Submission under the United Nations Framework Convention on Climate Change 2008

National Inventory Report

For the German Greenhouse Gas Inventory

1990 - 2006

Federal Environment Agency

(Umweltbundesamt)

Dessau, May 2008

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* (*Nationalen Systems Emissionsinventare*; NaSE), sited within the Federal Environment Agency (UBA). The information on agriculture, changes in land use and forestry was provided by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) and the Federal Agricultural Research Institute (Bundesforschungsanstalt für Landwirtschaft; FAL).

The electronic version of this report, along with the pertinent emissions data in the Common Reporting Format (CRF) (Version 1.00, based on the CSE database, and last revised as of 29 November 2006), is available on the Web site of the Federal Environmental Agency: http://www.umweltbundesamt.de/emissionen/veroeffentlichungen.htm

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Chapter 4.3.5	N.N.
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Chapters 7.4, 7.5	N.N.
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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
Corg	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}	Einwohner mit Kläranlagenanschluss (Inhabitants connected to wastewater-treatment systems)
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
EU	European Union
EU-EH	European Emissions Trading System (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
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
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 category (Hauptquellgruppe); includes 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	Institute for Energy and Environment (Institut für Energetik und Umwelt)
IFEU	Institute for Energy and Environmental Research (Institut für Energie- und Umweltforschung)
IKW	Industrial power stations
IMA	Interministerial Working Group (Interministerielle Arbeitsgruppe)
IPCC	Intergovernmental Panel On Climate Change
K	Fuel input for power generation (direct drive)
k.A.	keine Angabe (no entry)
KP	Kyoto Protocol
KS	Sewage sludge

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
MFC	Factor for quality of landfill-gas management (methane correction factor)
MS	Medium voltage
MSW	Amount of municipal waste stored
MVA	Waste incineration plant (Müllverbrennungsanlage)
MW	Megawatt
N_2O	Nitrous oxide (laughing gas)
NA	Not applicable
NASA	National Aeronautics and Space Administration
NaSE	National System of Emissions Inventories
NBL	New German Länder
NE	Not estimated
NEAT	Non-energy Emission Accounting Tables
NEC	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)
NH_3	Ammonia
NIR	National Inventory Report
NMVOC	Non-Methane Volatile Organic Compounds
NO	Not occurring
NO	Nitrogen monoxide
NSCR	Non-selective catalytic reduction
OCF	One-component foam (installation foam)
OX	Oxidation factor
PAH	Polycyclic aromatic hydrocarbons (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	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
SF_6	Sulphur hexafluoride
SKE	Hard-coal units (Steinkohleneinheiten)
SNAP	Selected Nomenclature for Air Pollution
SO_2	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
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
cal	calorie
g	gram
h	hour
ha	hectare
J	joule
m^3	cubic metre
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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 uncertaintaies	T	U	-	-	-	U				
Method of EF determination	CS	Tier 2	-	-	-	Tier 2				

Key category

The upper section of the table shows the key-category-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 very 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 an annual National Inventory Report (NIR) 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 now, on a voluntary basis, to fulfill this reporting obligation.

Germany now presents its sixth National Inventory Report (NIR 2008), following its inventories for the years 1990 to 2006. This latest report covers the same period (1990 to 2006), 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 2007, 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 2007 National Inventory Report, because the quality assurance system has now been applied to the entire emissions reporting process. In particular, a relevant inventory plan has been derived and implemented, and minimum requirements have been defined with regard to quality checking and quality assurance in emissions reporting. No changes have been made in the methods used to calculate emissions.

General information on recalculations and improvements 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, changes in land use and forestry were provided by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) and the Federal Agricultural Research Institute (Bundesforschungsanstalt für Landwirtschaft, FAL).

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 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

[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]

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: 1990-2006

By 2006, Germany had already fulfilled a large part of its obligations within the framework of the aforementioned European burden-sharing, amounting to a reduction of 18.4 % with regard to the base-year emissions reported in 2006[5] , 1,232,429.543 Gg of CO_2 equivalents (cf. Figure 1). Emissions remained virtually unchanged with respect to the previous year.

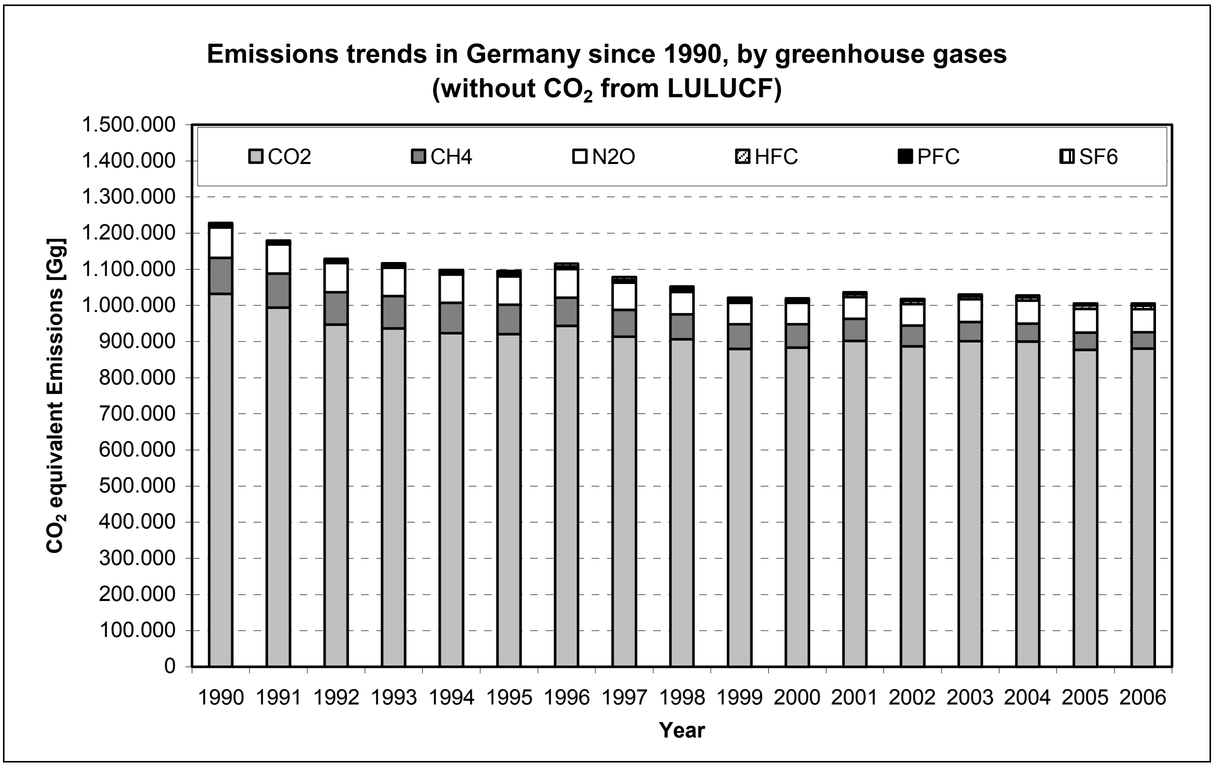


Figure 1: Development of greenhouse gases in Germany since 1990, by greenhouse gases [6]

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 2006, carbon-dioxide releases were the most significant greenhouse-gas emissions, accounting for 87.6 % of all such emissions. Most of the carbon dioxide is released via stationary and mobile combustion. As a result of a disproportionately large reduction of other greenhouse-gas emissions, CO_2 emissions' share of total emissions has increased by 3.8 percentage points since the base year. Methane (CH_4) emissions from animal husbandry, fuel distribution and landfills account for 4.6 %. Emissions of nitrous oxide (N_2O), caused primarily by agriculture, industrial processes and transport, contribute 6.3 % of greenhouse-gas releases. Fluorocarbons (so-called "F gases") account for about 1.6 % of total emissions.

[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.

The distribution of Germany's greenhouse-gas emissions is typical for a highly developed and industrialised country.

Emissions of the individual relevant greenhouse gases are calculated for the source categories and sinks defined by the IPCC. The greenhouse-gas inventories do not take account of chemical reactions, in the atmosphere, of C-containing compounds (such as NMVOC as solvents) not emitted as CO_2.

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

GHG Emissions/Removals	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
	CO_2 equivalent (Gg)																
Net CO_2 emissions/removals	1,003,557	964,798	916,483	906,192	891,378	889,252	911,347	880,531	873,185	846,492	849,038	866,291	851,198	864,943	863,566	840,314	843,433
CO_2-emissions (w/o LULUCF)	1,032,172	994,270	946,633	936,824	922,655	920,789	943,316	912,899	905,812	879,580	883,392	901,418	886,547	900,813	899,819	876,811	880,253
CH_4	99,266	93,881	89,753	89,301	84,746	81,476	78,372	74,532	69,279	68,565	64,704	61,418	57,852	53,757	49,583	47,678	45,879
N_2O	84,763	80,354	81,116	77,633	78,026	77,679	78,872	75,659	62,465	59,097	59,486	60,421	59,759	62,400	64,619	66,119	63,353
HFCs	4,369	4,013	4,098	4,224	4,354	6,472	5,853	6,384	6,951	7,192	6,469	7,878	8,542	8,381	8,669	9,362	9,815
PFCs	2,708	2,333	2,102	1,961	1,650	1,750	1,714	1,369	1,473	1,243	786	723	795	858	830	718	582
SF_6	4,785	5,118	5,634	6,405	6,694	7,220	6,929	6,903	6,701	5,310	5,078	4,898	4,197	4,311	4,486	4,734	5,333

Total Emissions/Removals with LULUCF	1,199,447	1,150,497	1,099,186	1,085,715	1,066,847	1,063,849	1,083,087	1,045,377	1,020,053	987,899	985,561	1,001,628	982,343	994,650	991,753	968,925	968,395
Total Emissions without CO2 from LULUCF	1,228,063	1,179,969	1,129,336	1,116,348	1,098,124	1,095,385	1,115,055	1,077,746	1,052,680	1,020,987	1,019,916	1,036,756	1,017,692	1,030,521	1,028,005	1,005,422	1,005,215

GHG Emissions/Removals	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
GHG Emission Source and Sink Categories	CO_2 equivalent (Gg)																
1. Energy	987,692	952,637	904,695	897,804	875,562	871,146	897,435	861,331	852,723	830,505	828,119	848,872	833,476	845,291	840,644	819,362	818,905
2. Industrial Processes	119,799	114,432	114,433	110,734	118,976	121,275	117,242	119,939	106,040	97,676	100,929	99,659	99,782	102,972	107,063	107,139	108,178
3. Solvent and Other Product Use	2,089	2,005	1,922	1,839	1,756	1,673	1,590	1,507	1,423	1,340	1,257	1,174	1,174	1,174	1,174	1,174	1,174
4. Agriculture	77,685	70,132	68,129	67,001	64,968	66,589	66,581	65,486	65,688	66,951	67,122	66,586	64,612	64,287	63,957	63,542	63,542
5. Land-Use Change and Forestry	-28,241	-29,097	-29,775	-30,258	-30,902	-31,162	-31,593	-31,994	-32,252	-32,713	-33,933	-34,706	-34,927	-35,449	-35,831	-36,076	-36,399
CO_2	-28,616	-29,472	-30,150	-30,633	-31,277	-31,537	-31,968	-32,369	-32,627	-33,088	-34,354	-35,128	-35,349	-35,870	-36,252	-36,497	-36,821
N_2O	375	375	375	375	375	375	375	375	375	375	422	422	422	422	422	422	422
6. Waste	40,423	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	14,746	13,783	12,995

