in the time series, in each case, for the old/new German Länder.

14.2 Other detailed methodological descriptions for the source category "Industrial processes" (2)

14.2.1 Mineral products (2.A)

14.2.2 Chemical industry (2.B)

14.2.3 Metal production (2.C)

14.2.4 Other production (2.D)

14.2.4.1 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.

14.2.4.1.1 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 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; same source as the aforementioned)

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; same source as the aforementioned).

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; same source as the aforementioned)

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. This 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 fibres

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.

14.2.4.1.2 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 13.

14.3 Other detailed methodological descriptions for the source category "Solvents and other product use" (3)

14.4 Other detailed methodological descriptions for the source category "Agriculture" (4)

14.5 Other detailed methodological descriptions for the source/sink category "Land-use change and forestry" (5)

14.5.1 Land use changes and forestry (5.A)

The C stocks in forest biomass, and their changes, were derived, for the first time, for the 1990-2003 greenhouse-gas inventory, under commission to the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), by the Biometry and Information Science department of Baden-Württemberg's Institute for Forestry Experimentation and Research (Forstliche Versuchs- und Forschungsanstalt (FVA), from Federal Forest Inventory data and in keeping with the provisions of the Good Practice Guidance relative to Land-Use, Land-Use Change and Forestry (GPG-LULUCF, IPCC, 2003). Those data have been extrapolated for the present inventory by the Institute for Forest Ecology and Forest Surveys, of the Federal Research Centre for Forestry and Forest Products (Bundesforschungsanstalt für Forst- und Holzwirtschaft; now part of the Johann Heinrich von Thünen Institute, Federal Research Institute of Rural Areas, Forestry and Fisheries (vTI)).

The C-stock changes in dead wood, debris and forest soils, and the other greenhouse-gas emissions from forests and forest conversion, were not estimated, since complete relevant data and evaluations are not yet available. The provisional assessments made in this regard have been made by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV).

14.5.1.1 Forest

The basis for reporting consists of the definition of "forest" used by the Federal Forest Inventory (Bundeswaldinventur - BWI)[80].

The BWI's survey instructions differentiate between the following sub-categories of forest:

- Productive forest, wooded ground
- Unproductive forest, wooded ground
- Forest, opening
- Forest, non-wooded ground

In calculations for greenhouse-gas inventories, the categories **unproductive forest** and **openings** were included with forest, while **non-wooded ground**, in keeping with the

[80] **Forest** within the meaning of the FFI is any area of ground covered by forest vegetation, irrespective of the information in the 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. Watercourses up to 5 m wide do not break the continuity of a forest area. The cultivation of Christmas trees and ornamental brushwood in the forest is forest within the meaning of the Federal Forest Inventory (BWI). Areas with forest cover in open pasture land or in built-up areas of less than 1000 m²; coppices less than 10 m wide; cultivations of Christmas trees and ornamental brushwood; and parkland attached to country houses are **not forest** within the meaning of the FFI.

definition of "forest" used in decision 11/CP.7 of the 7th Conference of the Parties in Marrakesh (UNFCCC, 2002: p. 58) was excluded, as non-forest.

Unproductive forest areas are fields of dwarf pines and green alders, areas of shrubs (but not openings) and other forest areas which are sparsely covered or which have low productivity (≤1 m³ average total growth (dGZ)/hectare).

The **wooded-ground area** is that part of the forest that is covered with trees used in forestry and that is used for wood production.

Non-wooded ground includes forest tracks, rides and firebreaks over 5 m wide, landings, tree nurseries, seed and plant nurseries, wood-pastures and fields for game, the areas of yards and buildings used for forestry purposes, recreational facilities linked to the forest and rocks, boulders, gravel and water located in the forest. In addition, if they are not overgrown, swamps and moors located in the forest fall under “non-wooded ground”.

In the GPG-LULUCF (IPCC, 2003), and in the official reporting tables for the greenhouse-gas inventories sent to the Climate Secretariat (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). Pursuant to IPCC GPG-LULUCF (2003), new forest remains for at least 20 years within this category, after which it is transferred to the "remaining forest land" category[81].

In Germany, with existing data, new forest additions in the old German Länder can be traced only back to 1987; for the new German Länder, it has been possible only to derive the net new forest since 1993.

14.5.1.1.1 Forest Land remaining Forest Land

14.5.1.1.1.1 Source-category description

14.5.1.1.1.1.1 Changes in biomass

For the old German Länder, data is available from two federal forest inventories (key dates: 1 October 1987 and 1 October 2002). Between the two forest inventories, C stocks in forests of the old German Länder underwent a net increase of 1.52 Mg/ha/a. 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) was compared with forest-establishment data, given the lack of an initial inventory comparable to BWI I. The comparison showed a marked net C-stock increase of 3.01 MgC/ha/a.

The forest-establishment data is not completely suited for comparison with the Federal Forest Inventory (BWI). It seems clear that the forest-establishment data underestimates stocks. If the initial value for total stocks is assumed to be 10 % higher (and evenly distributed among all tree species), a marked net C-stock increase of 2.32 MgC/ha/a results.

Overall, the forests of the Federal Republic of Germany are thus a net sink for C.

[81] Countries may opt for new forest to remain longer in this category if that seems suitable in light of the time required, as a result of the relevant local conditions, for "typical" forest relationships, with respect to carbon stocks and their changes, to become established in all compartments, including soil.

14.5.1.1.1.1.2 Dead wood, debris and soils

The deadwood stocks of 11.5 m^3/ha found by the BWI II correspond to C stocks of some 2.6 Mg C /ha. Federal Forest Inventory I (BWI I) did not collect data on dead wood, and thus no conclusions can be drawn regarding changes in stocks.

On the whole, more dead wood is now left in forests than was left in the 1950s to 1980s. The reasons for this include changes in demand in the wood market, changes in wood-harvesting methods and an interest in protecting forest biotopes. Storm damage in 1990 and 1999 sharply increased dead wood stocks in some regions. For this reason, it may be assumed that dead wood stocks tended to increase, rather than decrease, between 1990 and 2002.

The inventories did not include a complete survey of debris. Finer debris fractions are part of the humus layer, which was surveyed by the forest-soil-condition survey (BZE).

The BZE estimated the carbon stocks in the humus layer, and in the first 30 cm of mineral soil lying beneath the humus layer, as amounting to about 0.858 Pg C. No conclusions can be drawn regarding changes in stocks, since a subsequent inventory remains to be carried out.

For purposes of greenhouse-gas inventories, therefore, changes in dead wood, debris and soil were neglected, in keeping with the Tier 1 assumption that such stocks do not change in existing forests.

14.5.1.1.1.1.3 Other greenhouse-gas emissions from forests

Figures for CO_2 emissions from liming of forest floors are provided in category 5.G (Other). They range between 130 and 210 Gg CO_2 per year, and are tending to decrease.

BUTTERBACH-BAHL (2003), using the PnET-N-DNDC model, estimated total nitrous oxide (N_2O) emissions from forest soils for the years 1990-1999 as amounting to about 14 Gg per year. This includes the effects of considerable nitrogen discharges from deposition of nitrogen compounds, which come from emissions of industry, and from the energy, residential, transport and agriculture sectors.

These "indirect" N_2O emissions, which must be assigned to sources outside of the forestry sector, are outside the scope of greenhouse-gas inventories in the area of land-use changes and forestry, however. Reporting in this area includes only N_2O emissions from nitrogen fertilisation of forest soils and from drainage of forest soils.

Forests in Germany are not normally given nitrogen fertilisers. In CRF Table 5(I), therefore, this activity has been marked "NO".

In the 19th and early 20th centuries, many wet locations were drained and afforested, and forested wet locations were "ameliorated", via drainage, in order to increase yields. Some of the drainage ditches from that era are still present in today's forests. In addition, in the second half of the 20th century, areas were afforested that had previously been drained as a means of obtaining or enhancing agricultural land. There is a lack of reliable data for reporting on this category, however (CRF 5(II)).

N_2O, CH_4, NO_x, CO and other gases are released in forest fires and in controlled burning of biomass (for example, in burning-off of logged areas following wood harvesting).

The areas in which forest fires occur in Germany are small and, since surveys commenced, have decreased markedly as a result of improved forest-fire prevention and response. Only in 2003, a year with months of continuing dryness and extreme heat, did they increase again.

Table 162: Forest-fire burn areas

1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
[ha]												
3,267	1,493	1,114	592	1,381	599	397	415	581	122	122	1,315	274

Forest-fire statistics (BML 1992 ff., Part G., Table “Waldbrände und ihre Ursachen” ("Forest fires and their causes")) unfortunately include no data on the amounts of biomass effectively burned; such data would at least support rough estimates, within the meaning of a "Tier 1" approach, of the relevant amounts of gases released. In light of the small size of the areas in question, this source is considered negligible, and "NO" has been entered in Table 5 (V) "Biomass burning" next to N_2O and CH_4.

This also applies to controlled burning of biomass. Burning-off of vegetated areas is prohibited in Germany. Burning of unusable crown parts and branches is carried out in exceptional cases, in combatting of bark beetles. Increasingly, other methods (chopping, crushing) are also being used for this purpose.

As a result of use of the "stock-change method" (cf. Chapter 7.1.1.2.3), CO_2 from biomass combustion has already been taken into account in changes of biomass stocks; the entry for this category is thus "IE".

14.5.1.1.1.2 Methodological issues

14.5.1.1.1.2.1 Data sources

The basis for the biomass and area calculations consists of the data from the two Federal Forest Inventories. Pursuant to provisions of the IPCC GPG-LULUCF (2003), this data is processed in keeping with requirements pertaining to international reporting obligations.

The Federal Forest Inventory is a terrestrial random-sampling inventory with permanently marked sampling points. Data collection is carried out at the corners of about 44,000 quadratic plots, with side lengths of 150 m, that are distributed systematically throughout the entire country. As in the first Federal Forest Inventory, random sampling is distributed in a 4 x 4 km basic grid whose resolution may be increased, at Länder request, on a regional basis. A double random-sampling density is used in parts of Bavaria, Lower Saxony and Thuringia, and a quadruple sampling density is used in the Länder Baden-Württemberg, Mecklenburg-West Pomerania, Schleswig-Holstein and Rhineland-Palatinate[82].

The first Federal Forest Inventory, BWI I, covered only the territory of the Federal Republic of Germany in its pre-1990 boundaries and West Berlin. For the new German Länder, therefore, forest-establishment data has to be taken from another source – the publication "The Forest in the New German Länder" ("Der Wald in den neuen Bundesländern" (BML, 1994)).

Due to the differences in the data situations for the two areas, and to the resulting need to use different calculation methods, reporting in the CRF tables is broken down by old and new German Länder.

[82] Further information: http://www.bundeswaldinventur.de

The Federal Forest Inventory II (BWI II) took a first accounting of dead wood, and thus no information can yet be provided regarding changes in dead-wood stocks. The dead-wood stocks of 11.5 m^3/ha found by the BWI II correspond to C stocks of some 2.6 Mg C /ha.

The first soil condition survey, which was carried out from 1987 to 1993 (BMELF, 1997), supports estimates of carbon stocks in humus layers and mineral soils; it does not support estimates regarding changes in such stocks, however. These carbon stocks (humus layer and the first 30 cm of mineral soil) were estimated at about 0.858 Pg C (BMELF, 1997).

Data on liming of forest soils was derived from fertiliser statistics (Düngemittelstatistik) (DESTATIS, Fachserie 4, Reihe 8.2). Until 1992/93, the results published by the Federal Statistical Office referred to the territorial status of the former Federal Republic of Germany. For the territory of the former GDR, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) adapted data for the years 1950 to 1989, based on GDR statistics, to the fertiliser-statistics categories of the Federal Republic of Germany, to facilitate comparison. Due to a lack of relevant surveys, data on fertiliser consumption in the former GDR during the years 1990-1992 was extrapolated linearly. From 1993/94 onwards, the results have been collected and published for unified Germany.

Since 1992, data on areas on which forest fires have occurred is available in official forest-fire statistics pursuant to Council Regulation (EEC) No. 2158/92 of 23 July 1992 on protection of the Community's forests against fire.

14.5.1.1.1.2.2 Forest land remaining as forest land

Forest-area data is not required for calculation of biomass stocks pursuant to the stock-change method, but it must be reported in the CRF. The area data for individual years is based on linear interpolation.

For the old German Länder, such data can be derived from the results of the two Federal Forest Inventories. In that region, the total forest area (not including non-wooded ground) increased by 54.12 kha, to 7,693.72 kha. Pursuant to IPCC GPG-LULUCF (2003), new forest must be classified as "new forest" for a period of 20 years, and thus each year the category "forest land remaining forest land" is reduced by that forest area converted to other land uses. As a result, the category "forest land remaining forest land" decreased from 7,626.14 kha (1990) to 7,572.27 kha (2002).

The only recourse with regard to the new German Länder, therefore, is to compare BWI II data and forest-establishment data from the publication "The Forest in the New German Länder" ("Der Wald in den neuen Bundesländern" (BML, 1994)).

According to forest-establishment data, in the new German Länder, the forest area (not including non-wooded ground) in 1993 amounted to 2,852.5 kha; by BWI II it had increased to 3,027 kha. As a result, the first of these values can be assigned to the category "forest land remaining forest land".

14.5.1.1.1.2.3 Derivation of stock changes pursuant to 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 I) and some 377,000 trees in key year 2002 (BWI II) – 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). For use of the "stock-change method", the categories "standing-timber volume", "branch wood volume" and "root mass" were separated. Above-ground volumes were converted into masses using specific volume densities for the various tree species in question. The basic equation (Equation 23 and Equation 24) for C-stock determination via the stock-change method was thus converted into the form of Equation 25. The first part of Equation 25 (standing timber, branch wood) was applied to each tree, while the second part was applied to stands. The total value was then extrapolated from the stand values.

Equation 23:

$$\Delta C = \left(C_{t_2} - C_{t_1}\right) / \left(t_2 - t_1\right)$$

Equation 24:

$$C = \left[V \bullet D \bullet BEF\right] \bullet \left(1 + R\right) \bullet CF$$

Equation 25:

$$C = \underbrace{[V \bullet D_D}_{\text{standing timber}} + \underbrace{V \bullet D_A \bullet (VEF - 1)]}_{\text{branch wood}} \bullet \underbrace{(1 + R)}_{\text{root wood}} \bullet CF$$

where:

C = carbon stock
V = standing-timber volume
D_D = basic density of standing timber
D_A = basic density of branches
BEF = biomass-expansion factor
VEF = volume-expansion factor[83]
R = root / sprout relationship
CF = carbon content

14.5.1.1.1.2.4 Procedure

For central European conditions, there are no generally valid biomass functions that could have been applied 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, existing biomass studies comprise only small numbers of random samples, and they represent only local growth and site conditions, along with relevant variations in management. Use of such data would distort extrapolations.

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 above-ground standing-timber volume and the above-

[83] 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".

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.[84]

In a next step, the trees' above-ground mass was calculated from tree wood volume, via volume density data. A range of different volume density figures were used. Among these are the volume densities of KNIGGE & SCHULZ (1966), as they are used, for example, by BURSCHEL et al. (1993). Other wood-science handbooks, such as BOSSHARD (1984), use density figures of KOLLMANN (1982). The default values pursuant to IPCC (2003) also provide volume densities for many native tree species. Since densities have a direct influence on total carbon stocks, 3 different density extrapolations were used for the individual-tree calculations.

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. Such separation was carried out for densities pursuant to KOLLMANN (1982) and IPCC GPG-LULUCF (2003). In the third extrapolation, the procedure pursuant to BURSCHEL et al. (1993) was methodically applied, with constant volume densities, to above-ground volumes, in order to permit comparison with other scenarios.

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. This value was then used to derive root biomass. Root masses were calculated with the help of two sources (DIETER & ELSASSER, 2002; IPCC, 2003). Overall, three extrapolations for above-ground C stocks, and 6 calculations of underground C stocks, are thus available. In addition, results for spruce can be compared with the general biomass function of WIRTH et al. 2004b. The various calculations may be seen as scenarios that approximate the actual circumstances and that can reveal the range of deviations and their sensitivity.

For the new German Länder, forest-establishment data is available in aggregated form. 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 C-stock determination.

14.5.1.1.1.2.5 Total stocks of remaining forest land

The results described here refer, in connection with individual-tree calculations for BWI I and BWI II, to volume densities pursuant to KOLLMANN (1982), whereas branch volumes, with their greater densities, were extrapolated pursuant to HAKKILA (1972). Above-ground tree volume was estimated with the function coefficients given in Table 166. Root biomass was calculated using default values from IPCC GPG-LULUCF (2003). In the extrapolation for the new German Länder for 1993, the biomass-expansion factors (BEF) of BURSCHEL et al. (1993) were separated into above-ground and below-ground components, and the upper branch volume was estimated from the difference between above-ground volume and standing-timber volume. In the interest of comparability between the extrapolation of forest-

[84] Since the regressions describe the relationship between rounded table values, the actual variation is not taken account of, and no true prediction error can be given. Such an error could be given if the original data were available as a base for calculating new tree wood-volume functions.

establishment data and individual-tree calculation pursuant to BWI, the same volume densities were used throughout this process.