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

GHG Emission Fractions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
without CO2 from LULUCF	(%)																
CO_2 -Emissionen (ohne LULUCF)	84.0	84.3	83.8	83.9	84.0	84.1	84.6	84.7	86.0	86.2	86.6	86.9	87.1	87.4	87.5	87.2	87.6
CH_4	8.1	8.0	7.9	8.0	7.7	7.4	7.0	6.9	6.6	6.7	6.3	5.9	5.7	5.2	4.8	4.7	4.6
N_2O	6.9	6.8	7.2	7.0	7.1	7.1	7.1	7.0	5.9	5.8	5.8	5.8	5.9	6.1	6.3	6.6	6.3
HFCs	0.4	0.3	0.4	0.4	0.4	0.6	0.5	0.6	0.7	0.7	0.6	0.8	0.8	0.8	0.8	0.9	1.0
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
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	0.4	0.5	0.5
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

GHG Emissions Fractions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Categories without CO_2 from LULUCF	(%)																
1. Energy	80.4	80.7	80.1	80.4	79.7	79.5	80.5	79.9	81.0	81.3	81.2	81.9	81.9	82.0	81.8	81.5	81.5
2. Industrial Processes	9.8	9.7	10.1	9.9	10.8	11.1	10.5	11.1	10.1	9.6	9.9	9.6	9.8	10.0	10.4	10.7	10.8
3. Solvent and Other Product Use	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
4. Agriculture	6.3	5.9	6.0	6.0	5.9	6.1	6.0	6.1	6.2	6.6	6.6	6.4	6.3	6.2	6.2	6.3	6.3
5. Land-Use Change and Forestry	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6. Waste	3.3	3.4	3.5	3.5	3.3	3.1	2.9	2.7	2.5	2.4	2.2	1.9	1.8	1.6	1.4	1.4	1.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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 dominance of energy-related emissions. On the other hand, energy-related emissions have continuously decreased over time. The slight re-increase seen, especially in 1996, is temperature-related. That year had lower winter temperatures, leading to intensified energy consumption for indoor heating and, thereby, to higher emissions.

Overall, greenhouse-gas emissions have decreased considerably with respect to the base year (decrease of CO_2-equivalent emissions by 18.4 %). 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 by amount are as follows: -14.7 % for carbon dioxide (CO_2), -53.8 % for methane (CH_4) and -25.3 % for nitrous oxide / laughing gas (N_2O). The corresponding trends for the so-called "F" gases, which contribute about 1.6 % of greenhouse-gas emissions overall, have not been as clearly similar to each other, however. In keeping with the introduction of new technologies, and with use of these substances as substitutes, since base year 1995 SF_6 emissions decreased by 26.1 % and PFC emissions dropped by 66.7 %, while HFC emissions increased by 51.7 %.

These emissions changed hardly at all with respect to the previous year, 2005 (the decrease amounted to 0.02 %). A 0.4 % increase in CO_2 emissions, resulting from increases in energy consumption and in iron and steel production, was offset by 3.8 % and 4.2 % reductions, respectively, in methane and nitrous oxide emissions. The main factors contributing to the methane reductions include significant increases in use of pit gas and continuing decreases in waste-sector emissions. The main reason for the decrease in nitrous oxide emissions is a decrease in emissions from adipic acid and nitric acid production.

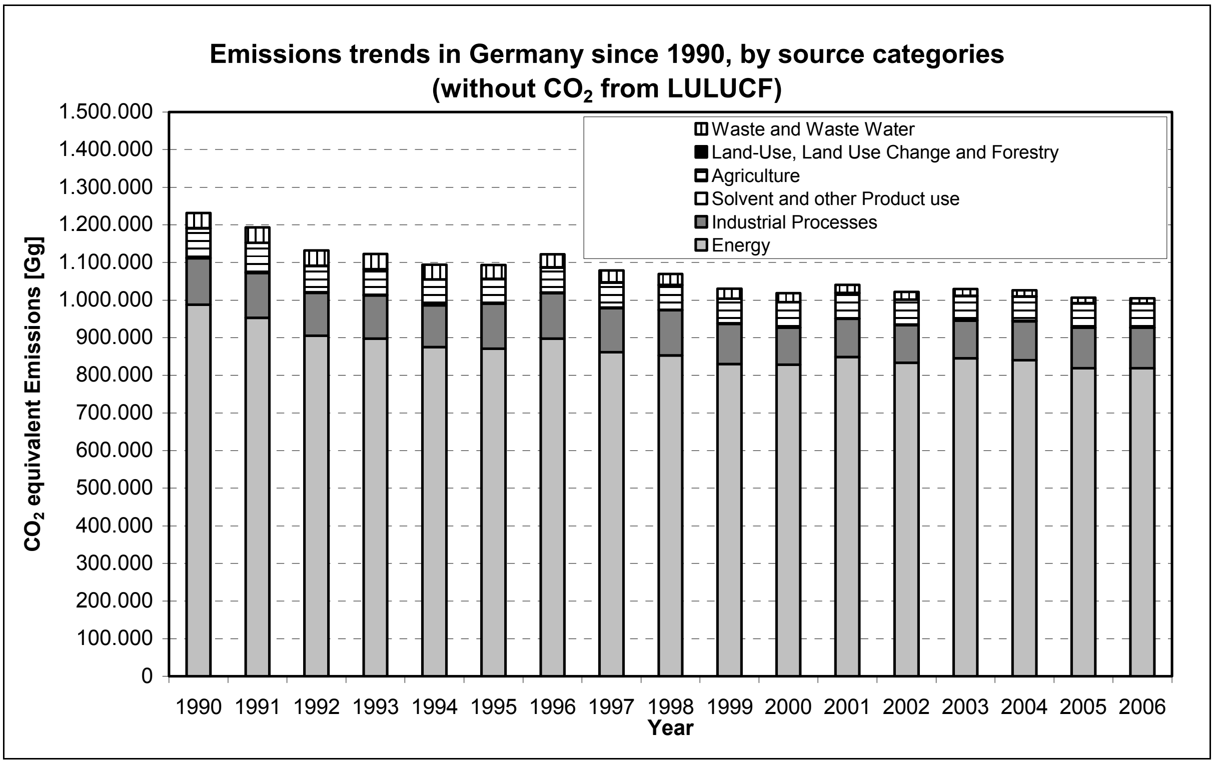


Figure 2: Emissions trends in Germany since 1990, by source categories[7]

Figure 2 shows the relative developments of emissions from source 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.

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

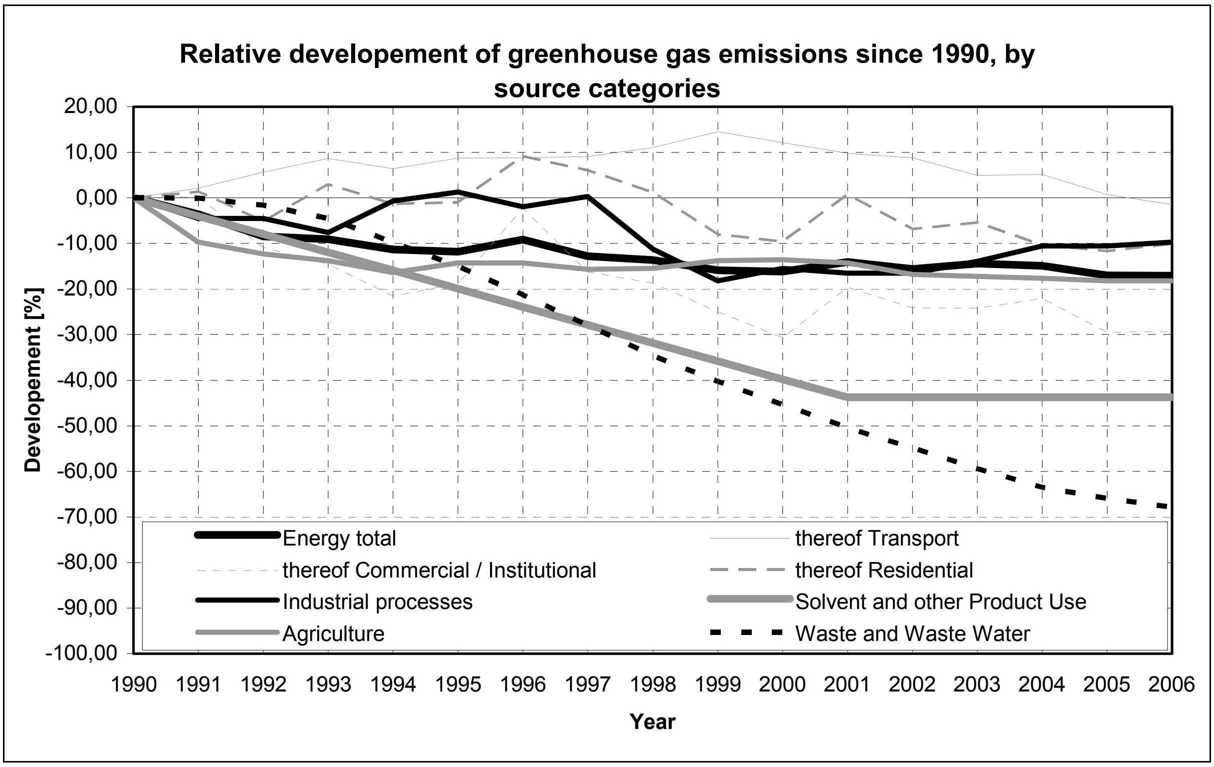


Figure 3: Relative development of greenhouse-gas emissions since 1990, by source categories[8] [9]

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

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

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.

Although the Parties, acting on the basis of findings of the IPCC's fourth Assessment Report, have already begun negotiating with regard to more extensive obligations, the carbon-dioxide intensity of the world's energy supply has begun increasing again – the previous slow, decreasing trend has reversed since the year 2000.

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

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 checking compliance are reliable. As a result, national reporting and the subsequent international review of emissions inventories play a key role.

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 continual 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 Affairs (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 state's key institutions that are in a position to make high-quality specialised contributions to it. Sufficient resources are being provided for proper fulfillment of all tasks in greenhouse-gas reporting.

In keeping with an agreement reached by state secretaries of the aforementioned ministries, a paper of 5 June 2007 on basic principles, entitled "National System", set forth, with regard to emissions reporting, that existing emissions-reporting structures are to be retained and that the Federal Environment Agency is to serve as the Single Entity (National Co-ordinating Agency) for Germany. The relevant state secretaries' resolution defines the distribution of tasks and responsibilities pertaining to the various source and sink categories, along with the necessary relevant financing for 2008.

The policy paper "National System" of 5 June 2007 on basic principles of emissions reporting, is provided in Annex Chapter 17.1.

1.2.1 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 – SNE). Via its internal directive 11/2005, the Federal Environment Agency has made its Section I 4.6 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. During the 2003-2005 period, the Single National Entity has given priority to developing new data sources and to identifying institutions and organisations that need to be added to the *National System*. The instruments through which such efforts have been carried out have included a workshop on the *National System* that took place at the end of 2004 (cf. Chapter 1.2.3.8). Other important work in this connection has included the introduction of the Quality System of Emissions Inventories (cf. Chapter 1.2.3.7) and further institutionalisation of the *National System* (cf. Chapter 1.2.3).

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

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 can be included in the quality management process. 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. The QSE is described in detail in Chapter 1.2.5.

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 instrument contains all tabular documents for the QC/QA (QC/QA plan, checklists, lists of responsibilities, etc.. In addition, the PlaSte also contains all tabular correspondence relative to the inventory reviews, including the German responses, since the 2004 report year.

The manner in which these instruments interact in implementation of quality measures within the framework of inventory preparation is outlined in Figure 4.

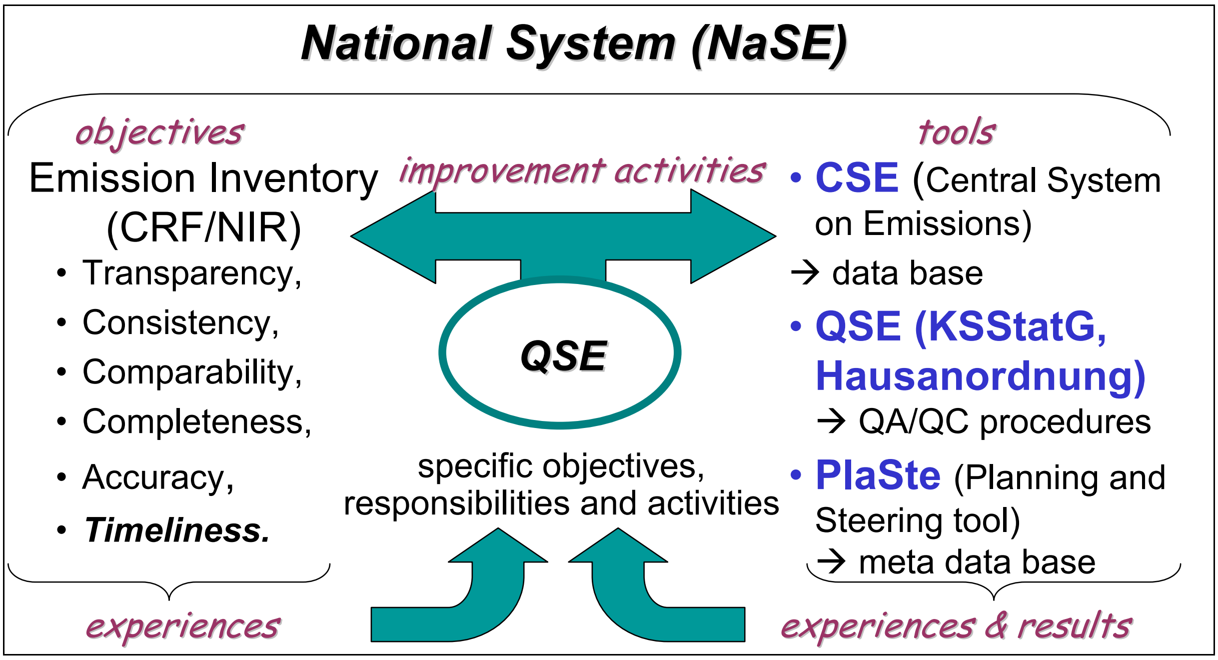


Figure 4: NaSE - Objectives and instruments

1.2.3 Institutional and legal specifications of the National System

In the last three years, decisive progress has been made in institutionalising the National System. This has been accomplished via an agency directive for the Federal Environment Agency (cf. Chapter 1.2.3.2), through development of a procedure for using monitoring data from European emissions trading (cf. Chapter 1.2.3.3) and through drafts of relevant agreements between the *Single National Entity*, other federal institutions and non-governmental organisations (cf. Chapter 1.2.3.5).

1.2.3.1 Working Group on Emissions Inventories within 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 ten times since it was established. Necessary information is provided via the Working Group's events and through an intranet area devoted to emissions reporting.

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

1.2.3.3 Procedure for using monitoring data from European emissions trading

In efforts to fulfil mandatory quality criteria, demands have been raised – especially within the EU – using data from the EU Emissions Trading System (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 general procedures for individual data queries related to inventory preparation. In the main, these procedures involve 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.

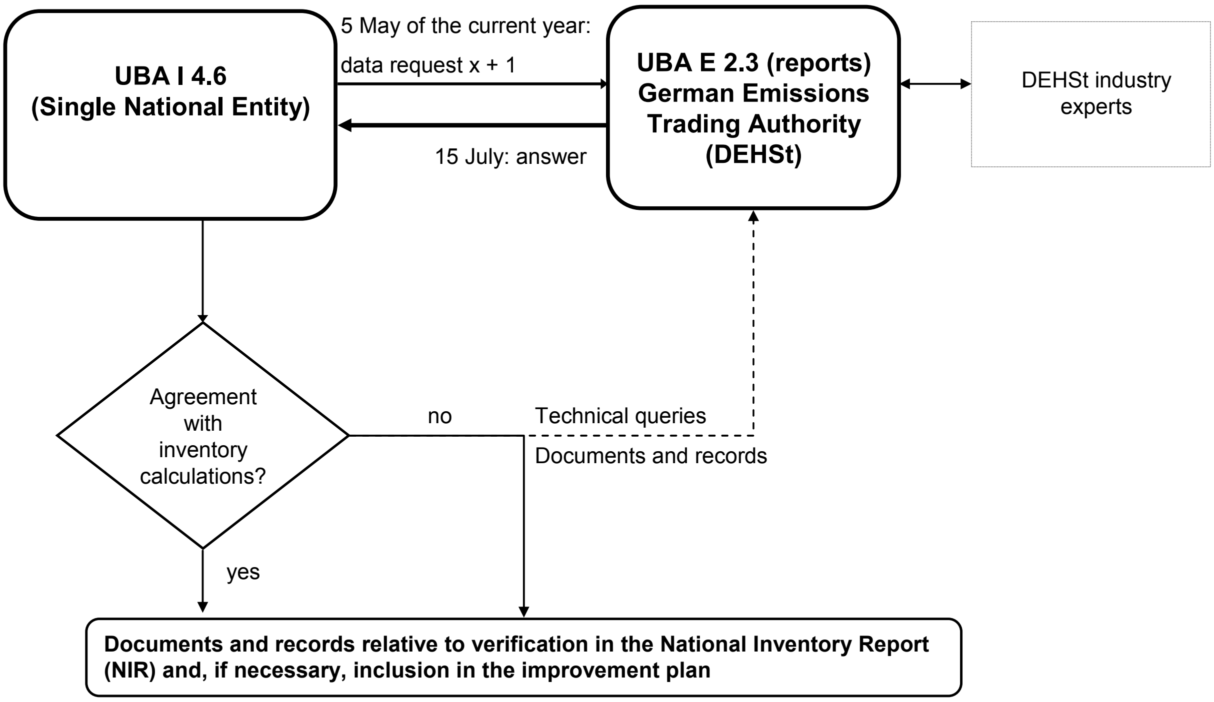


Figure 5: Procedural flow for annual inventory verification using ETS monitoring data

1.2.3.4 Budget positions 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 2002-2007 period, the Single National Entity has had a global project on *updating emissions-calculation methods*, a framework for initiating measures for continuous inventory improvement.

In addition, a separate budget position 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 position can be used to fund short-term projects for inventory improvement, within the Agency's responsibility.

1.2.3.5 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, via relevant calculations. In some cases, required data may be provided by reliable third parties.

The "National System" policy paper of 5 June 2007 on basic principles of emissions reporting is provided in Annex Chapter 17.1. Pertinent implementation status is presented in Annex Chapter 17.1.1.

1.2.3.6 National system relative to 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).

On 1 Januar 2008, as part of a restructuring of the BMELV's departmental research, oriented to changes of emphasis, the Johann Heinrich von Thünen Institute (vTI), Federal Research Institute for Rural Areas, Forestry and Fisheries (Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei), was founded. This research institute, which has the status of a higher federal authority, will provide scientific support for the Federal Government's policy-oriented decision-making. Its focuses will include climate-protection issues, and it will assume all of the climate-reporting tasks of the Federal Agricultural Research Institute (FAL) and the Federal Research Centre for Forestry and Forest Products (BFH).

A range of open issues relative to responsibilities, communications within the vTI and with the Single National Entity and certain aspects of reporting, including quality control and management, will be solved by the end of 2008. These efforts will also extend to a comprehensive reporting concept and to scheduling.

1.2.3.7 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.

The BMU has been negotiating mit EUROCONTROL since the end of 2006 regarding an agreement on exchange of air-traffic data. Current plans call for a pertinent agreement to be signed in 2008.

1.2.3.8 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 promotes 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.

1.2.3.9 Cross Country Review

In 2004, a first cross-country review was carried out, covering the key categories of energy and agriculture. This review, which was carried out in co-operation with Finland, proved to be of great use with regard to inventory improvement, and it was widely noted throughout the EU. This instrument as well, like the series of workshops on the National System, will continue to be used, because it facilitates effective implementation of requirements of Paragraph 15 (c) of the *Guidelines for National Systems*, calling for more intensive independent review of key categories.

1.2.4 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:

5 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
1 November	Internal co-ordination within the Federal Environment Agency
as of 15 November	Final quality assurance by the QSE/ZSE/NIR co-ordinator
30 November	Report of the Single National Entity to the Ministry, for commencement of inter-ministerial co-ordination
30 December	Approval via departmental co-ordination (initiated by BMU)
2 January	Final editing by the Federal Environment Agency's national co-ordinating agency (single national entity)
15 January	Report (CRF and certain parts of the NIR) to the European Commission (in the framework of the CO_2 Monitoring Mechanism) and to the European Environmental 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 Environmental 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

1.2.5 The Quality System for Emissions Inventories

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

The QSE covers all participants of the NaSE. Within the Federal Environment Agency, the QSE has been made binding via the agency's internal directive (UBA-Hausanordnung) 11/2005 (cf. Chapter 1.2.3.1). Details regarding making the QSE binding for other NaSE participants are provided in the Annex, in 17.1.

1.2.5.1 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 largely by Chapter 8 of the *IPCC Good Practice Guidance*.

From those provisions, the Federal Environment Agency has derived its own "General minimum requirements pertaining to quality control and quality assurance in connection with greenhouse-gas-emissions reporting" (cf. Chapter 17.2). Other National System participants will adopt minimum requirements after representatives 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) approve the aforementioned minimum requirements in the framework of the co-ordinating committee for the National System of Emissions Inventories (cf. Annex Chapter 17.1).