Table 163: Total C stocks, remaining forest

Gg C		1987 (BWI I)	1993 (BML)	2002 (BWI II)
Old German Länder	below-ground	174,670	-	212,849
	above ground	604,474	-	740,481
	Total	**779,144 (± 8%)**	**-**	**953,330 (± 7.55%)**
New German Länder	below-ground	-	34,723	63,690
	above ground	-	161,766	218,667
	Total	**-**	**196,489 (±12.71 %)**	**282,357 (± 10.02 %)**

14.5.1.1.1.2.6 Total stocks in various scenarios

The scenario calculations were carried out only for the individual-tree calculations. The error bar shows the simple standard deviation. For determination of the 95% confidence interval, this range must be doubled. The bars on the left in each approximately correspond to the values in Table 163, since in these cases the entire forest area (not including non-wooded ground) was considered. The abbreviations are to be understood as follows: the first refers to the assumptions for above-ground basic density (Table 164), while the second refers to the assumptions for below-ground basic density (Table 167, Table 168).

The last scenario in each case is also considerably below the other extrapolations. This is due to an underestimation of basic densities, since, pursuant to BURSCHEL et al. (1993), no separation was made between branch volume and standing-timber volume, which would lead to correspondingly higher basic densities for branches.

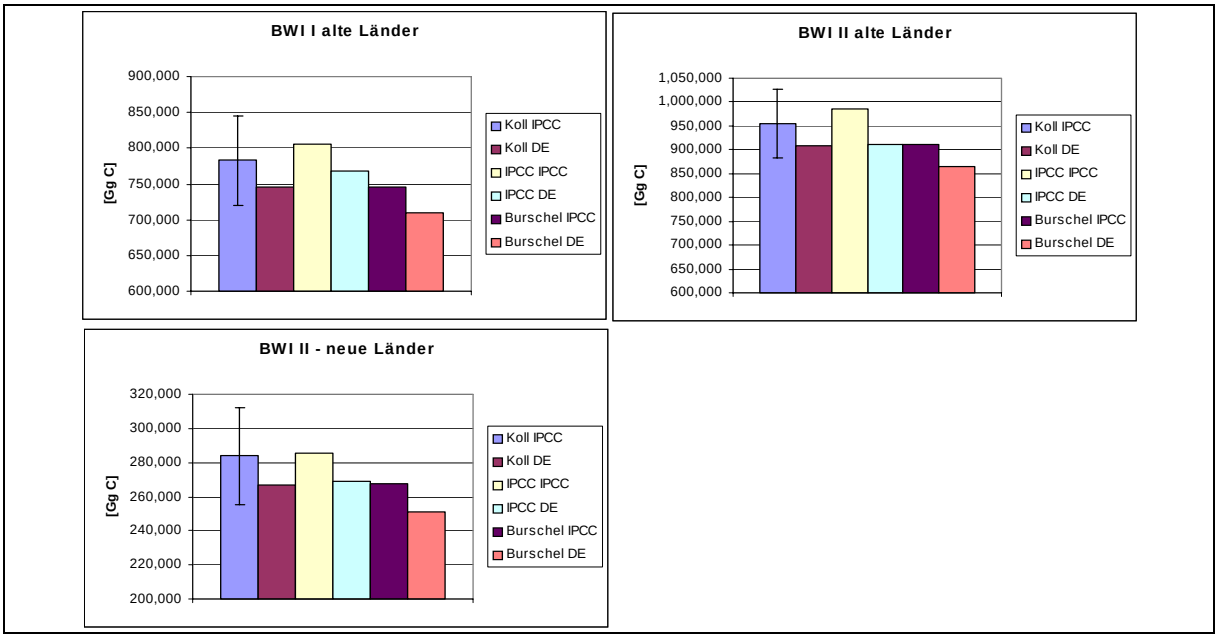


Figure 37: Total stocks in various scenarios [BWI = Federal Forest Inventory; alte Länder = old German Länder; neue Länder = new German Länder]

14.5.1.1.1.2.7 Basic density of trunk wood

In light of basic densities' strong influence on carbon balance, various basic densities (i.e. the relationship between dry weight and fresh-wood volume) were used. In two scenarios, the basic densities from KOLLMANN (1982) and IPCC GPG-LULUCF (2003) were used and linked with higher branch densities (see above).

The raw densities pursuant to KOLLMANN (1982: Annex, tables V) give the raw-density ranges and their average values for the most important tree species. These ranges were also used as a basis for error calculation. The basic densities were calculated from the raw densities, via relevant volume-loss measures.

Equation 26

$$R = r_0 * \left(1 - \frac{\beta_V}{100}\right)$$

where:

R = basic density (g/cm^3)
r_0 = raw density (g/cm^3)
$ß_V$ = volume-loss measure

For comparison, an extrapolation without this branch-wood correction, and with the basic densities used by BURSCHEL et al. (1993) from KNIGGE & SCHULZ (1966), was carried out. The resulting basic densities differ only between tree-species groups.

Table 164: Basic densities

		Basic density (R) [g/cm³]					
Genus	**Species**	**Stem (IPCC)**	**Branch (IPCC)**	**Stem (Kollmann)**	**Branch (Kollmann)**	**Knigge Schulz (Branch and stem)**	**β_v (%) (Kollmann)**
Picea	abies	0.40	0.54	0.3788	0.5093	0.3771	11.9
Picea	(other)	0.40	0.54	0.3788	0.5093	0.3771	11.9
Pinus	sylvestris	0.42	0.56	0.4307	0.5790	0.4307	12.1
Pinus	strobus	0.32	0.43	0.4307	0.5790	0.4307	12.1
Pinus	(other)	0.42	0.56	0.4307	0.5790	0.4307	12.1
Abies	alba	0.40	0.54	0.3629	0.4878	0.3700	11.5
Abies	(other)	0.40	0.54	0.3629	0.4878	0.3700	11.5
Pseudotsuga	menziesii	0.45	0.60	0.4141	0.5567	0.4124	11.9
Larix	decidua	0.46	0.62	0.4873	0.6551	0.4873	11.4
Larix	kaempferi	0.49	0.66	0.4873	0.6551	0.4873	11.4
Thuja	spec.	0.31	0.42	0.3788	0.5093	0.3771	11.9
Tsuga	spec.	0.42	0.56	0.3788	0.5093	0.3771	11.9
Nadelbäume	(other)	0.40	0.54	0.3788	0.5093	0.3771	11.9
Fagus	sylvatica	0.58	0.64	0.5583	0.6119	0.5543	17.9
Quercus	robur	0.58	0.62	0.5707	0.6056	0.5611	12.2
Quercus	petraea	0.58	0.62	0.5707	0.6056	0.5611	12.2
Fraxinus	exelsior	0.57	0.60	0.5642	0.5987	0.5642	13.2
Carpinus	betulus	0.63	0.69	0.6415	0.7031	0.5642	18.8
Acer	spec.	0.52	0.57	0.5222	0.5723	0.5642	11.5
Tilia	spec.	0.43	0.47	0.4170	0.4571	0.5642	12.1
Robinia	pseudoacacia	0.58	0.64	0.6468	0.7089	0.5642	11.5
Ulmus	spec.	0.51	0.54	0.5555	0.5895	0.5642	14.9
Castanea	sativa	0.48	0.51	0.5583	0.5924	0.5642	11.4
Betula	spec.	0.51	0.56	0.5264	0.5770	0.3768	13.2
Alnus	spec.	0.45	0.49	0.4283	0.4694	0.3768	17.9
Populus	spec.	0.35	0.38	0.3538	0.3878	0.3768	13.7
Salix	spec.	0.45	0.49	0.4618	0.5061	0.3768	13.7
Prunus	spec.	0.49	0.54	0.5583	0.6119	0.3768	12.6
Laubbäume	(other)	0.58	0.64	0.5583	0.6119	0.3768	13.7

14.5.1.1.1.2.8 Basic densities of branches

In keeping with Equation 25, other basic densities are used for branches. Due to the stresses it is subject to, branch wood is denser than trunk wood. Separation into various categories makes it possible to use different densities. The necessary data was derived by analogy to HAKKILA (1972), who divides trees by physiological groups – into conifers, ring-porous deciduous trees and diffuse-porous deciduous trees.

Table 165 shows average values for 8 conifers, 8 ring-porous deciduous trees and 4 diffuse-porous deciduous trees. A relationship for these physiological tree-species groups was derived, and the basic densities were correspondingly increased.

Table 165: Basic density of branches

	Stem wood [g/cm^3]	Branch wood [g/cm^3]	Relationship branch/stem density [ ]
Conifers	0.363	0.488	1.3444
Diffuse-porous deciduous trees	0.489	0.536	1.0961
Ring-porous deciduous trees	0.54	0.573	1.0611

14.5.1.1.1.2.9 Volume-expansion factors

For above-ground expansion, BURSCHEL et al. (1993) used the brushwood percentages of GRUNDNER & SCHWAPPACH (1952). They have the advantage of being generally valid for central European conditions and of representing a large number of sample trees. This extrapolation has often been criticised for being too coarse, since the brushwood percentages are shown in the tables only as aggregated values. What is more, WIRTH et al. (2004a) note that use of BEF (remark: this refers to volume-expansion factors, i.e. the relationship between standing-timber volume and total tree volume) pursuant to BURSCHEL et al. (1993) probably results in underestimation of biomass stocks, since the various categories (compartments) were not separated, and thus basic densities were not differentiated.

For this reason, a different approach was selected for these calculations. First, a compartment-oriented calculation was carried out, divided into three tree-part categories (standing timber, tree wood, root wood). In addition, in preparation of generally valid volume-expansion factors (VEF) for above-ground expansion, brushwood tables were not used; instead, data from the tables of GRUNDNER & SCHWAPPACH (1952), for standing timber and tree wood, was placed into a linear regression. These factors provide a functional relationship, as shown in the tables, between standing timber and tree wood. This relationship makes it possible to estimate tree wood from the size of standing timber, which itself depends on the measured values BHD, height and D7. In addition, the tables separate the tree species spruce, fir, beech and pine by age classes, since for these trees it was found that, for trunks with the same dimensions, older trunks are more completely woody than younger trunks; the older trunks have a greater wood volume. This separation was retained, since the tables are based on separate basic totalities.

First of all, various models were tested for predicting tree-wood volume from standing timber, models with varying terms for diameter and height. It emerged that the models could be improved somewhat via inclusion of diameter and height (as BHD^2*height) as predictors. Unfortunately, use of these models has shown that the Federal Forest Inventory (BWI) database includes trees that depart sharply from the normal allometry. This produced tree-wood volumes that were smaller than the corresponding standing-timber volumes. As a result of this implausibility, these models were not used; instead, models with simple linear regression were used. The relevant relationships are shown in the following Table 166:

Table 166: Above-ground-expansion functions

Model	a	b
Birch	0.017493	1.121933
Beech, age 61 to 100	0.008184	1.196184
Beech, age at least 101	0.030255	1.128104
Beech, age to 60	0.011942	1.207371
Oak	0.101879	1.051529
Alder	0.004825	1.068903
Spruce, age at least 61[1]	0	1.177947
Spruce, age to 60	0.036697	1.148143
Pine, age at least 81	0.036883	1.076103
Pine, age to 80	0.009946	1.156659
Fir, age to 80	0.019457	1.168262
Fir, age 81 to 120[85]	0	1.228069
Fir, age at least 121[85]	0	1.219492
Larch	0.063265	1.057712

Tree-wood volume = a + b * standing-timber volume

This leads to the following relationship for volume-expansion factors:

Equation 27

$$VEF = \frac{B}{D} = \frac{a + bD}{D}$$

where:

B = tree wood volume
D = standing-timber volume
VEF = volume-expansion factor

14.5.1.1.1.2.10 Root 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 stand values, the above-ground biomass, differentiated by tree-species groups, was extrapolated to the hectare level for each sampling point, and then the underground 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 28:

$$\sqrt{rb} = \beta * \sqrt{ab} + \delta_{treespecies} + \varepsilon$$

[85] Here, a negative constant was calculated; for this reason, the model was used without a constant.

where:

ab = above-ground biomass
rb = root biomass

It must be remembered that this derived function is oriented to stand values that always refer to one hectare.

Table 167: Root mass

Tree Species	β	δ	Degrees of freedom	Sig. level	r^2
Abies	0.4259	1.8114	266	**	0.8
Picea		1.169		**	
srb		0.691		**	
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 = 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 168: Root mass

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

Source: IPCC 2003

The following Figure 38 shows the R/S values for fir and spruce, along with the average R/S relationship pursuant to DIETER & ELSASSER 2002. In addition, the relevant values pursuant to IPCC GPG-LULUCF (2003: "Conifer Plantation") are included for comparison.

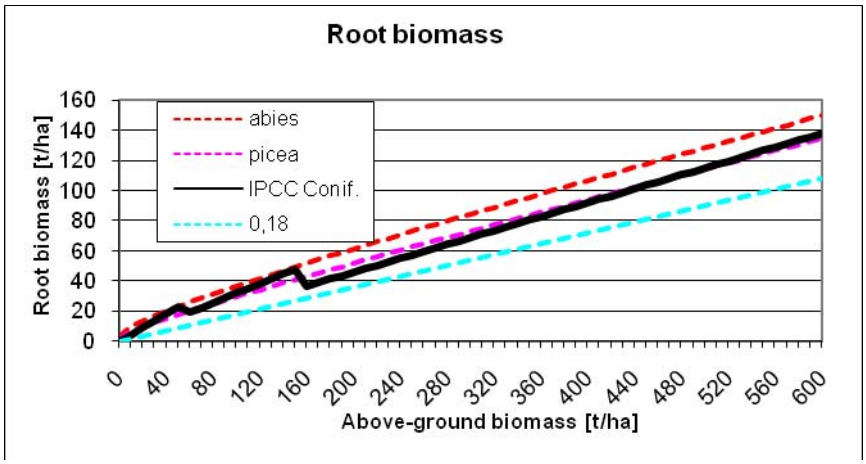


Figure 38: Root biomass

14.5.1.1.2 Derivation of CO_2 emissions from liming of forest soils

The data for liming was derived from the overall calculation for fertilisers. For this reason, sampling errors cannot be specified. Because companies have a statutory duty to supply information, the data collection is complete.

The data describes deliveries, by producers and importers, to wholesalers and end users. It does not provide direct information on the annual use of fertilisers in agriculture and forestry. Deviations from actual fertiliser use are possible

- due to changes in commercial stocks
- due to use of fertiliser outside of agriculture and forestry, e.g. on private land, gardens, sports facilities

The relevant emissions were derived using equation 3.3.6 from IPCC GPG-LULUCF (2003: p. 3.80).

14.5.1.1.2.1 Uncertainties

For the old German Länder, stratification was carried out in accordance with tree-species groups pursuant to BWI (ALH[86], ALN[87], beech, douglas fir, oak, spruce, pine, larch, fir). This is accomplished by estimating or calculating the relative standard deviation for each input item (standing-timber volume, volume density, above-ground biomass expansion, root biomass and carbon fraction). This relative standard deviation is then extrapolated using the extrapolation procedure in question – additive error propagation or multiplicative error propagation. The calculation does not take account of every possible error source (divergence of allometry, model errors in standing-timber calculation). For this reason, the assumptions below must always be seen as a way of approximating the actual error values. Where assumptions had to be made, they tended to be made carefully (with higher error).

As a result, the relative standard deviation for the total stocks was obtained. The 95% confidence interval for this estimate corresponds to double the relative standard deviation.

[86] ALH = all other deciduous trees with high life expectancies
[87] ALN = all other deciduous trees with low life expectancies

Equation 29

$$U_{tot} = \frac{\sqrt{\sum_i (U_i \bullet x_i)^2}}{\sum_i x_i}$$

where

Ui uncertainty in quantity i
xi quantity

For the new German Länder, C stocks can be calculated only as estimates, based on aggregated values; this is accomplished pursuant to the publication "The forest in the new German Länder" ("Der Wald in den neuen Bundesländern" (BML 1994)). The calculations continue to be carried out separately with respect to Federal Forest Inventory I (BWI I), BWI II new German Länder and BWI II old German Länder.

14.5.1.1.2.1.1 Uncertainties, standing-timber stocks

For the Federal Forest Inventory I (BWI I), random-sampling errors can be taken from the publication "Bundeswaldinventur" ("Federal Forest Inventory", BMELF 1990). The random-sampling errors for BWI II were taken (broken down by tree-species groups and German Länder) from the Internet[88]. For error extrapolation from the Länder level to the level new/old German Länder, error propagation by sums was used (Equation 29). The model errors cannot be calculated via estimation of standing timber, since relevant studies for this are lacking.

Table 169: Relative standard error, basic density

Tree species	Average raw density	min. raw density	max. raw density	Standard error, estimated	Rel. standard deviation
BU[89]	0.68	0.49	0.88	0.0929	13.66%
DGL	0.47	0.32	0.73	0.0976	20.77%
EI	0.65	0.39	0.93	0.1286	19.78%
LÄ	0.55	0.4	0.82	0.1000	18.18%
ES (ALH)	0.65	0.41	0.82	0.0976	15.02%
FI	0.43	0.3	0.64	0.0810	18.83%
KI	0.49	0.3	0.86	0.1333	27.21%
PA (ALN)	0.41	0.37	0.52	0.0357	8.71%
TA	0.41	0.32	0.71	0.0929	22.65%

14.5.1.1.2.1.2 Uncertainties, basic density

Wood basic 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 basic 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 basic density, since no relevant data is available. In this case, it was assumed that this error would not affect the basic-density range.

[88] http://www.bundeswaldinventur.de/testergebnisse/

[89] EI = oak, BU = beech, FI = spruce, TA = fir, DGL = douglas fir, KI = pine, LÄ = larch

Table 170: Relative standard error, basic density

Tree species	Average raw density	min. raw density	max. raw density	Standard error, estimated	Rel. standard deviation
BU[90]	0.68	0.49	0.88	0.0929	13.66%
DGL	0.47	0.32	0.73	0.0976	20.77%
EI	0.65	0.39	0.93	0.1286	19.78%
LÄ	0.55	0.4	0.82	0.1000	18.18%
ES (ALH)	0.65	0.41	0.82	0.0976	15.02%
FI	0.43	0.3	0.64	0.0810	18.83%
KI	0.49	0.3	0.86	0.1333	27.21%
PA (ALN)	0.41	0.37	0.52	0.0357	8.71%
TA	0.41	0.32	0.71	0.0929	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.

14.5.1.1.2.1.3 Uncertainties of volume expansion

The natural variability of above-ground allometry is not included here. 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 residues of the models is shown in the following Table 171:

Table 171: Relative standard error, VEF model

Model		Average (calculated tree wood)	s(residues)	Rel. standard error
Oak		4.688483	0.1921357	4.10%
Birch		0.6871404	0.007478048	1.09%
Alder		0.6902273	0.006260212	0.91%
Beech	**Age to 60**	0.3631021	0.01984793	5.47%
Beech	**Age 61 to 100**	1.253777	0.05095927	4.06%
Beech	**Age at least 101**	2.665235	0.06851797	2.57%
Spruce	**Age to 60**	0.4466276	0.05036626	11.28%
Spruce	**Age at least 61**	3.595929	0.1637905	4.55%
Pine	**Age to 80**	0.6035531	0.01861142	3.08%
Pine	**Age at least 81**	2.112509	0.06913789	3.27%
Fir	**Age to 80**	0.8898365	0.05534219	6.22%
Fir	**Age 81 to 121**	3.526363	0.2644826	7.50%
Fir	**Age at least 121**	6.980293	0.6241895	8.94%
Larch		3.209294	0.07115059	2.22%

Since the errors for a given tree species, with respect to age classes, can vary considerably, the errors from the extrapolation are amount-weighted with the stocks from BWI I and BWI II. The following values were thus determined:

[90] ES = ash, PA = poplar

Table 172: Errors for VEF model, tree-species groups

	BWI I RSE	BWI II, a.Bl. RSE	DS Waldfonds RSE	BWI II, new German Länder RSE
BU	3.55%	3.47%	3.40%	3.41%
ALH	4.22%	4.37%	4.55%	4.37%
ALN	5.01%	5.10%	5.01%	4.94%
FI	7.08%	7.16%	6.89%	7.06%
TA	7.32%	7.70%	6.91%	7.49%
DGL	9.63%	9.89%	10.01%	9.94%
KI	3.16%	3.18%	3.14%	3.14%

RSE = relative standard error

14.5.1.1.2.1.4 Uncertainties, root biomass and carbon content

The standard errors in root-biomass calculation can only be obtained from the tables pursuant to IPCC GPG-LULUCF (2003). Here as well, amount-weighted error extrapolation was carried out. To carry out error propagation by sums (IPCC, 2000: Equation 6.3), the sums of above-ground mass calculations were calculated for each stratification of the table; it was then possible to derive the total errors for conifers, oak, and other broadleaves.

The following values then resulted:

Table 173: Relative standard deviation, roots

	BWI I	BWI II
Conifers	25,34%	25,45%
Oaks	58,11%	59,17%
Broadleaves	19,34%	19,07%

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 %. WIRTH et al. (2004a) 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 0.5-0.56 gC/g in conifers. Overall, therefore, a mean C content of 0.5 gC/g, as a good assumption for average content, and with a relative standard error of ±2 %, seems appropriate.

14.5.1.1.2.1.5 Error estimation for the new German Länder, 1993

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 this error has had a systematic impact on extrapolation, a value of ±12.5 % may be assumed for tree-species groups.

The basic densities pursuant to BURSCHEL et al. (1993) exhibit no range; for this reason, the basic-density variations pursuant to Table 164 are used.

The biomass-expansion factors of BURSCHEL et al. (1993) were divided into above-ground and below-ground components. As an approximation for above-ground expansion, therefore,

the values from Table 172 can be accepted, with a small addition for aggregation in the brushwood-percentage class averages. Since the data situation for underground root percentages is unclear, as an approximation the standard errors of IPCC GPG-LULUCF (2003), as derived in 4.4, are used.

Following multiplicative error propagation

Equation 30

$$U_{tot} = \sqrt{\sum_i U_i^2}$$

for above-ground parts, and summing (Equation 29) of tree-species groups, the following overall values were derived:

Table 174: Error estimation, new German Länder, 1993

	RSE standing timber	RSE density	RSE VEF above-ground	RSE VEF aggr. (+ 1%)	above ground total RSE	below-ground total RSE	RSE above-ground + below-ground	RSE C content	RSE C calculation	RSE dead wood
Ei	12.50%	19.78%	4.10%	5.10%	23.95%	59.17%	22.35%	2.00%	22.44%	
Bu	12.50%	13.66%	3.40%	4.40%	18.76%	19.07%	15.79%	2.00%	15.92%	
Alh	12.50%	15.02%	4.55%	5.55%	19.91%	19.07%	16.80%	2.00%	16.92%	
Aln	12.50%	8.71%	5.01%	6.01%	15.97%	19.07%	13.65%	2.00%	13.80%	
Fl	12.50%	18.83%	6.89%	7.89%	23.40%	25.45%	19.38%	2.00%	19.48%	12.78%
Ta	12.50%	22.65%	6.91%	7.91%	26.45%	25.45%	22.28%	2.00%	22.37%	
Dgl	12.50%	20.77%	10.01%	11.01%	26.26%	25.45%	21.73%	2.00%	21.82%	
Ki	12.50%	27.21%	3.14%	4.14%	30.13%	25.45%	25.17%	2.00%	25.25%	
Lä	12.50%	18.18%	2.22%	3.22%	22.30%	25.45%	18.85%	2.00%	18.96%	

RSE = relative standard deviation

Many of these values are estimates and thus cannot be considered true errors.

14.5.1.1.2.1.6 Total error

For estimation of the total errors for BWI I, old German Länder, and BWI II, new and old German Länder, the values for the tree-species groups can be combined, for each individual calculation factor. For the above-ground error propagation (standing-timber volume, biomass expansion, density), the multiplicative error propagation can be calculated (Equation 30). Since calculated underground C stocks are added to the above-ground stocks, error propagation by sums must again be assumed (Equation 29). The same applies for the summation over all tree-species groups. The following Table 175 summarises the various individual rel. standard deviations:

Table 175: Error overview

BA		RSE Standing timber	RSE Density	RSE BEF	above ground RSE	below-ground RSE	RSE above-ground + below-ground	RSE C content	RSE pursuant to C calculation	RSE dead wood
BWI I old German Länder	Ei	2.50%	19.78%	4.10%	20.35%	58.11%	21.55%	2.00%	21.65%	
	Bu	2.00%	13.66%	3.55%	13.96%	19.34%	11.74%	2.00%	11.91%	
	Alh	3.10%	15.02%	4.22%	15.58%	19.34%	12.63%	2.00%	12.78%	
	Aln	3.30%	8.71%	5.01%	10.19%	19.34%	9.07%	2.00%	9.28%	
	Fl	1.40%	18.83%	7.08%	19.56%	25.34%	16.36%	2.00%	16.49%	8.16%
	Ta	3.30%	22.65%	7.32%	23.33%	25.34%	18.82%	2.00%	18.93%	
	Dgl	6.00%	20.77%	9.63%	23.26%	25.34%	18.70%	2.00%	18.81%	
	Ki	2.00%	27.21%	3.16%	27.38%	25.34%	21.92%	2.00%	22.02%	
	Lä	3.70%	18.18%	2.22%	18.69%	25.34%	15.43%	2.00%	15.56%	
new German Länder	Estimation, 1993									12.78%
BWI II old German Länder	Ei	2.24%	19.78%	4.10%	21.03%	59.17%	22.08%	2.00%	22.17%	
	Bu	1.96%	13.66%	3.47%	14.72%	19.07%	12.29%	2.00%	12.46%	
	Alh	2.61%	15.02%	4.37%	16.78%	19.07%	13.52%	2.00%	13.67%	
	Aln	2.94%	8.71%	5.10%	12.12%	19.07%	10.26%	2.00%	10.45%	
	Fl	1.59%	18.83%	7.16%	19.86%	25.45%	16.61%	2.00%	16.73%	7.70%
	Ta	3.76%	22.65%	7.70%	23.98%	25.45%	19.37%	2.00%	19.47%	
	Dgl	4.14%	20.77%	9.89%	24.76%	25.45%	20.00%	2.00%	20.10%	
	Ki	2.28%	27.21%	3.18%	27.79%	25.45%	22.29%	2.00%	22.38%	
	Lä	3.65%	18.18%	2.22%	20.05%	25.45%	16.41%	2.00%	16.53%	
BWI II new German Länder	Ei	4.31%	19.78%	4.10%	22.39%	59.17%	22.80%	2.00%	22.89%	
	Bu	4.23%	13.66%	3.41%	16.53%	19.07%	13.67%	2.00%	13.81%	
	Alh	4.85%	15.02%	4.37%	18.76%	19.07%	14.99%	2.00%	15.12%	
	Aln	3.84%	8.71%	4.94%	12.28%	19.07%	10.37%	2.00%	10.57%	
	Fl	3.48%	18.83%	7.06%	20.72%	25.45%	17.18%	2.00%	17.30%	10.08%
	Ta	40.40%	22.65%	7.49%	61.51%	25.45%	46.55%	2.00%	46.60%	
	Dgl	13.94%	20.77%	9.94%	26.80%	25.45%	21.48%	2.00%	21.57%	
	Ki	2.46%	27.21%	3.14%	31.37%	25.45%	25.14%	2.00%	25.22%	
	Lä	5.87%	18.18%	2.22%	20.49%	25.45%	16.83%	2.00%	16.95%	

14.5.1.1.2.2 Source-specific quality assurance / control and verification

The calculated data is based on ACCESS queries of Federal Forest Inventory data. With regard to the quality assurance developed for the Federal Forest Inventory, the reader's attention is called to the literature for the Federal Forest Inventory.

First, an estimate was carried out using the BURSCHEL et al. (1993) method, to provide an indication of the orders of magnitude of the extrapolation. This estimate, which is based on aggregated values (average stocks, by tree-species groups), was carried out by two different persons, using two different methods (published BWI results and ACCESS queries). The results obtained with the two methods agreed.

In the individual-tree calculations, a "Burschel" scenario (cf. Annex 0), using the same basic densities used for the estimate (using aggregated values), was calculated. The resulting values agreed with the calculations using the aggregated values. Consequently, it is clear that the ACCESS queries, in general, provide correct values; on the other hand, their results can deviate depending on what assumptions are made for volume densities and root-shoot ratios.

One systematic error persists, however: It was not possible to estimate rejuvenation below the standing-timber threshold, and the relevant figure is not found in the stock data, because the volume-expansion function is based on standing-timber volumes. The lack of rejuvenation stocks results in a systematic underestimation of total stocks.

14.5.1.1.2.3 Source-specific recalculations

The 2002 Federal Forest Inventory II provided new random-sample data. For the old German Länder, this was a repeat inventory using the same random-sample points. As a result, it was possible to derive, from its data, the C-stock changes for these countries, with the "stock-change method". For the new German Länder, this was possible only to a limited extent, since only forest-establishment data is available for that region for 1993.

In addition, for the first time the calculation took account of underground biomass as well as above-ground biomass (cf. methods 14.5.1.1.1.1.2).

The "stock-change method" was applied for the new and old German Länder, and linearly interpolated and extrapolated for the relevant period.

14.5.1.1.3 Land converted to Forest Land

14.5.1.1.3.1 Source-category description

Forest is created through succession, afforestation and reforestation; new forest areas begin storing C equivalents as soon as they are converted. In a rigorous approach, the C-stocks of previous land uses should be deducted. But no data is available on previous plant coverage (for example, individual trees, hedges or long-lived woody cultivations) and its biomass. Overall, such stocks are considered negligible, especially since the total area of new forest land is very small in comparison to the total forest area (old German Länder 2002: 121 kha to 7,694 kha).

14.5.1.1.3.2 Methodological issues

14.5.1.1.3.2.1 New forest land

Pursuant to IPCC GPG-LULUCF (2003), new forest lands must remain in the category "new forest lands" for 20 years. No land-use-change data that could support comparisons is available prior to BWI I. For the old German Länder, direct comparison between BWI I and BWI II makes it possible to separate new forest land and deforested land since 1987. The new forest lands occurring between BWI I (key year 1987) and BWI II (key year 2002), and amounting to 121.45 kha (not including the non-wooded ground) can be categorised as follows in keeping with their existing uses:

Table 176: New forest lands, old German Länder

Category	Area [kha]	Annual increase in area [kha/a]
Cropland and long-lived cultivations	30.57	2.04
Permanent grassland	45.46	3.03
Wetlands	15.67	1.04
Settled areas	29.75	1.98

For derivation of area figures for the various years in question, it was assumed that new forest land increased linearly between BWI I and II. In the CRF tables, these area increases are shown beginning with the key year for BWI I (1987).

When these areas are considered in comparison to the entire forest area of the old German Länder, 7693.72 kha, then the increases seem marginal – 1.58% over 15 years (both figures not including non-wooded ground).

For the new German Länder, only the net forest-land increase between 1993 and 2002 can be determined; it amounts to 174.56 kha. This difference is considered the new forest land. Its annual rate of increase is 17.46 kha/a; the data does not permit any allocation into outset categories. The area increases were assumed to progress linearly between 1993 and 2002.

14.5.1.1.3.2.2 Biomass stocks, new forest land

For the old German Länder, an individual-tree calculation was carried out for the new forest land (cf. 14.5.1.1.1.2.6). The distribution of stocks by outset categories (Table 177) is weighted by areas, however.

Table 177: Stocks, new forest lands, end of 2002

Outset category	Stocks [Gg C]
Cropland and long-lived cultivations	922
Permanent grassland	1,372
Wetlands	473
Settled areas	897

For the new German Länder, assumptions had to be made relative to these figures. The area increase was seen solely as a net increase; for this reason, area losses are not considered. The area increases were assumed to progress linearly between 1993 and 2002. The wood stocks on this area must be considered to be only stocks of the 1st age class (0-20 years, BWI II, new German Länder). For determination of the stocks on these areas, the standing-timber stocks of tree-species groups of the 1st age class were converted into C stocks. The average C stocks in the biomass of these areas, as of the end of 2002, was assumed – due to its young age – to be half of the average C stocks of the 1st age class. This produces a value of 18.01 t C/ha, or total stocks of 3,144 Gg C, for these areas at the end of the 2002 vegetation period.

The biomass stocks at the end of the 2002 vegetation period correspond to the biomass stock increases throughout the entire period under consideration since 1987 (old German Länder) and 1993 (new German Länder), as long as any possible previous plant cover is ignored. These stock increases were suitably weighted and then linearly interpolated, throughout the entire period under consideration, using the figures for new forest areas produced in the relevant report years.

14.5.1.1.3.2.3 Stocks in dead wood, debris and soils in new forest areas

In our latitudes, it takes decades for typical forests stocks to form in these compartments. The annual rates were considered negligible – also in light of the small size of the new forest area overall – and not taken into account in the greenhouse-gas inventory.

14.5.1.1.4 Forest Land converted to Other Land

14.5.1.1.4.1 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 C-stock losses from dead wood, debris and soil, and relevant emissions of other greenhouse gases, cannot be precisely determined. The CRF tables thus contain only the C losses from above-ground and underground biomass. 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 (2003). As a result, the area has increased in each report year.

In addition to biomass, C stocks in dead wood and debris, 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.

14.5.1.1.4.2 Methodological issues

14.5.1.1.4.2.1 Deforested areas

The total deforested area in the old German Länder (not including the non-wood floor) is about half as large (67.33 kha and 4.49 kha/a) as the new forest area. 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.

The corresponding figures for the new German Länder cannot be derived from the available data.

14.5.1.1.4.2.2 Stock losses on deforested areas

In the old German Länder, individual-tree-based extrapolation was carried out for this category (cf. 14.5.1.1.1.1.2). 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 4,035 Gg C were lost from biomass in this category. Applying linear interpolation, this corresponds to an annual loss of 269 Gg C. For the sake of simplicity, it was assumed that these C stocks are emitted into the atmosphere in the year in which they are converted.

As to C-stock losses from dead wood, debris and soil, only a first, very rough estimate, based on average stocks identified by the Federal Forest Inventory (BWI) and the soil-condition survey (BZE; BMELF 1997), can be provided. In this estimate, it was assumed that dead wood and the humus layer decompose completely, while about 30% of the C stocks in the uppermost 30 cm of the mineral soil are lost. The results are reported here as a memo item, but they have not been included in the CRF tables.

In light of the great variability, by area, of dead-wood, humus 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 178: Losses from dead wood, humus layer and soil upon deforestation

Category	Stocks [Mg C/ha]	Stock loss [Gg C]
Dead wood	2.6	11.7
Humus layer	18.0	80.8
Mineral soil (0-30 cm)	62.2	83.8
Total	**82.8**	**176.3**

Stock losses from deforestation cannot be calculated for the new German Länder.