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.

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

Within the QSE framework, a concept for an 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 co-ordinator (NIRK)	Co-ordination of supporting textual work, preparation of the NIR from the various relevant contributions, overarching QC and QA for the NIR	An appointed staff member of the Single National Entity (SNE)
CSE Co-ordinator (ZSEK)	Overarching QC and QA throughout the entire inventory process Ensuring the integrity of databases Emissions reporting and data aggregation into report formats	An appointed staff member of the Single National Entity (SNE)
QC/QA 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

1.2.5.3 Organisation for operating 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 (see Figure 6).

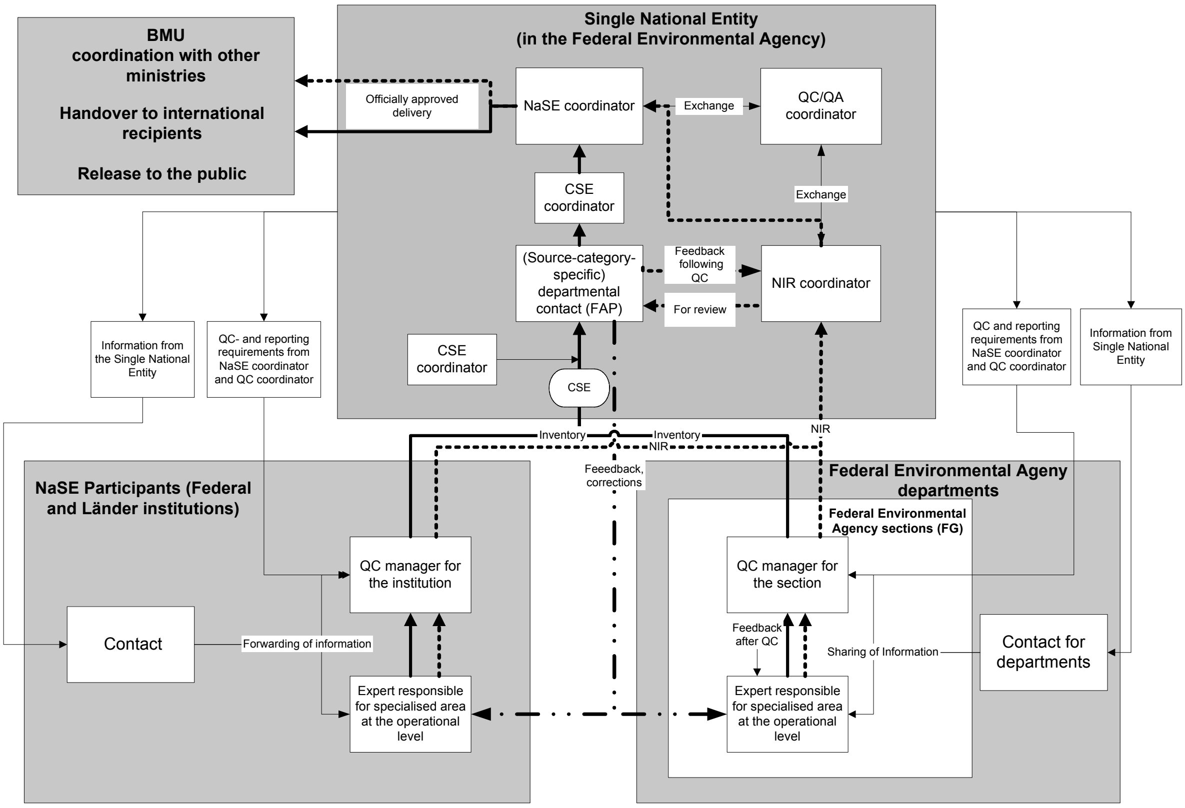


Figure 6: QSE – Roles, responsibilities and work procedures

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 in 2005. They were sent to the involved experts, in the form of QC checklists containing data requests, and then were completed throughout the course of support work. 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. 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 source-category-specific QC checks in accordance with Tier 2 and oriented to key categories.

1.2.5.4 Documentation in the Quality System of 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) 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 7.

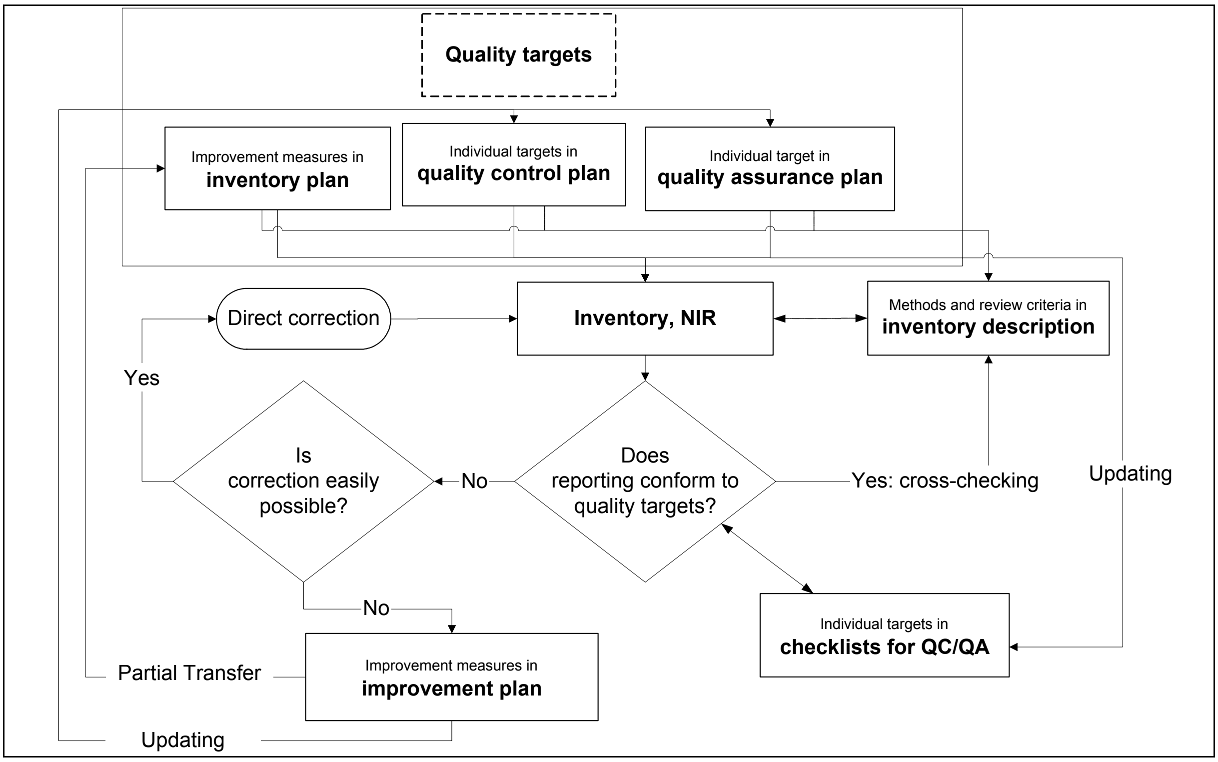


Figure 7: NaSE & QSE – control and documentation

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, 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 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 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. The checklists are oriented not to execution of specific reviews, but to the achievement of specified quality objectives. Such quality control checklists are to be filled out by NaSE participants[12] along with inventory preparation. They are designed to

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

[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

provide information about the quality of the data and methods on which the inventory is based. In 2005, the UBA carried out the first system quality controls in co-operation with the NaSE participants, via checklists.

The two plans and the QC checklists taken together thus 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 prepared defined documentation was introduced in the Federal Environment Agency via an internal directive (cf. Chapter 1.2.5.5). 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:

- The body of data that provides the basis for calculating the German inventory is extensive, and non-centralised,
- Responsibility for that data is distributed,
- For legal reasons, confidentiality considerations apply that 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.

1.2.5.5 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

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) 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 (Tier 1),
- The quality assurance plan (Tier 1),
- The role-specific QC/QA checklists,
- The improvement plan,
- The requirements for reporting from the Guidelines,
- The results of inventory reviews,
- The available data for each source category (source-category-specific data),
- The results of assessment of key categories,
- The NIR,
- The CRF Table 8(b) for documentation of recalculations (for sample completion),
- 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.

1.2.5.6 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 correspondence relative to inventory reviews, including German responses, has been stored in a searchable Access database that also contains the tabular documents for the national QC/QA. The PlaSte planning and control instrument will be the most important instrument for monitoring success in the QSE framework.

1.2.5.7 Use of EU ETS monitoring data for improvement of GG-emissions inventories

Monitoring data from the European emissions trading system (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 regime.

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 via which data from verified emissions reports can be compared with data from the inventories' database on a year-by-year basis. The comparisons, which have been carried out only once to date, have confirmed, in principle, the usefulness of such comparisons for verifying individual source categories and identifying data gaps. 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 1.2.3.3).

1.3 Short description of inventory preparation

The emissions-reporting process is a regular, annual process. Decentralised, and carried out by a range of different persons, it can vary extensively, depending what part of the inventory is concerned. For this reason, in 2003, prior to the introduction of the QSE, this process was 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.

These main processes are broken down into sub-processes (cf. Figure 8). 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*.

[13] FKZ 205 41 521

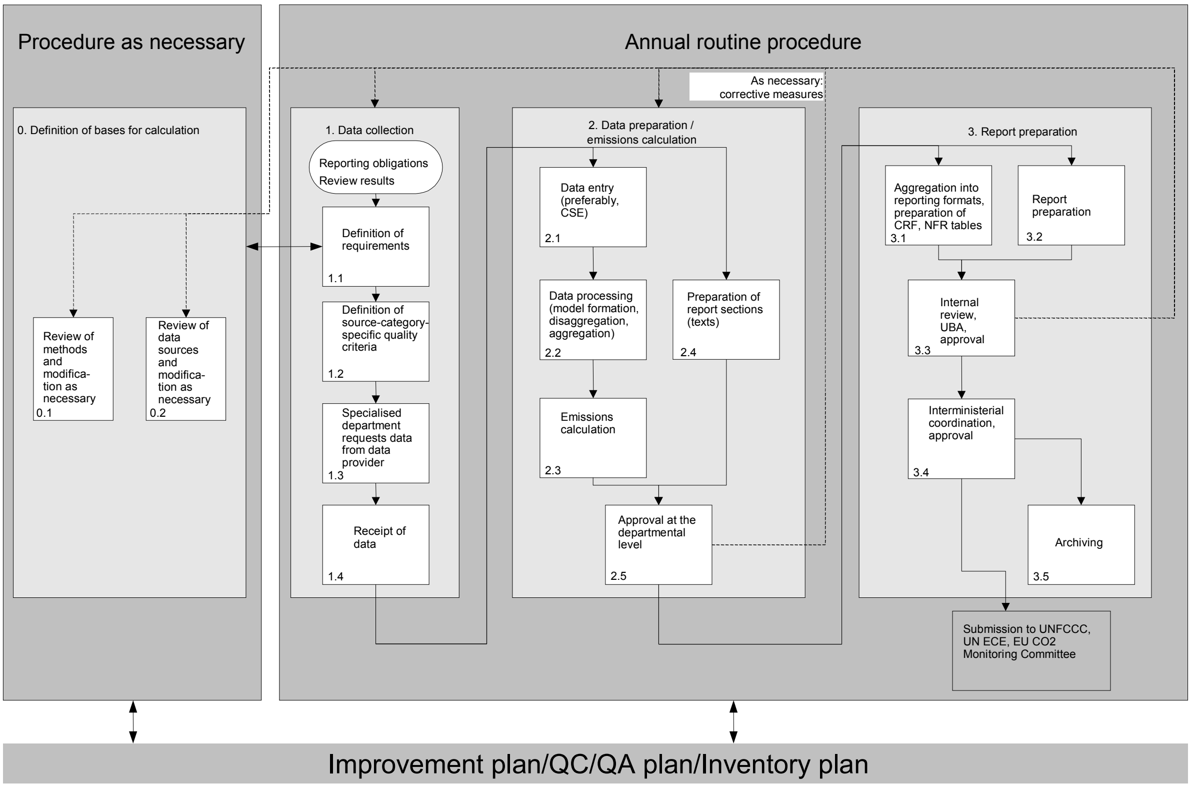


Figure 8: Overview of the emissions-reporting process

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 category". 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 emission 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 categories 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 8.

The following sub-processes are considered preliminary processes:

- Determination of key categories (pursuant to Tier 1, in keeping with Chapter 7.2 of the *IPCC Good Practice Guidance*);
- Calculation and aggregation of uncertainties relative to emissions, using Monte Carlo simulation (pursuant to Tier 1 or Tier 2, in keeping with the *IPCC Good Practice Guidance*);
- Expanded determination of key categories via Monte Carlo simulation (pursuant to Tier 2, in keeping with Chapter 6.4 of the *IPCC Good Practice Guidance*).

1.3.2 Determination of key categories (pursuant to Tier 1)

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

The key categories have been defined by applying two Tier 1 procedures, Level (for the base year and for 2006) and Trend (for 2006, 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.

1.3.3 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 have been 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.

1.3.4 Expanded determination of key categories

Expanded determination of key categories, 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.

1.3.5 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.

1.3.6 Data collection

Data collection and documentation take place under the responsibility of the relevant experts. An organisation may collect data by evaluating statistics from official sources or from associations, studies, periodicals or external research projects, by conducting its own research projects, by obtaining information from relevant persons, or by accessing data exchanges between the Federal Government and the *Länder*. 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.

1.3.7 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. 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.

1.3.8 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,
- Inter-departmental co-ordination, followed by
- 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) and for the UN ECE Geneva Convention on Long-range Transboundary Air Pollution (NFR = New Format on reporting), **emissions data** from CSE time series (in the data-collection format) must be **aggregated** into the CRF/NFR source-category **report formats**. This is accomplished via hierarchical allocation within the CSE, a process that, in Annex 3, is described in detail for the various key categories. Where no changes with respect to the previous year have occurred, the aggregations are carried out automatically.

Following calculatory aggregation, activity data, emission factors and emissions are read, via export in XML-file form, into the CRF reporter, which automatically prepares the IPCC CRF reporting tables. Because a number of major problems with the CRF-reporter software persist, extensive quality controls are required. Such controls ensure data agreement between the CSE and the CRF reporter.

Mathematical conversion of greenhouse gases into CO_2 equivalents takes place pursuant to 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 over a time horizon of 100 years.

Table 4: Global Warming Potential (GWP) of greehouse 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

Source: 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**. 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 departmental 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

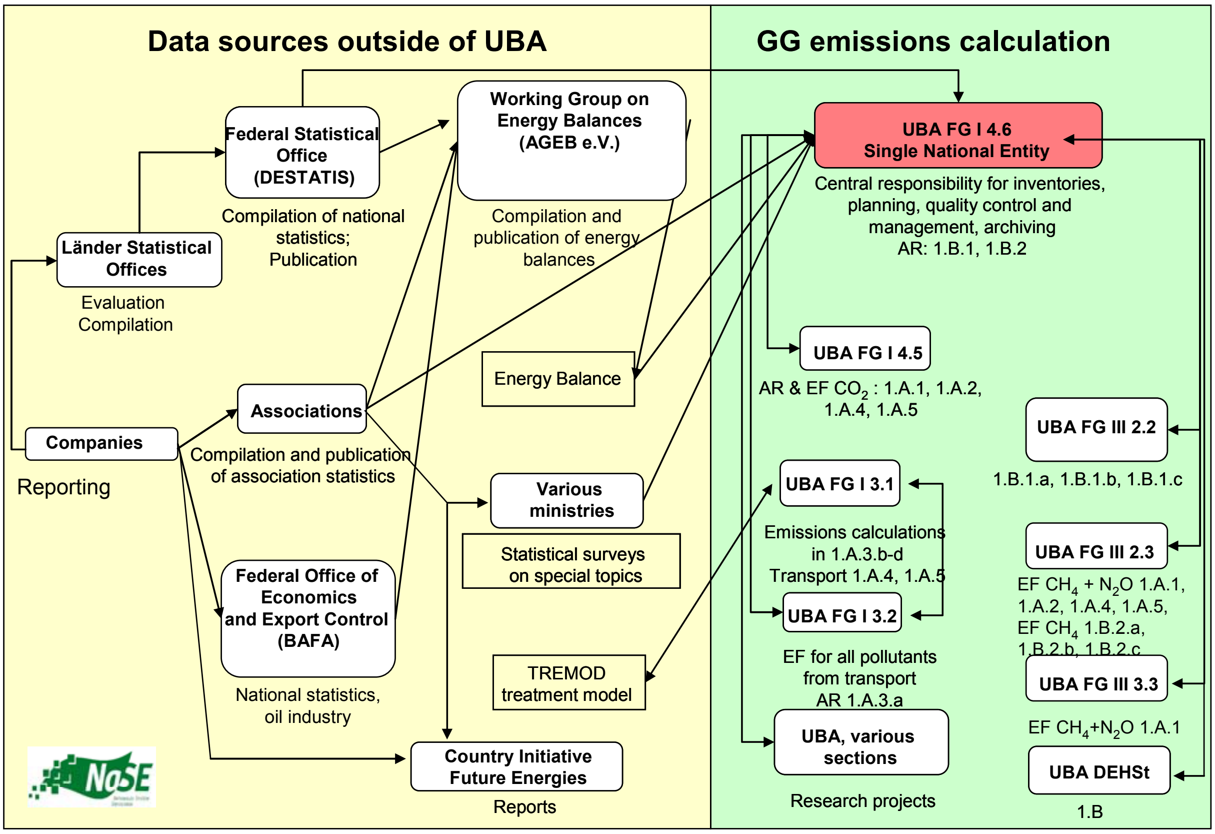


Figure 9: Responsibilities and data flows for calculation of greenhouse-gas emissions in the energy sector

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. The 2004 energy balance was not yet available at the time of current data entry.

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" (*Auswertetabellen 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 is 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).

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).

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), Interessenverband Grubengas e.V. (IVG; association for the pit-gas sector). Technical co-operation arrangements are in place with some of these associations and with some companies.

The publication "Statistik der Kohlenwirtschaft" (coal-industry statistics) is especially important. Work procedures 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 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).

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 climate-protection data published in the framework of CO_2 monitoring

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.

under the industry's voluntary commitment (VDZ, 2007). 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 reporded under other source categories (included elsewhere); the pertinent data sources are noted in the relevant categories. The production quantities for asphalt roofing (2.A.5) are provided by the industry association Industrieverband Bitumen-Dach- und Dichtungsbahnen e.V. (vdd). 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 – BV Glas, 2006), although relevant 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).

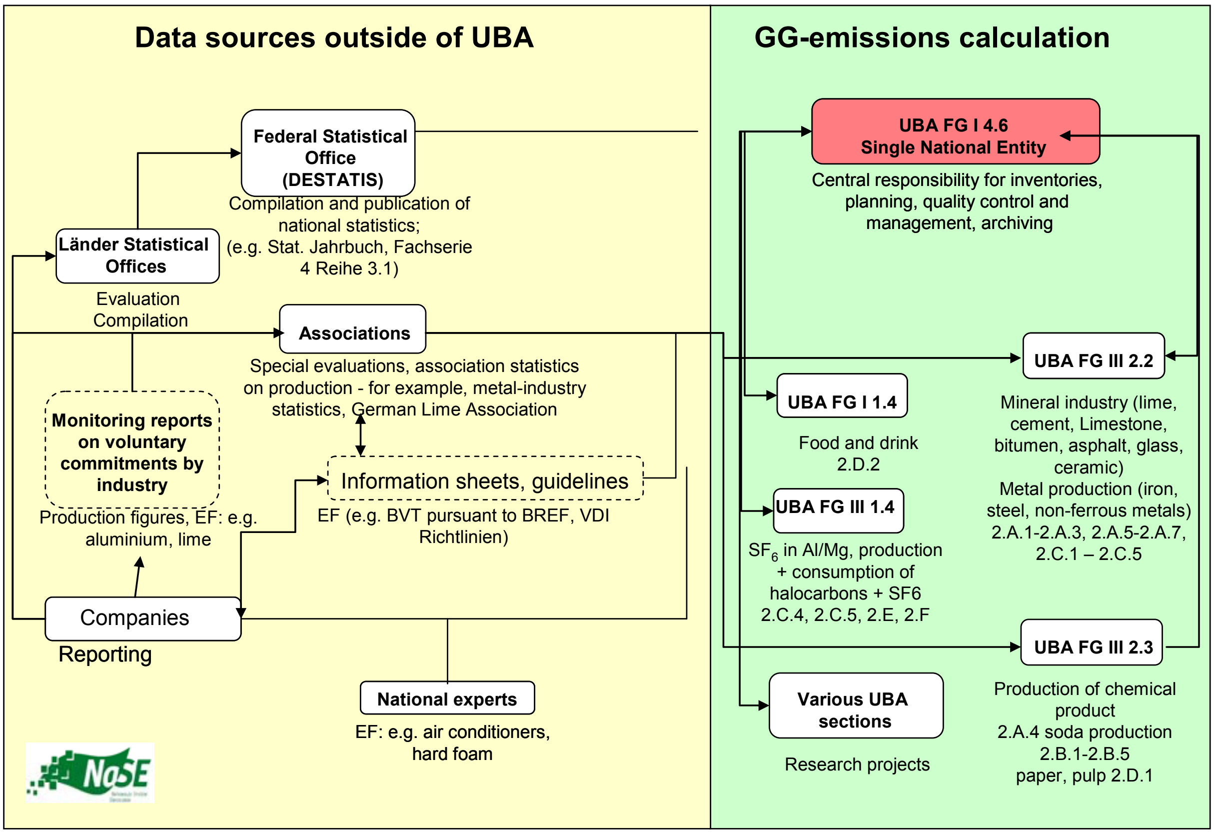


Figure 10: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of industrial processes

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 roofing and tar paper (2.A.5), and for production of asphalt for road paving (2.A.6) refer only to NMVOC, and they have been taken from research reports. The CO_2-emission factors for various types of glass (2.A.7 Glass) have been derived from glass-composition data, while CO_2-emission factors for the ceramics industry (2.A.7 Ceramics) have been derived, by Federal Environment Agency experts, from raw-material inputs.