14.5.2 Cropland, grassland, wetlands, settlements and other areas (5B/5C/5D/5E/5F)

14.5.2.1 Land-area distribution and allocation of usage categories

In recent years, a "wall-to-wall" approach has been developed for identification of land-use categories and land-use changes in Germany. This approach was used for the first time for the present report. 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. The data was processed with commercial GIS software (Arc-GIS, from the firm of ESRI), as well as with software we developed especially for this purpose. For the overall system, and its calculation processes, this approach ensures transparency, consistency, comparability and completeness.

14.5.2.1.1 Data sources and their adaptation

The following data sources were used for LULUCF reporting:

1.) Basic digital landscape model of ATKIS® (AdV)
2.) Administrative-boundaries database of ATKIS®
3.) CORINE LAND COVER (BMU)
4.) Digital soil map of Deutschland, 1:1.000.000 (BUEK 1000) (BGR 1997)
5.) Data from Federal Forest Inventories I and II (BMELV)
6.) Data from official German statistics (Federal Statistical Office):
    - Main soil-use survey (Bodennutzungshaupterhebung) 1991, 1999, 2003
    - Harvest survey, 1989 - 2005
    - Data from the district reform of 1998

For determination of emission factors

Soil:

- Literature

Biomass:

- Main soil-use survey (Bodennutzungshaupterhebung) 1991, 1999, 2003 (Federal Statistical Office)
- Harvest survey, 1989 – 2005 (Federal Statistical Office)
- Data from district reform of 1998 (Federal Statistical Office)
- Statistical Yearbook (Statistisches Jahrbuch) (BMVEL 2003, 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"), maintained by 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 included in the DLM, and the manner in which objects are to be formed, are defined in the ATKIS® object catalogue (Objektartenkatalog; ATKIS®-OK)" (AdV, http://www.adv-online.de/extdeu/broker.jsp?uMen=9db50769-dad3-19fa-6d78-79f08a07b51a). 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 (the aim is to achieve precision of ± 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 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

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.

14.5.2.1.2 Determination of land-use changes, and of 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). The ArcGis™ system from the firm of ESRI was used for this purpose. The necessary extensive GIS processing was controlled via scripts, of our own development, written in Visual Basic Script (VBS). They were coded with the help of the document "Writing Geoprocessing Scripts With ArcGis" (Writing_Geoprocessing_Scripts.pdf) from the firm of Esri. In some cases, Win32 programmes of our own development, and written in PowerBasic 8.3 (from the firm of PowerBasic Inc.), were also used. With this approach, all procedures for manipulating the relevant data records are transparent, consistent and comparable.

All pertinent processing made use of breakdowns by Germany's districts (439). This approach was necessary because currently available software and hardware systems (desktop PCs) are still unequal to the task of processing voluminous national GIS data.

Table 179: 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	4107/4108 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	4110/4120/4199 and attributes	331/332/333/334/335

Via a range of complex and involved calculations (time-intensive, and requiring extensive "number crunching"), it proved possible to allocate a year's worth of ATKIS® land-use data to the IPCC categories (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. Due to constraints of data availability, and of development and computing resources, the time periods 2000 – 2005 and 2005 – 2007 had to be processed in combined form. Plans now call for year-to-year calculations in future.

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).

14.5.2.1.3 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. A preliminary study, "organic soils", will remedy this situation in coming years 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®).

14.5.2.2 Determination of carbon stocks, and of their changes as a result of land-use changes

Data on spatial distribution of soil communities in Germany are 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) to 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 72 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 to a depth of 30 cm were added. 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 soil-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.

Since the data on forest-conversion areas were available only in aggregated form for Germany, average carbon stocks - averaged over all districts and soil types - were assumed for these soils.

14.5.2.3 Changes in carbon stocks in the soil and in biomass

14.5.2.3.1 Derivation of EF for mineral soil as a result of land-use changes

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 study, were compared to the relevant values for the overall study duration, in order to obtain annual loss percentages, as a function of study duration and total loss from, or additions to, the original stocks. The results are shown in Figure 39 and Figure 40.

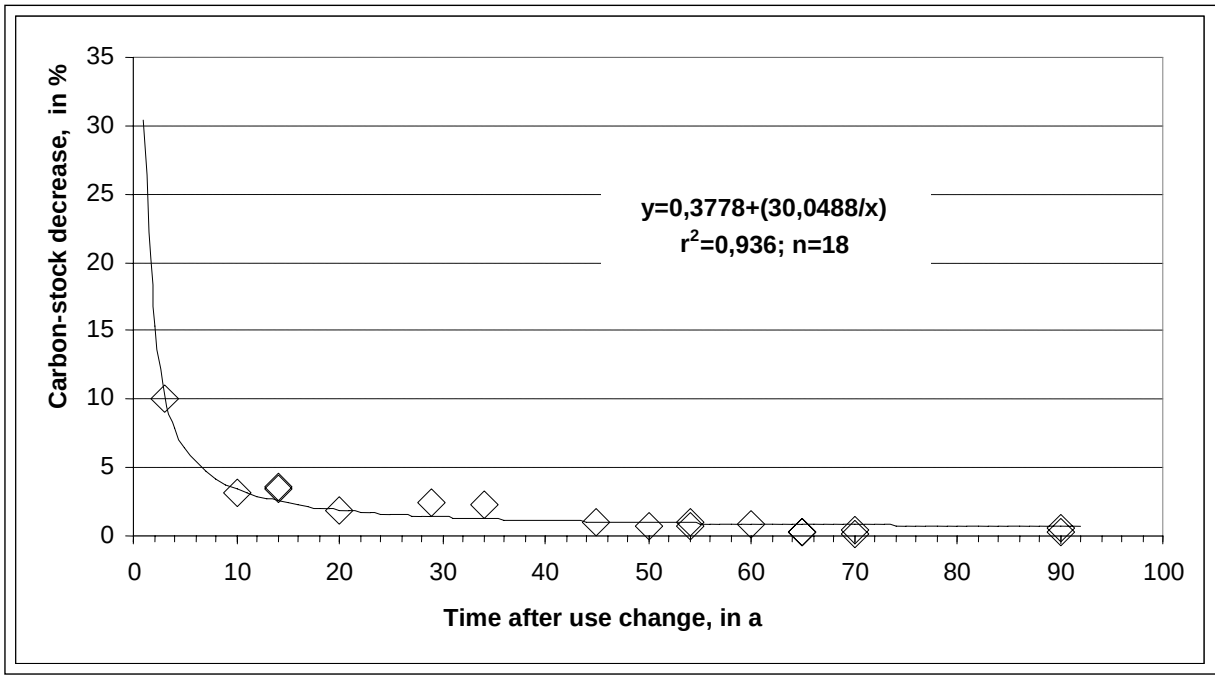


Figure 39: Relationship between annual percentage losses from outset carbon stocks and study duration following land-use changes (grassland, permanent cultivations, fallow land or forest to cropland (annual crops)).

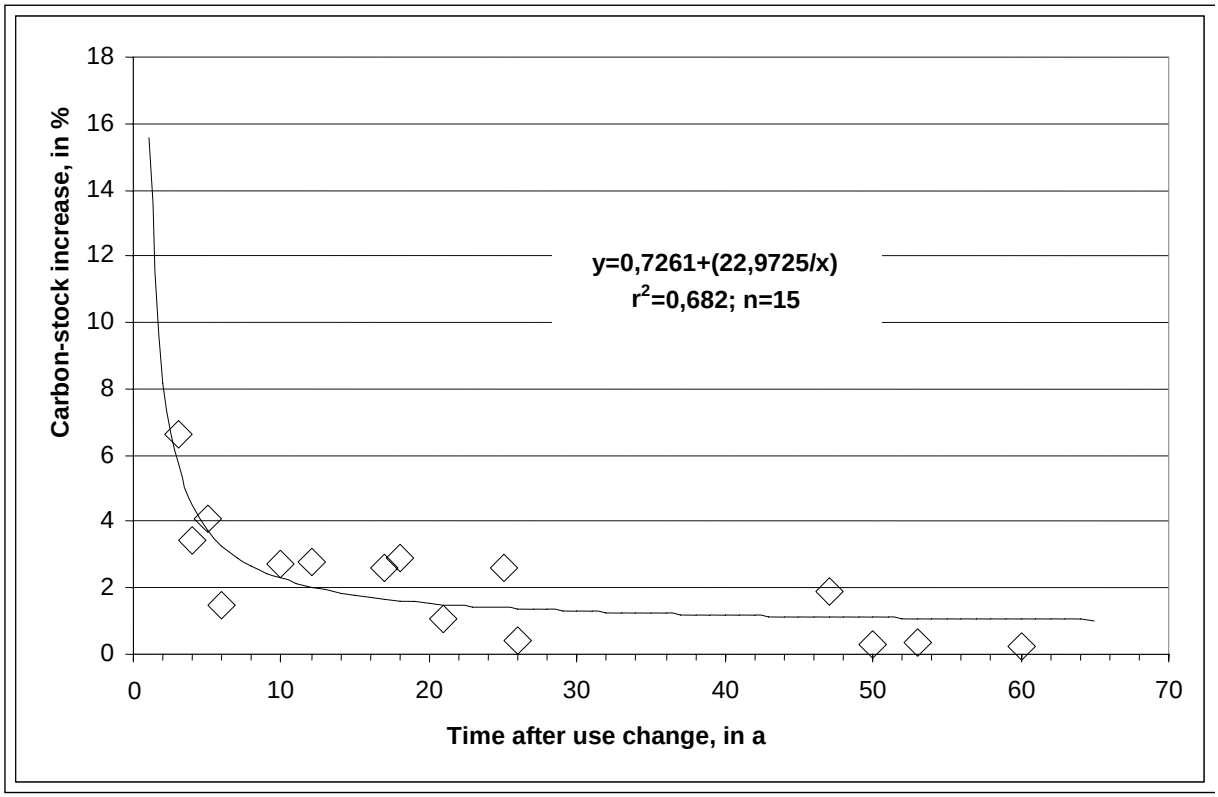


Figure 40: Relationship between annual percentage additions to outset carbon stocks and study duration following land-use changes (cropland (annual crops) to grassland, permanent cultivations, fallow land or forest).

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 14.5.2.6.1). Consequently, a general consideration indicates that the procedure chosen is actually the closer approximation to the real situation.

From the formulae shown in Figure 39 and Figure 40, 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 180 result:

Table 180: 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.: perannual

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.

14.5.2.3.2 Derivation of calculation figures (emission factors) for biomass

14.5.2.3.2.1 Forest, permanent cultivations, wetlands and groves within settled areas

Estimates of carbon stocks in forest biomass are based on the relevant average values for Germany as determined in the Federal Forest Inventory (Bundeswaldinventur); that value amounts to 121.13 t C/ha. For woody permanent cultivations (such as vineyards and orchards), and for groves 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.

14.5.2.3.2.2 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 and 2003 main surveys of soil use (Bodennutzungshaupterhebungen) and from harvest surveys for the period 1989 – 2005 (DESTATIS). 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). 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 181).

Table 181: 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.

14.5.2.4 Liming

The annual figures for liming were taken from official statistics (DESTATIS, Fachserie 4, Reihe 8.2). The methods by which they were obtained are described in DÄMMGEN et al. 2008. 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.

14.5.2.5 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.

14.5.2.6 Uncertainties

14.5.2.6.1 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). This leads to an inconsistency in results for the periods 1990-2000 and 2000-2007.

14.5.2.6.2 Area designations, carbon and nitrogen stocks of mineral soils

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). This 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 39 and Figure 40) 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 $\%_{*}a^{-1}$.

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 such formation and release.

14.5.2.6.3 Area designation, greenhouse-gas emissions from organic soils

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.

14.5.2.6.4 Area designation, carbon stocks in biomass

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 groves) – cannot

be determined until area-based data for the relevant biomass are available and country-specific emission factors for groves have been obtained.

14.5.2.7 Planned improvements

The following measures will be carried out in the coming years in the interest of improving the LULUCF inventory:

1. The reporting basis for the key source "organic soils" will be improved via the preliminary study "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")

- That project will generate 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 on an ongoing basis.

2. The emission factors for mineral soils will be improved via

- Evaluation of results for all German long-term soil-survey sites
- A national inventory of soil carbon on non-forest areas

The results of those studies will also be used for parametrisation and validation of pertinent mathematical models.

3. Determination of emission factors for biomass outside of forests. In a preliminary study, "methodical survey of biomass of woody perennials outside of forests" ("Methodische Erfassung der Biomasse mehrjährig verholzter Pflanzen außerhalb von Wäldern"), the carbon stocks in the biomass of fruit trees, vines and hedges will be determined, and emission factors for the plants in question will be derived.

4. 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")

5. Improvement of processing of ATKIS® data:

- Improvement of calculation algorithms
- Development of a standardised system for data storage and processing
- Minimisation of uncertainties, via norming of data records, and via replacement of imprecise VG250 data ("administrative boundaries 1:250,000)" with administrative boundaries derived from the Basis-DLM.

6. Improvement of reconstruction of land use and land-use changes for the years 1990 – 2000, by bringing CORINE data into line with ATKIS® data.

7. Improvement of activity data for settlement and transport areas, and derivation of emission factors for soils in those land-use categories.

14.6 Other detailed methodological descriptions for the source category "Waste and wastewater" (6)

14.6.1 Solid waste disposal on land (6.A)

14.6.1.1 Uncertainties for the source category "solid waste disposal on land"

The following uncertainties were estimated by the responsible Federal Environment Agency expert on 23 February 2004. The uncertainties must be considered provisional for the time being, since no national experience has yet been gained with the FOD method. In addition, an effort is being made to hold an experts' hearing that will adjust the estimated uncertainties as necessary, thereby placing them on a broader, more reliable basis.

	Definition of time series						Uncertainties data					
		Source description					Basisjahr 1990 [4]		2002			
lfd.-Nr.	CRF	for example, CSE module name or suitable aggregate within the listed CRF code [1]	If applicable, further source differentiation [2]	If applicable, CSE time series ID	Value type (EF / EM / AR)	If EF / EM: gas	Uncertainty [+/-%] [3]	Distribution type [5]	Uncertainty [+/-%] [3]	Distribution type [5]	Remarks on considerations, literature sources, etc.	Estimated by
1	6A1	Waste landfilling			MSW_T (x)							
2	6A1	Waste landfilling			MSW_F(x)		+/-5%	N	+/-2%	N	For 1990: low reliability in ABL, no data for NBL	
3	6A1	Waste landfilling			DOC(x)	CH_4	+/-20%	N	+/-20%	N	Reliable results from projects for study of raw waste in waste-incineration facilities are available	
4	6A1	Waste landfilling			DOC_F	CH_4	+/-30%	N	+/-30%	N		
5	6A1	Waste landfilling			MCF(x) (for MCF=1)	CH_4	+ 0% -10%	L	+0% -10%	L	Pursuant to IPCC-GPG	
6	6A1	Waste landfilling			F	CH_4	+10% -0%	L	+10% -0%	L		
7	6A1	Waste landfilling			k	CH_4	+50% -35%	L	+50% -35%	L		
8	6A1	Waste landfilling			R(t)	CH_4	+/-10%	N	+/-10%	N	Pursuant to IPCC-GPG, small by comparison to other uncertainties	
9	6A1	Waste landfilling			OX	CH_4	+50% -35%	L	+50% -35%	L	Corresponds to a half-life of 3.5 years (k = 0.23) to 8 years (k = 0.09)	

[1] If the CSE module name and CSE time-series ID are not available for estimation, or are too detailed, the sources may also be defined via CRF, and another unambiguous description, in the field "further source differentiation".
[2] Pursuant to CSE dimensions, if required for differentiation: e.g. fuel, 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)

14.6.2 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.

14.6.3 Determination of nitrous oxide emissions from wastewater treatment (6.B.2)

The remarks made in Chapter 14.6.3 of the NIR 2008 apply.

15 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 of that approach with the sectoral approach and relevant information on the national energy balance are found in Chapter 3.1.8.

16 ANNEX 5: ASSESSMENT OF COMPLETENESS, AND ASSESSMENT OF POTENTIALLY EXCLUDED SOURCES AND SINKS OF GREENHOUSE GAS EMISSIONS

The following two tables show the sources for greenhouse gases that have not been included in Germany's greenhouse-gas inventories to date. The tables also include explanations of the reasons for such omission. Thie table is a summary of CRF Table 9(a), which contains a more detailed overview of non-included sources and sinks.

Table 182: Overview, for completeness, of sources and sinks whose emissions are not estimated (NE)

Greenhouse gas	Source category	Explanation
Carbon	5.A.2 Land converted to Forest Land	Since in our latitudes it takes decades for typical forest stocks to develop in these categories, the annual increase was considered negligible and not taken into account in the greenhousegas inventory
Carbon	5.B.2 Land converted to Cropland	No estimations for Germany available.
Carbon	5.C.2 Land converted to Grassland	No estimations for Germany available.
Carbon	5.D.2 Land converted to Wetlands	No estimations for Germany available.
Carbon	5.E.2 Land converted to Settlements	No estimations for Germany available.
Carbon	5.F.2 Land converted to Other Land	No estimations for Germany available.
CH4	1.B.2.A.1 Exploration	no data available yet
CH4	1.B.2.A.6 Other	no data available yet
CH4	1.B.2.C.1 Venting	no data available yet
CH4	1.AA.2.E Food Processing, Beverages and Tobacco	No available data for 1A2e. If there were an input of gaseaus fuels in this industriel sector it is reported under 1A2f other (unspecified plants).
CH4	1.AA.3.B Road Transportation	There is no data available for use of natural gas in road transport.
CH4	1.AA.3.B Road Transportation	There is no data available on CH4 emissions from lubricants.
CH4	1.AA.3.C Railways	The German Energy Balance no longer provides data on the use of solid fuels for Railways.
CH4	1.C1.B Marine	There is no data available for the use of Lubricants in International Navigation.
CH4	1.B.2.D Geothermal	no data available yet
CH4	2.C.1.4 Coke	will be checked
CH4	2.C.2 Ferroalloys Production	will be checked
CH4	2.C.3 Aluminium Production	will be checked
CH4	5.A.1 Forest Land remaining Forest Land	Forest land cf. NIR 7.1.1.1.3: No reliable data is available for reporting of non-CO2-emissions from drainage of forest soils.
CH4	5.C.2.1 Forest Land converted to Grassland	See above.
CH4	5.D.2 Land converted to Wetlands	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
CH4	5.D.2.1 Forest Land converted to Wetlands	Emissions are not estimated according appendices 3a.2, 3a.3 and 3a.4 of the IPCC GPG for LULUCF.
CH4	5.E Settlements	No data available.
CH4	5.E.1 Settlements remaining Settlements	No estimations for Germany available.
CH4	5.F Other Land	No estimations for Germany available.
CH4	5 Forest Land converted to Other Land-Use Categories	No reliable data is available for reporting on CH4, NOx, CO, NMVOC emissions.
CH4	5 Grassland converted to Other Land-Use Categories	No reliable data is available for reporting on CH4, NOx, CO, NMVOC emissions.
CH4	5.G Harvested Wood Products	According to IPCC GPG 2003 HWP do not have to be reported (p.1.11 chp.1.7).
CH4	5.G C from lime to forest	Germany only reports emissions of CO2 due to liming of forest soils, other categories are reported in respective categories.
CO2	1.B.1.B Solid Fuel Transformation	no data available
CO2	1.B.2.A.2 Production	no data available yet
CO2	1.B.2.C Venting and Flaring	no data available yet
CO2	1.AA.2.E Food Processing, Beverages and Tobacco	No available data for 1A2e. If there were an input of gaseaus fuels in this industriel sector it is reported under 1A2f other (unspecified plants).

Greenhouse gas	Source category	Explanation
CO2	1.AA.3.B Road Transportation	There is no data available for use of natural gas in road transport.
CO2	1.AA.3.C Railways	The German Energy Balance no longer provides data on the use of solid fuels for Railways.
CO2	1.C1.B Marine	There is no data available for the use of Lubricants in International Navigation.
CO2	1.B.2.D Geothermal	no data available yet
CO2	2.C.1.4 Coke	will be checked.
CO2	5.C.2.1 Forest Land converted to Grassland	Forest land: 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. Emissions of other ghg were considered negligible, since areas burned are small cf. NIR 7.1.1.1.3
CO2	5.D.2.1 Forest Land converted to Wetlands	Emissions are not estimated according appendices 3a.2, 3a.3 and 3a.4 of the IPCC GPG for LULUCF.
CO2	5.F Other Land	No estimations for Germany available.
CO2	5.G Harvested Wood Products	According to IPCC GPG 2003 HWP do not have to be reported (p.1.11 chp.1.7).
CO2	5.G C from lime to forest	See above.
N2O	1.B.2.A.1 Exploration	no data available yet
N2O	1.B.2.C.2 Flaring	no data available yet
N2O	1.AA.2.E Food Processing, Beverages and Tobacco	No available data for 1A2e. If there were an input of gaseaus fuels in this industriel sector it is reported under 1A2f other (unspecified plants).
N2O	1.AA.3.B Road Transportation	There is no data available for use of natural gas in road transport.
N2O	1.AA.3.B Road Transportation	There is no data available on N2O emissions from lubricants.
N2O	1.AA.3.C Railways	The German Energy Balance no longer provides data on the use of solid fuels for Railways.
N2O	1.C1.B Marine	There is no data available for the use of Lubricants in International Navigation.
N2O	5.A.1 Forest Land remaining Forest Land	Forest land cf. NIR 7.1.1.1.3: No reliable data is available for reporting of non-CO2-emissions from drainage of forest soils.
N2O	5.C.2.1 Forest Land converted to Grassland	See above.
N2O	5.D.2 Land converted to Wetlands	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
N2O	5.D.2.1 Forest Land converted to Wetlands	Emissions are not estimated according appendices 3a.2, 3a.3 and 3a.4 of the IPCC GPG for LULUCF.
N2O	5.E Settlements	No estimations for Germany available.
N2O	5.F Other Land	No estimations for Germany available.
N2O	5.G C from lime to forest	Germany only reports emissions of CO2 due to liming of forest soils, other categories are reported in respective categories.

Table 183: Overview, for completeness, of sources and sinks whose emissions are included elswhere (IE)

Source category	Greenhouse gas	Explanation
1.AA.2.A Iron and Steel - Other Fuels	CO2	emissions are reported under 2C1
1.AA.2.A Iron and Steel - Other Fuels	CH4; N2O	emissions are reported under 1A1a and 1A2f (blast furnace gas combustion)
1.AA.2.B Non-Ferrous Metals - Gaseous Fuels	CO2; CH4; N2O	reported under 1A2f other because of confidential data
1.AA.2.C Chemicals	CO2; CH4; N2O	emissions are reported under 1A2f other
1.AA.2.D Pulp, Paper and Print	CO2; CH4; N2O	emissions are reported under 1A2f other
1.AA.2.F Other - Glass Wares	CO2; CH4; N2O	reported under 1A2f other because of confidential data
1.AA.2.F Other - Lime	CO2; CH4; N2O	reported under 1A2f other because of confidential data
1.AA.2.F Other - Ceramics	CO2; CH4; N2O	reported under 1A2f other because of confidential data
1.B.1.A.2.2 Post-Mining Activities	CH4	considered in 1.B.1.A.2.1
1.B.2.B.1 Exploration	CO2	considered in 1.B.2.a.i
1.B.2.B.1 Exploration	CH4	will be considered in 1.B.2.a.i as soon as data are available
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.2.1 Flaring - Oil	CH4	considered in 1.B.2
1.B.2.C.2.1 Flaring - Gas	CH4	considered in 1.B.2
1.B.2.C.2.1 Flaring - Combined	CH4; N2O	considered in 1.B.2
2.A.3 Limestone and Dolomite Use	CO2	data of limestone and dolomite use is estimated and reported under the using categories (see categories 1.A.1.a, 2.A.7, 2.C.1)
2.A.4.2 Soda Ash Use	CO2	emissions of using are estimated in using categories
2.A.7.2a - Ceramic production	CO2	see 2.A.7.2b bricks an tiles
2.B.5 Other - N2O for Medical Using	N2O	The laughing gas production emissions are included in 3D the emissions from anaestheticum use
2.C.1.2 Pig Iron	CO2	is considered in oxygen steel
2.C.1.2 Pig Iron	CH4	is considered in CRF 1A2
2.C.1.3 Sinter	CO2; CH4	is considered in CRF 1A2
2.C.5 Other - Magnesium production	SF6	SF6 emissions are reported under 2.C.4 Aluminium and Magnesium Foundries
2.F.1 Refrigeration and Air Conditioning Equipment	HFCs; SF6; PFCs	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions
2.F.2 Foam Blowing	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions
2.F.3 Fire Extinguishers	SF6	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	SF6	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions
2.F.7 Semiconductor Manufacture	HFCs; SF6; 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.9 Other	HFCs; 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
4.D.1 Direct Soil Emissions	CH4	included in 4.D.4 CH4-consumption

Source category	Greenhouse gas	Explanation
5.A.1 Forest Land remaining Forest Land - Wildfires	CO2	Forest land: 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. Emissions of other ghg were considered negligible, since areas burned are small cf. NIR 7.1.1.1.3
5.B.1 Cropland remaining Cropland - Dolomite CaMg(CO3)2	CO2	As data cannot be differentiated with regard to types of application (dolomite or lime) dolomite use is included on limestone use. Cropland contains the sum of lime applications to cropland and grassland
5.B.2 Forest Land converted to Cropland	N2O	Included in 4.D
5.C.1 Grassland remaining Grassland - Limestone CaCO3	CO2	As data cannot be differentiated with regard to types of application (dolomite or lime) dolomite use is included on limestone use. Cropland contains the sum of lime applications to cropland and grassland
5.C.1 Grassland remaining Grassland - Dolomite CaMg(CO3)2	CO2	As data cannot be differentiated with regard to types of application (dolomite or lime) dolomite use is included on limestone use. Cropland contains the sum of lime applications to cropland and grassland
5.G Other - C from lime to forest - Dolomite CaMg(CO3)2	CO2	As data cannot be differentiated with regard to types of application (dolomite or lime) dolomite use is included on limestone use. Cropland contains the sum of lime applications to cropland and grassland
5.G. Other - 5.B.2.4 Settlements converted to Cropland	N2O	Included in CRF 4 D

17 ANNEX 6: ADDITIONAL INFORMATION TO BE CONSIDERED AS PART OF THE NIR SUBMISSION (WHERE RELEVANT) OR OTHER USEFUL REFERENCE INFORMATION

17.1 Additional information relative to inventory preparation and to the National System

17.1.1 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[91] "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.

[91] Authors's note: currently, Section I 2.6 is responsible.

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 sent 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.

17.1.2 Status of implementation relative to the "National System" principles paper on emissions reporting

The co-ordinating committee, representing all affected departments, that is to be established pursuant to Paragraph 2 of the principles paper met for the second time on 1 July 2008. The primary purpose of the second meeting was to discuss the status of implementation of the state secretaries' resolution and to outline further procedures for such implementation. Table 184 shows the status of implementation of the resolution.

Table 184: Status of implementation of the state secretaries' resolution relative to the National System

Co-operation with:	Status
All areas	**1 July 2008:** second meeting of the co-ordinating committee
BMWi	**Energy area:** **April 2008:** Conclusion of an agreement with the Working Group on Energy Balances (AG Energiebilanz) relative to "Preparation of energy balances for the Federal Republic of Germany, 2007-2012)" **Area of industrial processes / solvent use:** **August 2008:** Technical discussion with the VCI (Association of the German chemical industry) regarding greenhouse-gas reporting for the areas of ammonia, nitric acid and adipic acid; discussion of the conclusion of an agreement between associations. **September 2008:** Technical discussion with the VCI and the Arbeitsgemeinschaft Bitumen Industrie (bitumen industries working group) relative to greenhouse-gas reporting in the area of bitumen for roofing sheeting; discussion of the conclusion of an agreement between associations. **October 2008:** Discussion with the Wirtschaftsvereinigung Metalle metal-industry association regarding reactivation of a voluntary commitment regarding data provision for emissions reporting in the area of primary aluminium, and expansion of same to include other non-ferrous metals.
BMI / Destatis	**July 2008:** Federal Cabinet resolution regarding the "Third Act on relieving burdens on SMEs" ("Drittes Mittelstandsentlastungsgesetze"), which is to serve as a legal basis for data transfer from the Federal Statistical Office to the Federal Environment Agency. **August 2008:** Administrative agreement between the Federal Statistical Office and the Federal Environment Agency, regarding data transfer, is being prepared; the final draft of Annex 1 of the agreement (list of required data) has been sent to the Federal Statistical Office.
EURO-CONTROL	Draft of an agreement on data exchange has been sent to EUROCONTROL; response still pending.
BMVBS	An R&D project on differentiation of transport loads, by individual road categories, has been added to the BMVBS' 2008 departmental research programme. The relevant requirements are being discussed by the Federal Environment Agency and BMVBS at the specialised-department level.
BMVg	No further action required on the basis of the resolution.
BMU / UBA	The Federal Environment Agency has entered into long-term agreements whereby it will assume responsibility for ensuring collection of data on F gases and solvents.
BMELV	**July / September 2008:** The BMELV submits a revised draft of a concept for emissions reporting pursuant to Arts. 3.3 and 3.4 of the KP. A pertinent overall concept is to be prepared by 15 December 08. Establishment of a Working Group on Emissions Reporting (Arbeitsgruppe Emissionsberichterstattung) within the von Thünen Institute (vTI), to serve as a liaison to the National System and the Single National Entity. That working group is also to have responsibility for planning and QC/QA.

17.2 Additional information about the Quality System of Emissions Inventories

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

As described above in the main section (Chapter 1.2.6.1), 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"). These are described below.

17.2.1.1 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.

17.2.1.2 System for quality control and quality assurance

The *rules (Commission Decision 2005/166/EC) implementing Decision 280/2004/EC* require that national greenhouse-gas inventories 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* requires that QC/QA systems be introduced with the aim of enhancing transparency, consistency, comparability, completeness and precision of national emissions inventories and, especially, that such inventories 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.

17.2.1.3 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).

17.2.1.4 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.

17.2.1.5 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.

17.2.1.6 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.

17.2.1.7 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.

17.2.1.8 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 for such provision.

17.2.1.9 Documentation and archiving

As a general requirement, all data and information used for inventory calculation must be documented (i.e. recorded) and archived, for each report year. The purpose of such documentation (i.e. recording) is to make it possible to completely reconstruct all emissions calculations after the fact. The general requirements pertaining to documentation and archiving for the entire process of preparation of greenhouse-gas inventories are described in Chapter 8.10.1 of the *IPCC Good Practice Guidance*.

Consequently, data providers have the obligation to keep records of the following information relative to data they supply to the Federal Environment Agency, for purposes of inventory calculations:

Data providers:

- Publication / source of activity data, with detailed referencing of the relevant Table numbers and names, and of the relevant pages in the original sources;
- Survey contents (definitions of the surveyed characteristics, delimitations used, survey units used) and survey methods;
- The legal foundations and ordinances on which surveys are based;
- Chronological and spatial comparability with previous-year data, and any changes with regard to definitions, scopes of validity, cut-off points, sources of activity rates or data-collection methods;
- Any revision of previously published data;
- The accuracy or quantitative error of activity data, methods used to estimate errors and the names of experts who have carried out error estimation.
- Secrecy and data protection: suitable notification with regard to any individual data items that are considered secret.

Such materials should be provided to the Federal Environment Agency on an annual basis, together with pertinent data, and they are centrally archived by the Federal Environment Agency.

Quality control (QC)

The records kept in the framework of quality control should include the names of the persons responsible for managing and carrying out relevant actions, the types of quality control carried out, the dates on which quality control measures were carried out, the pertinent

results, and the corrections and modifications triggered by quality control measures. In each case, record-keeping and archiving for quality control measures are carried out internally, by the institution supplying the pertinent data. A general description of regularly executed quality control measures is provided to the Federal Environment Agency for purposes of the national inventory report and inventory review.

Providers of emissions calculations

For providers of emissions calculations, the minimum requirements pertaining to record-keeping also include the following:

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 (QA)

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.

17.2.1.10 Annex 1: Minimum requirements pertaining to quality control and quality assurance in emissions reporting in the Federal Environment Agency

17.2.1.10.1 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 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.

17.2.1.10.2 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 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. 17.2.1.10.3). That work has led to the development of the Quality System of Emissions Inventories (QSE), via which the points mentioned in 17.2.1.2 have been implemented.

17.2.1.10.2.1 Agency responsible for co-ordinating QC/QA activities in the Federal Environment Agency

Pursuant to in-house directive No. 11/2005, section "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.

17.2.1.10.2.2 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 41). Additional relevant information is provided in the QSE manual, Chapter 4.3.

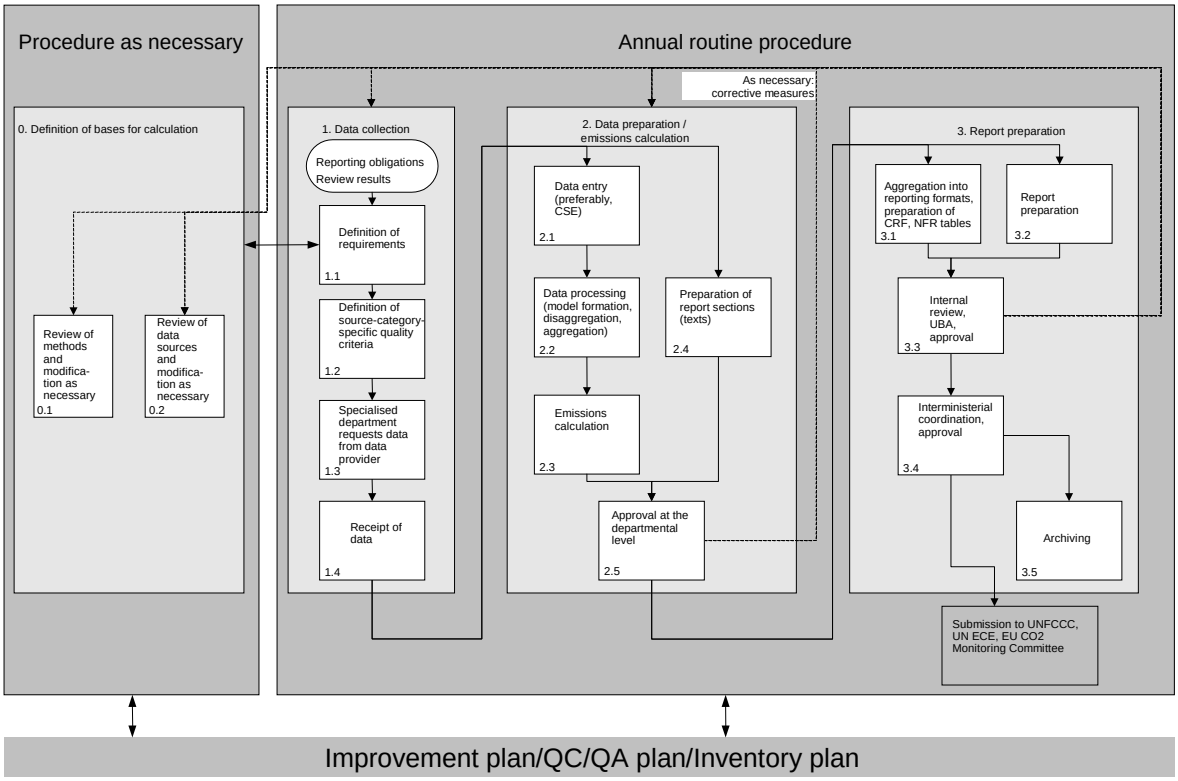


Figure 41: Overview of the overall emissions-reporting process

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 17.2.1.2), 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.