The activity data for source category 2.B Chemical industry are determined from data of the Federal Statistical Office 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 production (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

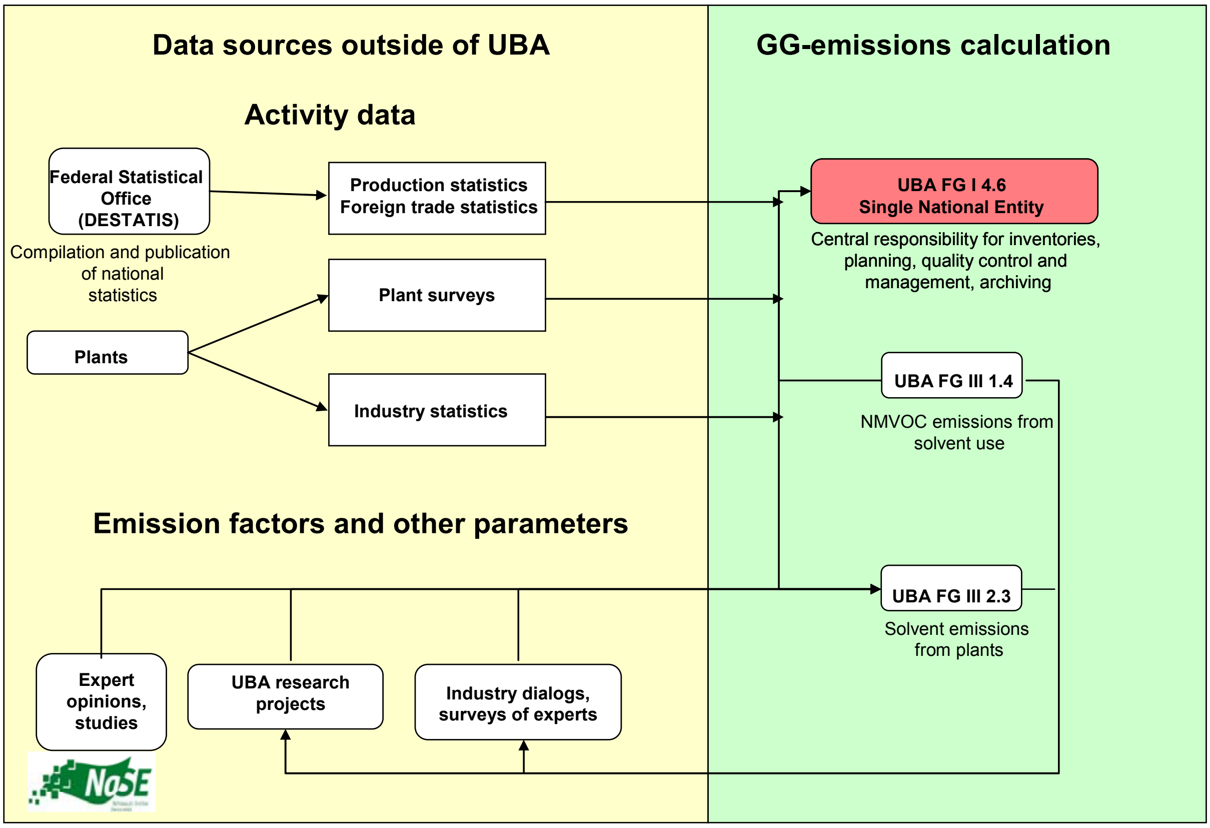


Figure 11: Responsibilities and data flows for calculation of greenhouse-gas emissions from use of solvents and other products

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

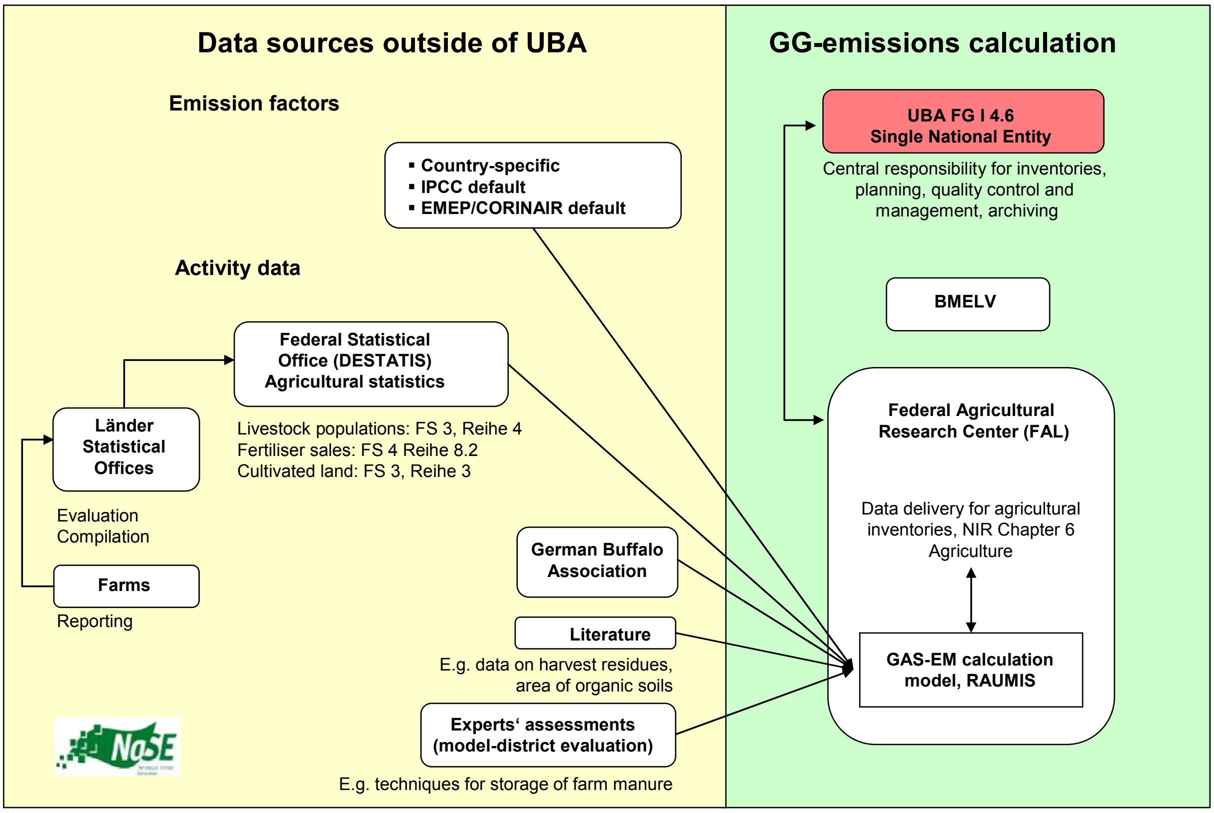


Figure 12: Responsibilities and data flows for calculation of greenhouse-gas emissions in the area of agriculture

Calculation of emissions for Chapter 6 (agriculture) is carried out by the Federal Agricultural Research Institute (FAL). 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 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 and agricultural land under cultivation. In some areas, such data are supplemented by figures from the pertinent literature (for example, harvest residues and area of organic soils). 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 – on methods that use standard emission factors from the Revised 1996 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 FAL has also compiled and integrated within the calculation model.

1.4.1.5 Land-use changes and forestry

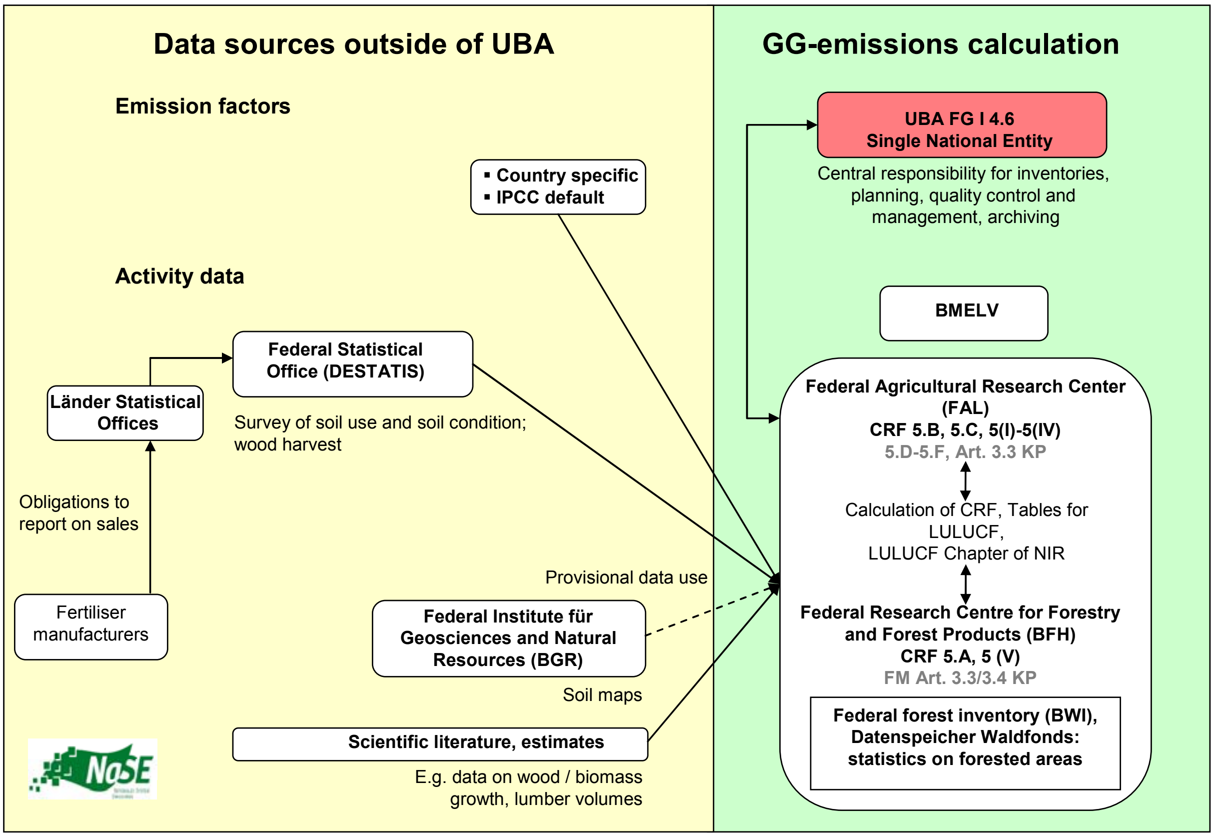


Figure 13: Responsibilities and data flows for calculation of greenhouse-gas emissions from the area of land-use changes and forestry[15]

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 the 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

[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").