17.2.1.10.3 QC plan, QA plan and inventory plan

To ensure that all potential improvements identified during the course of inventory work are systematically implemented, identified improvements must be listed in a co-ordinated way. In the process, identified potential improvements should be listed together with all relevant information (origin of the potential improvement, source category, pertinent responsibility, priority, etc.) needed for efficient further processing. Planning and arrangements for implementing identified potential improvements (required actions / corrective measures, deadlines, etc.) should then be made on the basis of such information.

In the interest of proper control and record-keeping in the framework of the NaSE and the QSE (cf. Figure 42), 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

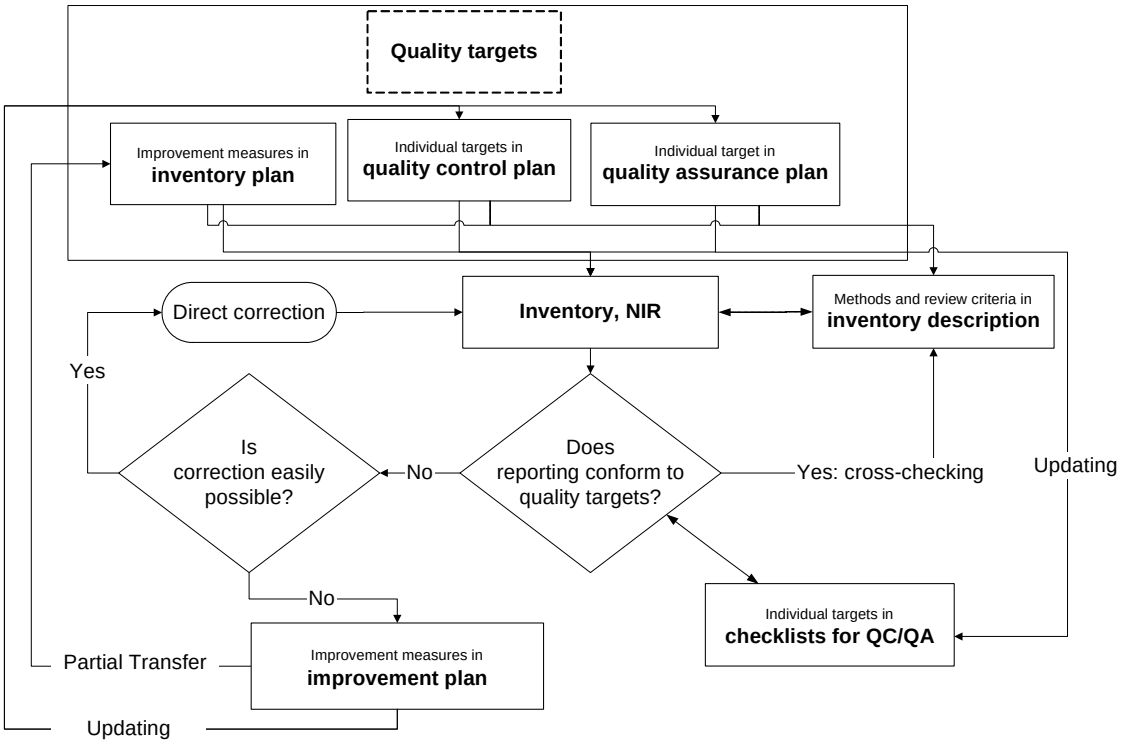


Figure 42: Control and documentation in the framework of the NaSE and the QSE

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).

17.2.1.10.4 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 use 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. 17.2.1.10.2.2), 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.

17.2.1.10.5 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; Chap. 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.

17.2.1.10.6 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 185. 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 185: 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).

17.2.1.11 Annex 2: Example of a general checklist for the responsible-expert role

The example shown below includes only relevant requirements. Detailed information has been removed in the interest of clarity.

Table 186: 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-category analysis.	
0.1	Review of methods, and modification as necessary	The calculation method has been selected in accordance with the pertinent decision tree of the IPCC Good Practice Guidance (where such a decision tree is available).	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 (where the plan includes pertinent requirements).	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 time series as of 1990.	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 content 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	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 explained, in keeping with logical and pertinent specialised criteria, 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 (for example, inter-/ 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.
0.2	Review of data sources, and modification as necessary	One / several complete time series as of 1990 are available in the data source(s).	Following closure of data gaps, time-series recalculation has been carried out as necessary, pursuant to QSE manual (Annex 2), and such recalculation has been documented and substantiated in the NIR and CRF.
0.2	Review of data sources, and modification as necessary	The data source(s) completely cover the source category.	Where coverage of the source category is incomplete, extrapolation has been carried out and taken into account in the uncertainties. All steps have been documented and justified clearly and logically.

Process No.	Sub-process name	Individual goal	Optional goal

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.	Where the EF and the AR do not agree, extrapolation was carried out and taken into account in the uncertainties. All steps have been documented and justified clearly and logically.
0.2	Review of data sources, and modification as necessary	The data have been clearly and logically described in terms of their underlying calculation procedures.	
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 (where the plan includes pertinent requirements).	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 documentation for the data source(s) conforms to the requirements of the QSE manual (Annexes 3, 4 and 5).	
0.2	Review of data sources, and modification as necessary	The data provider has carried out and documented routine quality controls of the data source(s).	
0.2	Review of data sources, and modification as necessary	Where one / several data source(s) other than those used in previous years has / have been used, recalculation pursuant to the QSE manual (Annex 2), and on the basis of these other data source(s), has been carried out for the affected time series.	

Main process: 1. Data collection			
1.1	Definition of requirements	The requirements pertaining to the data take account of the pertinent remarks from the inventory reviews (such as S&A Report, Centralized Review) and/or the inventory plan (where such remarks are made).	
1.3	The relevant specialised department requests the data from the pertinent data provider(s)	The defined requirements pertaining to QC, data and report formats, records and the results of key-category analysis have been forwarded to data providers and/or the pertinent contracting entity, and such forwarding has 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.	
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 explained by an expert or have been closed in accordance with IPCC Good Practice Guidance (Chap. 7.3.2.2), and clear and logical records of such action have been made.

Process No.	Sub-process name	Individual goal	Optional goal
1.4	Receipt of data	The received data are complete, without any gaps.	All non-closable data gaps in the time series that lead to incomplete emissions calculations for a source category have been described in the "Form for continual improvement" ("Formular zur kontinuierlichen Verbesserung"), along with the necessary improvement measures.
1.4	Receipt of data	The received data are consistent with the corresponding data from the previous year, in terms of source category coverage, and have been described in a clear and logical manner.	Where received data are inconsistent, the data provider has confirmed the correctness of the data.
1.4	Receipt of data	The received data are consistent with the corresponding data from the previous year, in terms of source category coverage, and have been described in a clear and logical manner.	Where the source category delimitations have changed, with the result that the inconsistency persists, a time-series recalculation pursuant to the QSE manual (Annex 2) has been carried out.
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 from inventories of other countries, etc.).	The reasons for any discrepancies have been properly, clearly and logically explained and duly documented.
1.4	Receipt of data	The assumptions on which the uncertainties determinations are based have been clearly and logically documented.	
1.4	Receipt of data	The uncertainties determinations are complete and plausible.	If necessary: error calculations, or a sample of the probability distributions used in Monte Carlo analysis (not the analysis itself), have been repeated on the basis of the QSE manual (Annex 1).
1.4	Receipt of data	The qualifications of persons who carry out expert assessment for uncertainties determination have been reviewed and confirmed, and the results have been duly documented.	
		Main process: 2. Data preparation / emissions calculation	
2.1	Data entry (preferably into the CSE)	The EF and the uncertainties for the EF are complete.	Any gaps have been properly, clearly and logically explained and duly documented.
2.1	Data entry (preferably into the CSE)	The origins of EF data, and the EF uncertainties, have been completely documented.	Lacking or incomplete documentation of data origin has been properly, clearly and logically explained and duly documented.
2.1	Data entry (preferably into the CSE)	Implausibilities (for example, in terms of orders of magnitude or via changes in units) in EF and in EF uncertainties within the time series have been reviewed and corrected as necessary.	Any uncorrected discrepancies have been properly, clearly and logically explained and duly documented.
2.1	Data entry (preferably into the CSE)	The AR and the uncertainties for the AR are complete.	Any gaps have been properly, clearly and logically explained and duly documented.
2.1	Data entry (preferably into the CSE)	The origins of AR data, and the AR uncertainties, have been completely documented.	Lacking or incomplete documentation of data origin has been properly, clearly and logically explained and duly documented.

Process No.	Sub-process name	Individual goal	Optional goal
2.1	Data entry (preferably into the CSE)	Implausibilities (for example, in terms of orders of magnitude or via changes in units) in AR and in AR uncertainties within the time series have been reviewed and corrected as necessary.	Any uncorrected discrepancies have been properly, clearly and logically explained and duly documented.
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.	
2.2	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..	
2.2	Data preparation (model formation, disaggregation, aggregation)	The calculation method and the calculation procedure used are consistent throughout the entire time series (consistent use of the same method).	Where a change in methods occurred, the time series was recalculated pursuant to QSE manual (Annex 2) and in keeping with the methods specified in IPCC Good Practice Guidance Chap. 7.3.2..
2.3	Emissions calculation	The current inventory calculations have been checked against previous calculations.	Where any obvious deviation from an expected trend has 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 emissions-calculation results have been cross-checked against results obtained with other data sources for Germany and have been found to be properly 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 aggregated EF (national implied EF) have been compared with international implied EF (S&A Report; depending on when the comparison was carried out, the previous year's report may have to be used), and the result has been duly documented.	Any EF and AR that contribute to extreme implied EF have been properly, clearly and logically explained, and duly documented, in the NIR, or reference to an existing explanation has been made.
2.4	Preparation of report sections (texts)	The source category has been completely and logically described, for the NIR, in terms of the required six sub-chapters for the NIR ("Source category description", "Methodological issues", etc.).	
2.5	Approval by the relevant experts	The AR, EF, ED and their uncertainties are up to date in the CSE and NIR and congruent throughout both.	Any gaps have been properly, clearly and logically explained and duly documented.
2.5	Approval by the relevant experts	Records of all origins of data for AR, EF, ED and their uncertainties are up to date in the CSE and NIR and congruent throughout both.	Lacking or incomplete documentation of data origin has been properly, clearly and logically explained and duly documented.

17.3 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 3ff – in each case, with regard to individual source categories. In addition to aggregation and model formation for calculations, the CSE also supports scenario and forecast calculations.

Data exchange within the framework of the National System – i.e. within the Federal Environment Agency and with third parties – is also organised via the Central System of Emissions. Such processes involve both direct data entry and imports of aggregated values, from existing databases and via a standard interface (for example, transport data from the TREMOD database and agricultural data from the GAS-EM database). Ideally, inventory data should be entered into the CSE directly by the relevant responsible experts or should be imported, by the CSE administrator, via the import interface. This applies to in-house UBA employees as well as to external parties involved in the National System. To this end, a range of measures have been implemented:

- Provision of a *standardised import format for 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.

18 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.

Subsequently, the basis for Tier-2 uncertainties analysis was created, and the "Crystal Ball" programme for Monte Carlo simulation was implemented. At the same time, additional uncertainties were determined via experts' assessments and added to the CSE database. A complete set of uncertainties determined via experts' assessments is not yet available, however. To obtain such a complete data set, which is required for calculations, uncertainties from adjustment procedures are applied, via IPCC Conservativeness Factors[92]. Systematic and complete experts' assessments are being hampered by the following issues, however:

- The fact that most activity rates are taken from data sources outside of the Federal Environment Agency (Destatis, industry associations or other statistics) complicates determination of uncertainties. Either assessments must be carried out by experts outside of the Federal Environment Agency, or the data-supplying institutions' own uncertainty figures must be used.
- In addition, many activity rates are determined through a process in which the Federal Environment Agency carries out a variety of calculations, for purposes of adaptation, on the basis of an external database (examples include the BEU, TREMOD, etc.). The question arises as to how changes in uncertainties resulting from such calculations, some of which are quite complex, can be determined.
- Furthermore, in some cases no further use of current emission factors and activity rates is planned. It thus must be asked whether it is at all useful to determine uncertainties for such values, which are badly in need of revision, or whether modification of calculation procedures has advanced enough to produce EF and AR for which uncertainties can be estimated.

The results of this year's Tier-1 uncertainties analysis are shown, in keeping with the specifications given in Table 6.1 of IPCC Good Practice Guidance, in Table 187.

[92] FCCC/SBSTA/2003/10/Add.2, Annex III, p. 24-27

Table 187: Table 6.2 of the IPCC Good Practice Guidance - Details

IPCC Source	Fuel Category	Gas	Base year emissions	Year t emissions (HQG)	Uncertainty Activity Data	Uncertainty Emission Factors / Emissions	Combined Uncertainty	Combined Uncertainty as % of total national emissions in year t	Tier1 Level Assesment	Type B sensitivity	Uncertainty in trend introduced by EF uncertainty	Uncertainty in trend introduced by AR uncertainty	Uncertainty introduced into the trend in total
Category			[Gg CO_2 equivalent]	[Gg CO_2 equivalent]	Input Data [%]	Input Data [%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1A1a	gaseous	N2O	68.165	167.229	3.1	19.9	20.1	0.0	0.0	0.0	3.97E-03	6.27E-04	4.02E-03
1A1a	gaseous	CO2	18,461.876	40,733.224	3.0	1.1	3.2	0.1	0.4	3.4	5.51E-02	1.47E-01	1.57E-01
1A1a	gaseous	CH4	4.967	20.933	3.8	23.5	23.8	0.0	0.0	0.0	5.86E-04	9.39E-05	5.93E-04
1A1a	liquid	N2O	39.034	14.352	2.8	22.4	22.5	0.0	0.0	0.0	3.83E-04	4.81E-05	3.86E-04
1A1a	liquid	CO2	8,506.922	3,556.424	3.2	1.5	3.6	0.0	0.0	0.3	6.46E-03	1.36E-02	1.51E-02
1A1a	liquid	CH4	7.707	1.902	3.5	28.1	28.3	0.0	0.0	0.0	6.37E-05	7.86E-06	6.42E-05
1A1a	other	N2O	35.739	104.207	14.7	45.2	47.5	0.0	0.0	0.0	5.62E-03	1.82E-03	5.91E-03
1A1a	other	CO2	4,120.893	10,253.787	14.7	1.5	14.7	0.1	0.5	0.9	1.84E-02	1.79E-01	1.80E-01
1A1a	other	CH4	6.796	4.236	14.7	37.7	40.4	0.0	0.0	0.0	1.91E-04	7.41E-05	2.04E-04
1A1a	solid	N2O	3,431.431	3,352.124	6.5	28.9	29.6	0.1	0.3	0.3	1.16E-01	2.59E-02	1.19E-01
1A1a	solid	CO2	304,691.812	291,129.290	6.2	1.6	6.4	1.7	6.2	24.6	5.53E-01	2.16E+00	2.23E+00
1A1a	solid	CH4	112.019	88.391	6.3	27.1	27.8	0.0	0.0	0.0	2.86E-03	6.60E-04	2.93E-03
1A1a	biomass	N2O	35.662	104.961	14.5	44.9	47.2	0.0	0.0	0.0	5.62E-03	1.82E-03	5.91E-03
1A1a	biomass	CH4	6.705	4.254	14.6	37.5	40.3	0.0	0.0	0.0	1.91E-04	7.41E-05	2.04E-04
1A1b	gaseous	N2O	5.598	2.670	4.4	31.5	31.8	0.0	0.0	0.0	1.00E-04	1.40E-05	1.01E-04
1A1b	gaseous	CO2	1,441.177	652.414	5.1	0.6	5.1	0.0	0.0	0.1	4.47E-04	3.95E-03	3.98E-03
1A1b	gaseous	CH4	0.449	0.281	4.3	26.4	26.7	0.0	0.0	0.0	8.84E-06	1.45E-06	8.96E-06
1A1b	liquid	N2O	78.104	66.280	2.8	33.6	33.7	0.0	0.0	0.0	2.66E-03	2.20E-04	2.67E-03
1A1b	liquid	CO2	15,314.871	21,351.374	3.1	0.5	3.1	0.1	0.2	1.8	1.31E-02	7.84E-02	7.95E-02
1A1b	liquid	CH4	8.574	8.066	2.8	29.8	29.9	0.0	0.0	0.0	2.87E-04	2.67E-05	2.88E-04
1A1b	solid	N2O	30.962	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1b	solid	CO2	3,075.895	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1b	solid	CH4	1.092	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1b	other	N2O	3.601	NE	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1b	other	CO2	173.935	NE	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1b	other	CH4	1.585	NE	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1b	biomass	N2O	3.601	NE	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1b	biomass	CH4	1.585	NE	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1c	biomass	N2O	2.789	1.136	29.2	50.0	57.9	0.0	0.0	0.0	6.78E-05	3.95E-05	7.84E-05
1A1c	biomass	CH4	0.525	0.214	29.2	50.0	57.9	0.0	0.0	0.0	1.28E-05	7.43E-06	1.48E-05
1A1c	gaseous	N2O	12.442	5.082	7.3	42.2	42.9	0.0	0.0	0.0	2.56E-04	4.45E-05	2.60E-04
1A1c	gaseous	CO2	2,501.188	1,016.269	7.4	4.1	8.4	0.0	0.0	0.1	4.97E-03	8.92E-03	1.02E-02
1A1c	gaseous	CH4	2.152	0.956	7.3	42.2	42.9	0.0	0.0	0.0	4.82E-05	8.37E-06	4.89E-05
1A1c	liquid	N2O	10.067	1.387	2.6	22.5	22.6	0.0	0.0	0.0	3.72E-05	4.34E-06	3.74E-05
1A1c	liquid	CO2	1,109.478	228.503	2.5	2.0	3.2	0.0	0.0	0.0	5.37E-04	6.73E-04	8.60E-04
1A1c	liquid	CH4	1.068	0.222	2.5	21.3	21.5	0.0	0.0	0.0	5.66E-06	6.58E-07	5.70E-06
1A1c	other	N2O	9.441	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00

IPCC Source	Fuel Category	Gas	Base year emissions	Year t emissions (HQG)	Uncertainty Activity Data	Uncertainty Emission Factors / Emissions	Combined Uncertainty	Combined Uncertainty as % of total national emissions in year t	Tier1 Level Assesment	Type B sensitivity	Uncertainty in trend introduced by EF uncertainty	Uncertainty in trend introduced by AR uncertainty	Uncertainty introduced into the trend in total
Category			[Gg CO_2 equivalent]	[Gg CO_2 equivalent]	Input Data [%]	Input Data [%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1A1c	other	CO2	456.064	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1c	other	CH4	4.157	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A1c	solid	N2O	649.429	233.181	8.0	35.0	35.9	0.0	0.0	0.0	9.73E-03	2.22E-03	9.98E-03
1A1c	solid	CO2	54,999.327	16,606.848	8.4	3.7	9.2	0.1	0.5	1.4	7.39E-02	1.66E-01	1.82E-01
1A1c	solid	CH4	19.235	6.090	7.7	34.5	35.4	0.0	0.0	0.0	2.51E-04	5.63E-05	2.57E-04
1A2a	biomass	N2O	NE	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A2a	biomass	CH4	NE	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A2a	gaseous	N2O	29.190	18.760	9.2	54.2	55.0	0.0	0.0	0.0	1.21E-03	2.06E-04	1.23E-03
1A2a	gaseous	CO2	3,500.324	3,765.523	9.2	3.6	9.9	0.0	0.1	0.3	1.62E-02	4.13E-02	4.44E-02
1A2a	gaseous	CH4	3.296	3.530	9.2	54.2	55.0	0.0	0.0	0.0	2.28E-04	3.88E-05	2.32E-04
1A2a	liquid	N2O	6.949	1.234	5.4	65.5	65.8	0.0	0.0	0.0	9.65E-05	7.97E-06	9.69E-05
1A2a	liquid	CO2	559.791	125.396	4.7	3.8	6.1	0.0	0.0	0.0	5.70E-04	7.07E-04	9.08E-04
1A2a	liquid	CH4	0.563	0.120	5.1	49.5	49.8	0.0	0.0	0.0	7.11E-06	7.33E-07	7.14E-06
1A2a	other	N2O	NE	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A2a	other	CH4	NE	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A2a	solid	N2O	122.113	82.201	6.2	43.7	44.1	0.0	0.0	0.0	4.29E-03	6.05E-04	4.33E-03
1A2a	solid	CO2	8,517.768	1,972.137	3.8	1.8	4.2	0.0	0.0	0.2	4.26E-03	8.89E-03	9.86E-03
1A2a	solid	CH4	50.761	54.175	7.8	22.2	23.6	0.0	0.0	0.0	1.44E-03	5.07E-04	1.52E-03
1A2b	gaseous	N2O	2.109	7.821	12.0	75.0	76.0	0.0	0.0	0.0	7.00E-04	1.12E-04	7.09E-04
1A2b	gaseous	CO2	253.296	1,569.733	12.0	5.0	13.0	0.0	0.1	0.1	9.37E-03	2.25E-02	2.44E-02
1A2b	gaseous	CH4	0.238	1.472	12.0	75.0	76.0	0.0	0.0	0.0	1.32E-04	2.11E-05	1.33E-04
1A2b	liquid	N2O	1.675	1.384	4.6	55.8	55.9	0.0	0.0	0.0	9.21E-05	7.54E-06	9.24E-05
1A2b	liquid	CO2	141.090	176.697	4.3	3.5	5.6	0.0	0.0	0.0	7.35E-04	9.13E-04	1.17E-03
1A2b	liquid	CH4	0.138	0.154	4.3	41.9	42.1	0.0	0.0	0.0	7.72E-06	7.96E-07	7.76E-06
1A2b	solid	N2O	14.031	4.160	8.9	67.7	68.3	0.0	0.0	0.0	3.36E-04	4.43E-05	3.39E-04
1A2b	solid	CO2	1,205.276	368.486	8.9	4.3	9.9	0.0	0.0	0.0	1.91E-03	3.91E-03	4.35E-03
1A2b	solid	CH4	0.788	0.074	12.3	50.3	51.8	0.0	0.0	0.0	4.43E-06	1.09E-06	4.56E-06
1A2d	biomass	N2O	2.907	9.668	15.0	46.4	48.8	0.0	0.0	0.0	5.35E-04	1.73E-04	5.63E-04
1A2d	biomass	CH4	0.547	1.819	15.0	38.7	41.5	0.0	0.0	0.0	8.39E-05	3.26E-05	9.00E-05
1A2d	other	N2O	0.012	0.057	22.0	67.1	70.6	0.0	0.0	0.0	4.54E-06	1.49E-06	4.78E-06
1A2d	other	CO2	3.647	17.520	22.0	3.7	22.3	0.0	0.0	0.0	7.79E-05	4.60E-04	4.66E-04
1A2d	other	CH4	0.002	0.011	22.0	55.9	60.1	0.0	0.0	0.0	7.12E-07	2.80E-07	7.65E-07
1A2e	gaseous	N2O	0.000	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A2e	gaseous	CO2	0.000	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A2e	gaseous	CH4	0.000	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A2e	liquid	N2O	12.150	1.296	6.0	72.0	72.3	0.0	0.0	0.0	1.11E-04	9.21E-06	1.12E-04
1A2e	liquid	CO2	888.784	116.140	5.9	4.5	7.4	0.0	0.0	0.0	6.29E-04	8.18E-04	1.03E-03
1A2e	liquid	CH4	0.947	0.121	5.9	56.0	56.3	0.0	0.0	0.0	8.05E-06	8.48E-07	8.10E-06
1A2e	solid	N2O	13.487	5.075	13.3	99.8	100.7	0.0	0.0	0.0	6.04E-04	8.05E-05	6.10E-04

IPCC Source	Fuel Category	Gas	Base year emissions	Year t emissions (HQG)	Uncertainty Activity Data	Uncertainty Emission Factors / Emissions	Combined Uncertainty	Combined Uncertainty as % of total national emissions in year t	Tier1 Level Assesment	Type B sensitivity	Uncertainty in trend introduced by EF uncertainty	Uncertainty in trend introduced by AR uncertainty	Uncertainty introduced into the trend in total
Category			[Gg CO_2 equivalent]	[Gg CO_2 equivalent]	Input Data [%]	Input Data [%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1A2e	solid	CO2	1,100.455	537.419	12.9	4.5	13.7	0.0	0.0	0.0	2.91E-03	8.26E-03	8.76E-03
1A2e	solid	CH4	2.819	0.332	14.8	55.6	57.5	0.0	0.0	0.0	2.20E-05	5.88E-06	2.28E-05
1A2f	biomass	N2O	39.010	129.873	20.1	61.9	65.1	0.0	0.0	0.0	9.60E-03	3.12E-03	1.01E-02
1A2f	biomass	CH4	15.460	6.068	18.5	45.4	49.0	0.0	0.0	0.0	3.28E-04	1.34E-04	3.55E-04
1A2f	gaseous	N2O	168.644	192.570	4.5	23.5	24.0	0.0	0.0	0.0	5.41E-03	1.03E-03	5.51E-03
1A2f	gaseous	CO2	41,786.747	46,262.410	5.5	2.3	6.0	0.2	0.9	3.9	1.27E-01	3.06E-01	3.31E-01
1A2f	gaseous	CH4	23.033	23.586	4.0	17.9	18.4	0.0	0.0	0.0	5.05E-04	1.11E-04	5.17E-04
1A2f	liquid	N2O	164.591	71.907	3.0	27.9	28.1	0.0	0.0	0.0	2.40E-03	2.53E-04	2.41E-03
1A2f	liquid	CO2	24,306.955	11,065.044	3.6	1.9	4.1	0.0	0.1	0.9	2.56E-02	4.74E-02	5.39E-02
1A2f	liquid	CH4	25.334	10.256	3.8	21.1	21.4	0.0	0.0	0.0	2.58E-04	4.62E-05	2.62E-04
1A2f	other	N2O	39.276	92.291	12.9	41.8	43.7	0.0	0.0	0.0	4.60E-03	1.42E-03	4.82E-03
1A2f	other	CO2	2,896.265	7,402.662	12.5	2.2	12.7	0.1	0.3	0.6	1.97E-02	1.11E-01	1.12E-01
1A2f	other	CH4	10.399	5.131	10.5	28.3	30.2	0.0	0.0	0.0	1.73E-04	6.45E-05	1.85E-04
1A2f	solid	N2O	831.196	231.584	3.5	18.5	18.8	0.0	0.0	0.0	5.11E-03	9.78E-04	5.21E-03
1A2f	solid	CO2	69,322.022	15,716.670	3.3	1.5	3.6	0.1	0.2	1.3	2.82E-02	6.20E-02	6.82E-02
1A2f	solid	CH4	106.693	8.923	3.6	19.6	20.0	0.0	0.0	0.0	2.09E-04	3.85E-05	2.13E-04
1A3a	liquid	N2O	20.791	34.437	0.0	147.2	147.2	0.0	0.0	0.0	6.05E-03	0.00E+00	6.05E-03
1A3a	liquid	CO2	3,024.917	2,329.623	0.0	73.7	73.7	0.2	0.6	0.2	2.05E-01	0.00E+00	2.05E-01
1A3a	liquid	CH4	0.866	0.622	0.0	147.2	147.2	0.0	0.0	0.0	1.09E-04	0.00E+00	1.09E-04
1A3b_DK	liquid	N2O	0.605	515.570	5.5	31.7	32.2	0.0	0.1	0.0	1.95E-02	3.38E-03	1.98E-02
1A3b_DK	liquid	CO2	54,458.080	79,406.136	4.7	0.7	4.8	0.3	1.3	6.7	6.92E-02	4.50E-01	4.55E-01
1A3b_DK	liquid	CH4	1.394	16.137	4.8	18.4	19.1	0.0	0.0	0.0	3.55E-04	9.24E-05	3.67E-04
1A3b_OK	liquid	CO2	95,794.488	64,072.901	0.4	1.1	1.2	0.1	0.2	5.4	8.35E-02	3.34E-02	9.00E-02
1A3b_OK	liquid	N2O	1.357	477.667	0.5	47.1	47.1	0.0	0.1	0.0	2.68E-02	2.86E-04	2.68E-02
1A3b_OK	liquid	CH4	59.134	125.324	0.3	20.3	20.3	0.0	0.0	0.0	3.04E-03	4.86E-05	3.04E-03
1A3b_FLG	liquid	N2O	0.000	3.720	0.0	75.0	75.0	0.0	0.0	0.0	3.33E-04	0.00E+00	3.33E-04
1A3b_FLG	liquid	CO2	8.970	458.770	0.0	7.0	7.0	0.0	0.0	0.0	3.83E-03	0.00E+00	3.83E-03
1A3b_FLG	liquid	CH4	0.000	0.445	0.0	50.0	50.0	0.0	0.0	0.0	2.65E-05	0.00E+00	2.65E-05
1A3b_PET	liquid	N2O	NE	0.209	8.2	61.6	62.1	0.0	0.0	0.0	1.53E-05	2.05E-06	1.55E-05
1A3b_PET	liquid	CO2	NE	44.400	8.4	5.9	10.2	0.0	0.0	0.0	3.11E-04	4.45E-04	5.43E-04
1A3b_PET	liquid	CH4	NE	0.012	7.7	38.3	39.0	0.0	0.0	0.0	5.66E-07	1.13E-07	5.77E-07
1A3b_BIO	biomass	CH4	NE	4.047	13.3	16.8	21.4	0.0	0.0	0.0	8.12E-05	6.42E-05	1.04E-04
1A3b_BIO	biomass	N2O	NE	80.250	5.5	29.3	29.8	0.0	0.0	0.0	2.81E-03	5.26E-04	2.86E-03
1A3b_SMS	liquid	CO2	96.788	131.999	10.0	7.0	12.2	0.0	0.0	0.0	1.10E-03	1.58E-03	1.92E-03
1A3c	liquid	N2O	11.922	5.354	11.0	75.0	75.8	0.0	0.0	0.0	4.79E-04	7.03E-05	4.84E-04
1A3c	liquid	CO2	2,825.541	1,277.980	11.0	2.0	11.2	0.0	0.0	0.1	3.05E-03	1.68E-02	1.70E-02
1A3c	liquid	CH4	2.128	0.580	11.0	50.0	51.2	0.0	0.0	0.0	3.46E-05	7.62E-06	3.54E-05
1A3c	solid	N2O	0.714	NE	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A3c	solid	CO2	53.741	NE	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00