Forestry (GPG-LULUCF, IPCC, 2003). CO_2 emissions were determined via the stock-change method. All data were extrapolated for subsequent years, including 2006, by the Federal Research Centre for Forestry and Forest Products (BFH). The activity data are based on the Federal Forest Inventories and on information from the Datenspeicher Waldfonds forest database. Currently, extrapolation methods are being improved for the period 2008 to 2012. The results of these efforts will lead to inventory-quality improvements by no later than the 2009 reporting year. In this connection, plans also call for complete revision of the inventory report, including a detailed description of methods used. 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 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.

In future, 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. In the coming years, projects will be carried out for improving activity data and, significantly, for determining land-category-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 cropland, 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

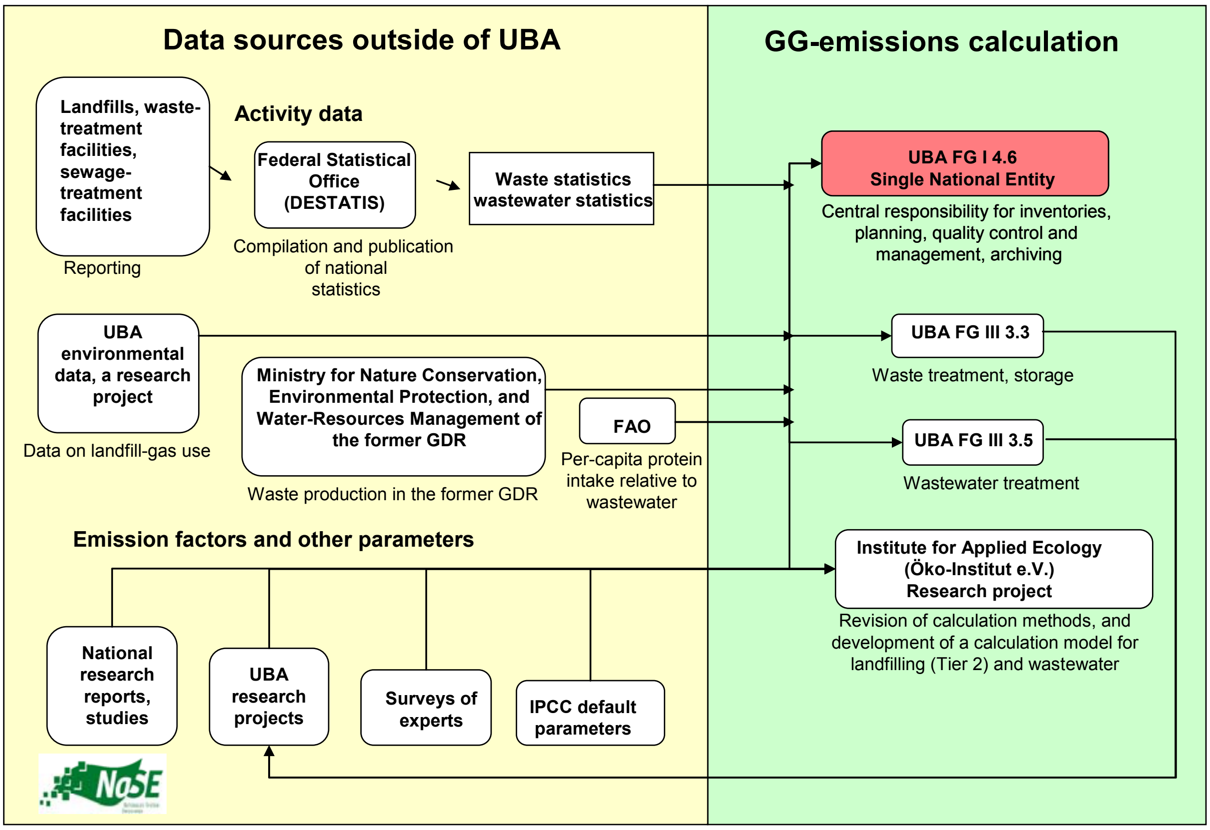


Figure 14: Data flows for calculation of greenhouse-gas emissions from the area of waste

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.

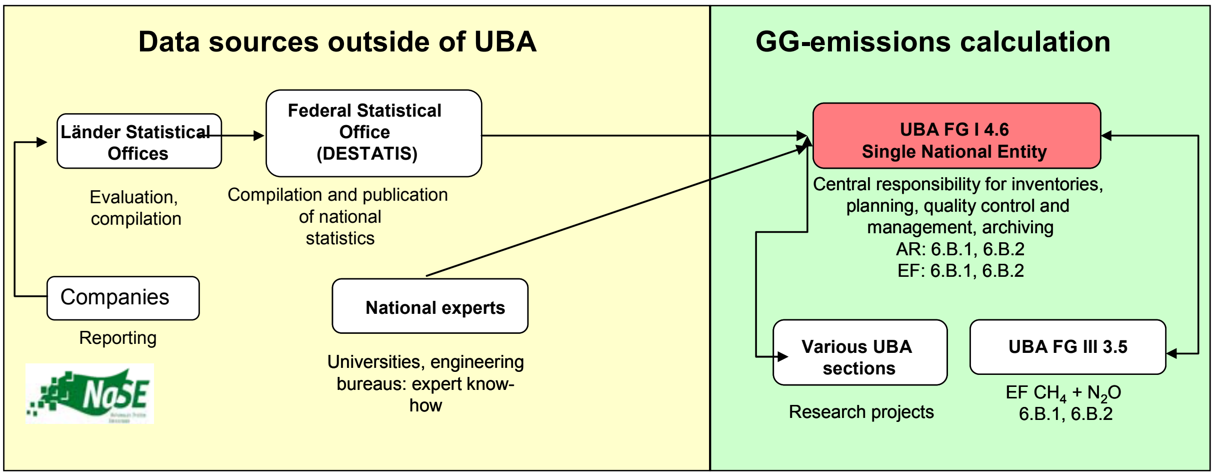


Figure 15: Data flows for calculation of greenhouse-gas emissions from the area of wastewater

Section FG III 3.5 is responsible for selecting the methods, parameters and data for calculating emissions from the wastewater and sludge-treatment sector.

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. Chapter 1.5 in this regard).

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 categories were carried out using an IPCC-Tier 2 procedure, with country-specific emission factors. Country-specific methods were applied only for agricultural soils (4.D).

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

All other source categories were shown in the IPCC Summary Tables as 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 categories

The key categories were defined by applying two Tier 1 procedures, Level (for the base year and for 2006) and Trend (for 2006, 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. In Level analyses carried out without including sinks, for 2006, 1 source category was eliminated (2.B.1 – CO_2 from ammonia production). In Trend analyses for the same year, 1 key category was eliminated (4.D.1 – N_2O from agricultural soils). The reason for these changes was that in all procedures that included sinks category 5.A Forest

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.

land proved to be an additional key category. All specified key categories resulted from work in 2006 – they resulted either from level analysis for 2006 or from trend assessment.

For 2006, this approach identified 39 source categories, out of a total of 114 source and sink categories studied, as key categories. Only 26 of these were identified, by both trend and level analysis, as key categories. In addition, 9 source categories were identified as key categories 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 97.0 % of greenhouse-gas emissions (not including LULUCF) in 2006 were released by the key categories. The identified key categories include different shares of the various greenhouse gases, with respect to the relevant total emissions of the gases (not including LULUCF): CO_2 : 99.1 %; CH_4 : 83.9 %; N_2O : 75.7 %; HFCs : 100 %; PFCs : 32.3 % and SF_6 : 96:0 %.

Table 5: Number of source categories and key categories

Sounce categories		**114**	
			Key categories
By Level	Level & Trend	Trend	
4	26	9	**39**

Table 6 provides an overview of the results of analysis of key categories. 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 (w/o Sinks)	Level 2006	Level 2006 (w/o Sinks)	Trend 2006	Trend 2006 (w/o Sinks)	Emission Baseyear	Emission 2006
1A1a Public electricity and Heat production	1A1a	all fuels	CO2	●	●	●	●	●	●	335864.1	329294.5
1A1b. Petroleum Refining	1A1b	all fuels	CO2	●	●	●	●	●	●	20005.9	20223.9
1A1c. Manufacture of Solid Fuels and Other Energy Industries	1A1c	all fuels	CO2	●	●	●	●	●	●	59066.1	16620.5
1A2a. Manufacturing Industries and Construction Iron and Steel	1A2a	all fuels	CO2	●	●	●	●	●	●	12577.9	11664.2
1A2e. Manufacturing Industries and Construction Food Processing	1A2e	all fuels	CO2					●	●	1989.2	636.2
1A2f. Manufacturing Industries and Construction Other	1A2f	all fuels	CO2	●	●	●	●	●	●	138312.0	88548.5
1A3a. Transport Civil Aviation	1A3a	Aviation Gasoline	CO2			●	●	●	●	2868.6	5289.7
1A3b. Transport Road Transportation	1A3b	all fuels	CH4					●	●	1271.1	155.5
1A3b. Transport Road Transportation	1A3b	all fuels	CO2	●	●	●	●	●	●	150358.3	148881.7
1A3c. Transport Railways	1A3c	all fuels	CO2					●	●	2879.3	1271.6
1A4a. Other Sectors Commercial/Institutional	1A4a	all fuels	CH4					●	●	1216.1	42.7
1A4a. Other Sectors Commercial/Institutional	1A4a	all fuels	CO2	●	●	●	●	●	●	63949.6	45976.0
1A4b. Other Sectors Residential	1A4b	all fuels	CO2	●	●	●	●	●	●	129474.0	117164.2
1A4c. Other Sectors Agriculture/Forestry/Fisheries	1A4c	all fuels	CO2	●	●	●	●	●	●	10917.1	6498.2
1A5 Other Include Military fuel use under this category	1A5	all fuels	CO2	●	●			●	●	11797.8	1546.2
1B1a. Fugitive Emissions from Fuels Coal Mining and Handling	1B1a	Solid Fuels	CH4	●	●			●	●	18415.2	4835.0
1B1c. Fugitive Emissions from Fuels Other (Abandoned Mines)	1B1c	Solid Fuels	CH4					●	●	1806.8	82.8
1.B.2.b. (all) Fugitive Emissions from Fuels, Natural Gas	1B2b	Natural Gas	CH4	●	●	●	●	●	●	6781.5	6710.6
2A1. Mineral Products Cement Production	2A1		CO2	●	●	●	●			15145.8	13208.2
2A2. Mineral Products Lime Production	2A2		CO2	●	●	●	●			6135.0	5502.1
2B1. Chemical Industry	2B1	Ammonia production	CO2	●	●		●	●	●	4596.4	5137.7
2B2 Chemical Industry	2B2	Nitric Acid Production	N2O	●	●	●	●	●	●	4673.4	8478.7