IPCC Source	Fuel Category	Gas	Base year emissions	Year t emissions (HQG)	Uncertainty Activity Data	Uncertainty Emission Factors / Emissions	Combined Uncertainty	Combined Uncertainty as % of total national emissions in year t	Tier1 Level Assesment	Type B sensitivity	Uncertainty in trend introduced by EF uncertainty	Uncertainty in trend introduced by AR uncertainty	Uncertainty introduced into the trend in total
Category			[Gg CO_2 equivalent]	[Gg CO_2 equivalent]	Input Data [%]	Input Data [%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1A3c	solid	CH4	0.181	NE	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
1A3d	liquid	N2O	8.590	2.225	11.0	75.0	75.8	0.0	0.0	0.0	1.99E-04	2.92E-05	2.01E-04
1A3d	liquid	CO2	2,049.777	531.098	11.0	2.0	11.2	0.0	0.0	0.0	1.27E-03	6.97E-03	7.09E-03
1A3d	liquid	CH4	1.674	0.362	11.0	50.0	51.2	0.0	0.0	0.0	2.16E-05	4.75E-06	2.21E-05
1A3e	gaseous	N2O	8.839	4.513	6.3	35.4	35.9	0.0	0.0	0.0	1.90E-04	3.41E-05	1.93E-04
1A3e	gaseous	CO2	637.275	867.352	6.3	3.5	7.3	0.0	0.0	0.1	3.66E-03	6.56E-03	7.51E-03
1A3e	gaseous	CH4	0.479	0.651	6.3	35.4	35.9	0.0	0.0	0.0	2.74E-05	4.92E-06	2.79E-05
1A3e	liquid	N2O	17.670	14.645	1.0	355.2	355.2	0.0	0.0	0.0	6.21E-03	1.80E-05	6.21E-03
1A3e	liquid	CO2	3,664.983	2,764.939	1.3	2.7	3.0	0.0	0.0	0.2	9.01E-03	4.19E-03	9.94E-03
1A3e	liquid	CH4	9.296	3.564	0.8	143.0	143.0	0.0	0.0	0.0	6.08E-04	3.24E-06	6.08E-04
1A4a	biomass	N2O	6.359	0.905	27.2	70.0	75.1	0.0	0.0	0.0	7.56E-05	2.94E-05	8.11E-05
1A4a	biomass	CH4	42.108	22.089	29.1	74.8	80.3	0.0	0.0	0.0	1.97E-03	7.67E-04	2.12E-03
1A4a	gaseous	N2O	25.209	40.647	7.9	131.7	132.0	0.0	0.0	0.0	6.39E-03	3.83E-04	6.40E-03
1A4a	gaseous	CO2	13,605.153	21,971.515	8.0	2.7	8.5	0.2	0.6	1.9	7.03E-02	2.11E-01	2.22E-01
1A4a	gaseous	CH4	0.604	1.153	8.9	73.8	74.3	0.0	0.0	0.0	1.02E-04	1.22E-05	1.02E-04
1A4a	liquid	N2O	64.143	28.224	9.1	136.1	136.4	0.0	0.0	0.0	4.58E-03	3.06E-04	4.59E-03
1A4a	liquid	CO2	27,632.854	12,460.396	8.8	2.6	9.2	0.1	0.4	1.1	3.94E-02	1.31E-01	1.37E-01
1A4a	liquid	CH4	0.191	0.136	7.4	53.5	54.1	0.0	0.0	0.0	8.68E-06	1.19E-06	8.76E-06
1A4a	solid	N2O	48.502	28.688	6.7	47.7	48.2	0.0	0.0	0.0	1.63E-03	2.29E-04	1.65E-03
1A4a	solid	CO2	22,711.623	1,418.362	4.9	2.1	5.3	0.0	0.0	0.1	3.53E-03	8.21E-03	8.94E-03
1A4a	solid	CH4	1,173.197	39.494	4.8	52.0	52.2	0.0	0.0	0.0	2.45E-03	2.26E-04	2.46E-03
1A4b	biomass	N2O	43.059	90.168	32.3	75.0	81.7	0.0	0.0	0.0	8.07E-03	3.48E-03	8.79E-03
1A4b	biomass	CH4	234.948	396.562	32.3	75.0	81.7	0.0	0.1	0.0	3.55E-02	1.53E-02	3.86E-02
1A4b	gaseous	N2O	54.375	67.322	12.5	150.0	150.5	0.0	0.0	0.0	1.21E-02	1.00E-03	1.21E-02
1A4b	gaseous	CO2	31,714.419	48,374.648	12.5	3.0	12.8	0.6	2.0	4.1	1.73E-01	7.19E-01	7.40E-01
1A4b	gaseous	CH4	13.085	42.153	12.5	75.0	76.0	0.0	0.0	0.0	3.77E-03	6.27E-04	3.82E-03
1A4b	liquid	N2O	146.739	78.689	14.3	141.6	142.3	0.0	0.0	0.0	1.33E-02	1.35E-03	1.34E-02
1A4b	liquid	CO2	56,344.410	34,095.022	14.4	2.9	14.7	0.4	1.7	2.9	1.16E-01	5.87E-01	5.99E-01
1A4b	liquid	CH4	3.130	3.331	6.8	48.4	48.9	0.0	0.0	0.0	1.93E-04	2.70E-05	1.94E-04
1A4b	solid	N2O	557.726	85.434	6.9	33.9	34.6	0.0	0.0	0.0	3.46E-03	7.05E-04	3.53E-03
1A4b	solid	CO2	41,415.142	3,480.171	5.3	1.8	5.6	0.0	0.1	0.3	7.48E-03	2.21E-02	2.33E-02
1A4b	solid	CH4	949.243	80.289	5.9	45.6	46.0	0.0	0.0	0.0	4.37E-03	5.61E-04	4.40E-03
1A4c	biomass	N2O	2.857	4.317	28.3	72.7	78.0	0.0	0.0	0.0	3.75E-04	1.46E-04	4.02E-04
1A4c	biomass	CH4	18.534	13.511	28.9	74.2	79.7	0.0	0.0	0.0	1.20E-03	4.65E-04	1.28E-03
1A4c	gaseous	N2O	0.898	1.266	7.9	131.7	132.0	0.0	0.0	0.0	1.99E-04	1.19E-05	1.99E-04
1A4c	gaseous	CO2	484.838	684.203	8.0	2.7	8.5	0.0	0.0	0.1	2.19E-03	6.57E-03	6.93E-03
1A4c	gaseous	CH4	0.021	0.036	8.9	73.8	74.3	0.0	0.0	0.0	3.16E-06	3.79E-07	3.18E-06
1A4c	liquid	N2O	29.946	22.632	1.3	28.2	28.2	0.0	0.0	0.0	7.61E-04	3.62E-05	7.62E-04
1A4c	liquid	CO2	7,483.989	4,879.198	2.2	2.2	3.1	0.0	0.1	0.4	1.29E-02	1.27E-02	1.81E-02

IPCC Source	Fuel Category	Gas	Base year emissions	Year t emissions (HQG)	Uncertainty Activity Data	Uncertainty Emission Factors / Emissions	Combined Uncertainty	Combined Uncertainty as % of total national emissions in year t	Tier1 Level Assesment	Type B sensitivity	Uncertainty in trend introduced by EF uncertainty	Uncertainty in trend introduced by AR uncertainty	Uncertainty introduced into the trend in total
Category			[Gg CO_2 equivalent]	[Gg CO_2 equivalent]	Input Data [%]	Input Data [%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1A4c	liquid	CH4	12.854	9.051	0.9	35.7	35.7	0.0	0.0	0.0	3.85E-04	9.37E-06	3.85E-04
1A4c	solid	N2O	6.831	4.723	6.8	48.7	49.2	0.0	0.0	0.0	2.75E-04	3.84E-05	2.77E-04
1A4c	solid	CO2	2,948.291	164.401	6.4	2.7	6.9	0.0	0.0	0.0	5.36E-04	1.25E-03	1.36E-03
1A4c	solid	CH4	145.482	3.211	7.0	74.7	75.1	0.0	0.0	0.0	2.86E-04	2.67E-05	2.88E-04
1A5	gaseous	N2O	0.821	0.646	9.0	150.0	150.3	0.0	0.0	0.0	1.16E-04	6.94E-06	1.16E-04
1A5	gaseous	CO2	509.516	402.674	9.0	3.0	9.5	0.0	0.0	0.0	1.44E-03	4.32E-03	4.56E-03
1A5	gaseous	CH4	0.004	0.006	9.0	75.0	75.5	0.0	0.0	0.0	5.24E-07	6.29E-08	5.28E-07
1A5	liquid	N2O	48.488	7.814	4.5	110.2	110.3	0.0	0.0	0.0	1.03E-03	4.21E-05	1.03E-03
1A5	liquid	CO2	6,630.932	875.216	3.1	2.1	3.7	0.0	0.0	0.1	2.17E-03	3.21E-03	3.87E-03
1A5	liquid	CH4	26.559	4.122	5.7	45.9	46.2	0.0	0.0	0.0	2.26E-04	2.78E-05	2.27E-04
1A5	solid	N2O	15.108	0.109	7.0	50.0	50.5	0.0	0.0	0.0	6.52E-06	9.13E-07	6.59E-06
1A5	solid	CO2	4,657.327	7.200	7.0	3.0	7.6	0.0	0.0	0.0	2.58E-05	6.01E-05	6.54E-05
1A5	solid	CH4	210.251	0.003	7.0	75.0	75.3	0.0	0.0	0.0	2.76E-07	2.58E-08	2.77E-07
1B1a	solid	CH4	18,415.178	3,982.346	0.2	138.7	138.7	0.5	1.8	0.3	6.59E-01	9.35E-04	6.59E-01
1B1b	solid	CH4	18.090	8.686	3.0	10.0	10.4	0.0	0.0	0.0	1.04E-04	3.11E-05	1.08E-04
1B1c	solid	CH4	1,806.840	73.779	0.0	150.0	150.0	0.0	0.0	0.0	1.32E-02	0.00E+00	1.32E-02
1B2a	liquid	CH4	700.406	186.388	5.7	75.3	75.5	0.0	0.0	0.0	1.68E-02	1.26E-03	1.68E-02
1B2b	gaseous	CH4	6,781.510	6,581.173	3.0	64.6	64.7	0.4	1.4	0.6	5.08E-01	2.37E-02	5.08E-01
1B2b	gaseous	CO2	0.003	0.004	0.0	150.0	150.0	0.0	0.0	0.0	6.54E-07	0.00E+00	6.54E-07
2A1		CO2	15,145.810	14,306.014	2.0	5.0	5.4	0.1	0.3	1.2	8.54E-02	3.41E-02	9.19E-02
2A2		CO2	6,135.029	5,670.919	1.9	10.4	10.6	0.1	0.2	0.5	7.06E-02	1.28E-02	7.17E-02
2A7_GI		CO2	695.617	759.347	3.0	7.6	8.2	0.0	0.0	0.1	6.87E-03	2.73E-03	7.39E-03
2A7_ZI		CO2	531.113	391.604	16.6	24.9	29.9	0.0	0.0	0.0	1.16E-02	7.77E-03	1.40E-02
2B1		CO2	4,596.386	5,200.451	5.0	50.0	50.2	0.2	0.9	0.4	3.10E-01	3.10E-02	3.12E-01
2B2		N2O	4,673.383	9,555.167	2.0	50.0	50.0	0.4	1.6	0.8	5.70E-01	2.28E-02	5.71E-01
2B3		N2O	18,804.600	5,623.503	20.0	7.0	21.2	0.1	0.4	0.5	4.70E-02	1.34E-01	1.42E-01
2B4		CO2	443.160	17.526	5.0	10.0	11.2	0.0	0.0	0.0	2.09E-04	1.05E-04	2.34E-04
2B5		N2O	292.687	62.000	20.0	75.0	77.6	0.0	0.0	0.0	5.55E-03	1.48E-03	5.74E-03
2B5		CH4	0.253	0.419	2.0	2.0	2.8	0.0	0.0	0.0	9.99E-07	9.99E-07	1.41E-06
2B5		CO2	6,869.781	10,338.090	1.4	2.9	3.2	0.0	0.1	0.9	3.53E-02	1.76E-02	3.95E-02
2C1		CH4	3.919	2.034	1.0	10.0	10.0	0.0	0.0	0.0	2.43E-05	2.43E-06	2.44E-05
2C1		CO2	48,326.016	46,243.621	4.7	4.7	6.7	0.3	1.0	3.9	2.62E-01	2.62E-01	3.70E-01
2C2		CO2	429.000	2.750	5.0	7.0	8.6	0.0	0.0	0.0	2.30E-05	1.64E-05	2.82E-05
2C3		CO2	1,011.923	757.228	1.0	15.0	15.0	0.0	0.0	0.1	1.36E-02	9.04E-04	1.36E-02
2C3		PFC´s	2,489.410	193.273	0.8	12.3	12.3	0.0	0.0	0.0	2.83E-03	1.84E-04	2.83E-03
2C4		SF6	188.810	2,355.393	0.2	26.2	26.2	0.1	0.2	0.2	7.37E-02	6.48E-04	7.37E-02
2C5		HFC´s	0.000	7.072	1.5	30.0	30.0	0.0	0.0	0.0	2.53E-04	1.30E-05	2.54E-04
2E		HFC´s	4,329.000	198.660	0.0	2.7	2.7	0.0	0.0	0.0	6.32E-04	0.00E+00	6.32E-04
2E		PFC´s	80.113	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00

IPCC Source	Fuel Category	Gas	Base year emissions	Year t emissions (HQG)	Uncertainty Activity Data	Uncertainty Emission Factors / Emissions	Combined Uncertainty	Combined Uncertainty as % of total national emissions in year t	Tier1 Level Assesment	Type B sensitivity	Uncertainty in trend introduced by EF uncertainty	Uncertainty in trend introduced by AR uncertainty	Uncertainty introduced into the trend in total
Category			[Gg CO_2 equivalent]	[Gg CO_2 equivalent]	Input Data [%]	Input Data [%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
2F		HFC´s	39.780	10,892.073	0.0	6.3	6.3	0.1	0.2	0.9	8.17E-02	0.00E+00	8.17E-02
2F		PFC´s	138.055	334.754	0.0	16.3	16.3	0.0	0.0	0.0	6.51E-03	0.00E+00	6.51E-03
2F		SF6	4,333.320	2,894.754	0.0	5.9	5.9	0.0	0.1	0.2	2.05E-02	0.00E+00	2.05E-02
2G		SF6	262.900	316.388	0.0	0.0	0.0	0.0	0.0	0.0	0.00E+00	0.00E+00	0.00E+00
3		N2O	2,088.542	1,174.007	64.9	17.3	67.1	0.1	0.3	0.1	2.42E-02	9.09E-02	9.40E-02
3		CO2	3,307.500	2,142.401	0.0	12.5	12.5	0.0	0.1	0.2	3.19E-02	0.00E+00	3.19E-02
4A1a		CH4	9,603.878	7,904.367	0.0	10.0	10.0	0.1	0.3	0.7	9.43E-02	0.00E+00	9.43E-02
4A1b		CH4	10,755.292	7,676.804	0.0	6.2	6.2	0.0	0.2	0.6	5.69E-02	0.00E+00	5.69E-02
4A2		CH4	1,444.109	1,413.339	0.0	5.3	5.3	0.0	0.0	0.1	9.00E-03	0.00E+00	9.00E-03
4B1a		CH4	1,841.699	1,677.297	0.0	20.0	20.0	0.0	0.1	0.1	4.00E-02	0.00E+00	4.00E-02
4B1b		CH4	1,530.874	1,026.860	0.0	12.9	12.9	0.0	0.0	0.1	1.59E-02	0.00E+00	1.59E-02
4B2		CH4	128.728	179.787	0.0	15.9	15.9	0.0	0.0	0.0	3.42E-03	0.00E+00	3.42E-03
4B8		CH4	2,726.977	2,593.472	0.0	16.6	16.6	0.0	0.1	0.2	5.13E-02	0.00E+00	5.13E-02
4B1a		N2O	1,040.287	881.537	0.0	25.6	25.6	0.0	0.1	0.1	2.69E-02	0.00E+00	2.69E-02
4B1b		N2O	1,284.376	912.511	0.0	15.2	15.2	0.0	0.0	0.1	1.65E-02	0.00E+00	1.65E-02
4B2		N2O	72.029	106.516	0.0	42.9	42.9	0.0	0.0	0.0	5.45E-03	0.00E+00	5.45E-03
4B8		N2O	435.343	456.400	0.0	18.7	18.7	0.0	0.0	0.0	1.02E-02	0.00E+00	1.02E-02
4B9		N2O	38.374	44.661	0.0	16.4	16.4	0.0	0.0	0.0	8.72E-04	0.00E+00	8.72E-04
4D1		N2O	22,889.252	20,087.493	0.0	378.5	378.5	6.7	24.9	1.7	9.07E+00	0.00E+00	9.07E+00
4D2		N2O	1,821.126	1,475.463	0.0	30.0	30.0	0.0	0.1	0.1	5.28E-02	0.00E+00	5.28E-02
4D3		N2O	6,693.401	5,676.336	0.0	611.6	611.6	3.1	11.5	0.5	4.14E+00	0.00E+00	4.14E+00
4D4		CH4	-674.706	-633.381	0.0	50.0	50.0	0.0	0.1	-0.1	-3.78E-02	0.00E+00	3.78E-02
5A_si		CO2	-74,399.453	-79,398.640	0.0	75.0	75.0	5.3	19.7	-6.7	-7.11E+00	0.00E+00	7.11E+00
5B		CO2	28,174.008	32,613.882	0.0	70.4	70.4	2.0	7.6	2.8	2.74E+00	0.00E+00	2.74E+00
5C		CO2	13,057.039	14,102.583	0.0	75.0	75.0	0.9	3.5	1.2	1.26E+00	0.00E+00	1.26E+00
5D		CO2	2,230.171	2,823.090	0.0	75.0	75.0	0.2	0.7	0.2	2.53E-01	0.00E+00	2.53E-01
5E		CO2	1,965.571	11,881.374	0.0	75.0	75.0	0.8	2.9	1.0	1.06E+00	0.00E+00	1.06E+00
5F		CO2	23.166	485.687	0.0	75.0	75.0	0.0	0.1	0.0	4.35E-02	0.00E+00	4.35E-02
5G		CO2	643.110	718.192	0.0	67.4	67.4	0.0	0.2	0.1	5.78E-02	0.00E+00	5.78E-02
5B		N2O	56.498	662.185	0.0	64.1	64.1	0.0	0.1	0.1	5.07E-02	0.00E+00	5.07E-02
6A		CH4	35,910.000	8,211.000	0.0	12.5	12.5	0.1	0.3	0.7	1.22E-01	0.00E+00	1.22E-01
6B		CH4	2,226.214	107.755	0.0	45.3	45.3	0.0	0.0	0.0	5.82E-03	0.00E+00	5.82E-03
6B		N2O	2,223.526	2,339.032	0.0	75.0	75.0	0.2	0.6	0.2	2.09E-01	0.00E+00	2.09E-01
6D		CH4	49.778	542.119	1.4	42.1	42.1	0.0	0.1	0.0	2.72E-02	9.09E-04	2.73E-02
6D		N2O	13.983	318.775	0.9	48.3	48.3	0.0	0.1	0.0	1.84E-02	3.61E-04	1.84E-02
Total			**1,185,141.6**	**940,001.4**				**9.7**	**100.0**				**12.97**

Uncertainties for source categories have been determined successively, within the framework of UBA sections' data deliveries for current emissions reporting. At the same time, guideline-supported experts' assessments are being continued especially in those source categories in which no uncertainties information, or only incomplete information, has been provided to date in the framework of contributions/support.

Uncertainties in the source category Agriculture (CRF 4) are being estimated by experts in the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) and in the Federal Agricultural Research Institute (FAL).

Current work planning calls for Tier-2 uncertainties analysis to be carried out every three years. In interim years, uncertainties are reported pursuant to a Tier-1 approach.

The first Tier-2 uncertainties analysis was carried out in the past report year.