IPCC Source Categories (cont.)	CRF	Activity	Emissions Of	Level Base Year	Level Base Year (w/o Sinks)	Level 2006	Level 2006 (w/o Sinks)	Trend 2006	Trend 2006 (w/o Sinks)	Emission Baseyear	Emission 2006
2B3 Chemical Industry	2B3	Adipic Acid Production	N2O	●	●			●	●	18804.6	3003.9
2B5 Chemical Industry	2B5	Other	CO2	●	●	●	●	●	●	6783.1	10143.2
2C1. Metal Production Iron and Steel Production	2C1	Steel (integrated production)	CO2	●	●	●	●	●	●	48326.0	44859.2
2C3. Aluminium Production	2C3		PFC´s					●	●	1551.7	188.2
2C4. SF6 Used in Aluminium and Magnesium Foundries	2C4		SF6					●	●	197.1	2604.2
2E. Production of Halocarbons and SF6	2E	production of HCFC-22	HFC´s					●	●	4218.5	291.0
2F. Industrial Processes	2F	Consumption of Halocarbons and SF6	HFC´s			●	●	●	●	2253.2	9522.7
2F. Industrial Processes	2F	Consumption of Halocarbons and SF6	SF6	●	●			●	●	6873.4	2520.9
4A.1. Enteric Fermentation	4A1a	Dairy Cattle	CH4	●	●	●	●			12653.6	10083.9
4A.1. Enteric Fermentation	4A1b	Non-Dairy Cattle	CH4	●	●	●	●	●	●	9985.6	6867.5
4D1. Agricultural Soils	4D1	Direct Soil Emissions	N2O	●	●	●	●		●	27711.2	23985.0
4D3. Agricultural Soils	4D3	Indirect Emissions	N2O	●	●	●	●			14906.4	12462.9
5.A Forest Land	5A		CO2	●		●		●		74399.5	79049.7
5.B Cropland	5B		CO2	●	●	●	●	●	●	26534.2	25007.1
5.C Grassland	5C		CO2	●	●	●	●	●	●	18555.2	16598.1
6 A1 Managed Waste Disposal on Land	6 A1		CH4	●	●	●	●	●	●	35910.0	9618.0
6B Wastewater Handling	6B2	Domestic and Commercial Wastewater	CH4					●	●	2226.2	115.4

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

Pursuant to the IPCC Good Practice Guidance requirements, the necessary QC/QA measures for emissions reporting should be summarised in a QC/QA plan. Such a QC/QA plan is to serve the primary purpose of organising, planning and 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 1.2.5. 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:

- 105 individual objectives and 46 optional objectives
- 49 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. Chapter 17.2.1.10.3) and individual process steps (cf. Chapter 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 1.2.5.2) and by the Federal German ministries involved in emissions reporting (cf. Chapter 1.2.3.5). 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

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.1, 1.A.3.a, 2.B.1-2, 2.B.5, 4.D, 6.B.2
Check whether it was possible to take pointers from inventory reviews into account.	1, 1.A, 1.A.1, 1.A.3.b, 1.B.1-2, 1.C.1, 2, 2.A.1, 2.B.3, 2.C.1+4, 2.F, 4, 5, 6.A-B
Check whether there are any gaps in the available data for time series as of 1990.	1.A.1-2, 2.D.2, 3.D.1, 3.D.4
Check whether the AR and their uncertainties are plausible and complete (have no gaps and are completely substantiated).	1.A.1-5, 1.B.1.c
Check whether the EF and their uncertainties are plausible and complete (have no gaps and are completely substantiated).	1.A.1, 1.A.2, 1.A4, 1.A.5.a, 2.A.6, 2.B.1, 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.1, 1.A.3, 2.D.2, 6.B.2
Check whether uncertainties have been determined and are complete.	1.A.1, 1.A.3-5, 1.C.1.a-b, 2.A.6-7, 2.C.3-4, 2.F.1, 2.F.3, 2.F.6, 4.A, 4.D, 5, 6.B.2
Check whether any recalculations are required.	1.A.1-2, 1.A.4, 2, 6.D
Check whether data-consistency requirements are fulfilled and whether the relevant documents are complete and meaningful.	1.A, 1.B.1.a , 1.B.2, 1.A.4.a, 2.B.2, 2.B.5, 2.C.1, 2.F.1, 4.A, 4.D, 5.A.2, 5.B.1, 5.C.1, 6.A.1, 6.B.2
Check whether requirements for cross-checking and verification of data and their underlying assumptions have been fulfilled.	1.A, 1.C.1, 2.A.5-7, 2.B.5, 2.C.2, 2.E, 2.F.1, 2.F.3, 2.F.5-7, 3.D.1, 3.D.4, 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.1, 4.A, 4.D
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.1-5, 1.C.1., 2.A.5, 2.C, 2.C.3, 6.B.2
Check whether obligations pertaining to keeping of records and documentation are fulfilled and whether the relevant documents are complete and meaningful.	1.A, 1.C.1.a, 2.A.5, 2.B.5, 2.D.2, 2.F.1-7, 4.A, 4.D, 5, 6.B.2
Check whether the data source (s) used will be available throughout the long term.	1.A.1-5, 2.A.2, 2.B.1-2, 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.B.2, 1.C.1.b, 2.A.5-7, 2.B.5, 2.C.3, 4.A, 4.D, 5, 6.B.2
Various types of required action.	1.A.1-2, 1.A.4-5, 2.C.2, 2.D.2
Check whether pertinent responsibilities need to be updated.	1.A.3, 1.A.5.b, 1.C.1.a, 2.A.5-6, 2.C.3, 2.D.2, 3.D.1, 3.D.4

Since the 2006 report, inventories are submitted in the CRF-Reporter provided by the climate secretariat. For the 2008 inventory, software version 3.2 of 13 June 2007 was used. Like previous versions, this version contains a range of programming errors. A list of identified programming errors was submitted to UNFCCC together with the 2008 inventory report. As a result of existing software errors, data-validity problems cannot be ruled out for some source categories.

The time and care required to carry out quality assurance for data entry exceed the relevant limits in light of the applicable deadlines. The German QSE cannot solve this problem with measures of its own; the FCCC Secretariat is requested to correct this situation.

1.7 General estimation of uncertainties

The IPCC Good Practice Guidance (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 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.

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.

Research project 202 42 266 (UBA, 2004) determined uncertainties in keeping with the Tier 1 and Tier 2 methods, pursuant to Chapter 6 of the GPG. For the 2008 report, this data basis has been improved, and the uncertainties data for the greenhouse-gas inventory have been expanded and improved. 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, Chapter 6 of the GPG

In the Tier 1 method, in keeping with Chapter 6 of the GPG, uncertainties are determined on the basis of the uncertainties for AR, EF and EM, as determined on the structural element level (primarily by responsible experts of the Federal Environment Agency), and as listed in the CSE. In cases involving asymmetric uncertainties values, and where a normal distribution is expected, the higher value is used as both the upper and lower value. 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 cases involving time series with activity rates, weighting is carried out via the individual activity rate's share of the sector's total activity rate or fuel category. The same approach is used for time series with calculated emissions. Time series with emission factors are assigned the weighting factor for the corresponding activity rate.

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. Among emission factors, uncertainties – which can be considerable, depending on the greenhouse gas in question – result, understandably, from strong technical dependence, coupled with extensive technical 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, higher uncertainties can result in that processes in which non-combustion-related activities generate emissions are often very complex, in that too little

is known about certain emissions-generating processes and in that too little is known 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 production volumes to be determined very precisely. 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 2006 is +/-12.5 %. Nitrous oxide emissions in sector 4.D account for the largest share – about 70 % – of that figure. The CO_2 emissions in sector 1.A contribute the second-largest share – 13.5 % – to the total uncertainty. And those emissions are shaped especially by the solid fuels in sector 1A1a and by the combustion systems of households and small consumers (1.A.4.a/b/c). The fuel category "biomass", in turn, accounts for a large share of emissions from such fuels and combustion systems. Other individual contributions worthy of mention are supplied by source category 5.B, at 3.3 % (CO_2), and by source category 2.B, at 2.3% (N_2O).

The large uncertainties for N_2O, for both experts' assessments and IPCC adjustment values, 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 agriculture and industry sectors.

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 industrial processes, no calculations are carried out at present for source category 2.A.4 Soda ash production and use. This source category is not covered by the IPCC Good Practice Guidance, since the emissions from this category are considered insignificant and since data for it are usually not available. Both of the reasons that the IPCC gives for not covering these groups also apply to Germany.

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 is confidential, due to data-protection requirements, and thus is reported only in aggregated form – although it is reported completely. The draft bill of the Act on climate-protection statistics (Klimaschutzstatistikgesetz) includes a provision that would make it possible, in future, to completely check data, in spite of any applicable secrecy requirements.

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 2008 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 equivalent emissions, decreased by 18.4 % compared to the aforementioned reference figure. Total emissions changed hardly at all with respect to the previous year, 2005 (the decrease amounted to 0.02 %). A 0.4 % increase in CO_2 emissions, resulting from increases in energy consumption and in iron and steel production, was offset by 3.8 % and 4.2 % reductions, respectively, in methane and nitrous oxide emissions. The main factors contributing to the methane reductions include significant increases in use of pit gas and continuing decreases in waste-sector emissions. The main reason for the decrease in nitrous oxide emissions is a decrease in emissions from adipic acid and nitric acid production.

Table 10 shows the relevant emissions changes, in comparison to the previous year, for the period since 1990. For CO_2, for example, the following emerges in addition to a continual decrease in emissions: in the year 1996, which was especially cold with regard to the development since 1990, additional energy had to be used for indoor heating, and this considerably increased CO_2 emissions in 1996, in comparison to the previous year's 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 directly and indirectly acting greenhouse gases and SO_2 in Germany since 1990

Emissions Trends	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
	(Gg)																
Net CO2 emissions/removals	1,003,557	964,798	916,483	906,192	891,378	889,252	911,347	880,531	873,185	846,492	849,038	866,291	851,198	864,943	863,566	840,314	843,433
CO_2 emissions (without LULUCF)	1,032,172	994,270	946,633	936,824	922,655	920,789	943,316	912,899	905,812	879,580	883,392	901,418	886,547	900,813	899,819	876,811	880,253
CH_4	4,727	4,471	4,274	4,252	4,036	3,880	3,732	3,549	3,299	3,265	3,081	2,925	2,755	2,560	2,361	2,270	2,185
N_2O	273	259	262	250	252	251	254	244	201	191	192	195	193	201	208	213	204
HFCs (CO_2 equivalent)	4,369	4,013	4,098	4,224	4,354	6,472	5,853	6,384	6,951	7,192	6,469	7,878	8,542	8,381	8,669	9,362	9,815
PFCs (CO_2 equivalent)	2,708	2,333	2,102	1,961	1,650	1,750	1,714	1,369	1,473	1,243	786	723	795	858	830	718	582
SF_6 (CO_2 equivalent)	4,785	5,118	5,634	6,405	6,694	7,220	6,929	6,903	6,701	5,310	5,078	4,898	4,197	4,311	4,486	4,734	5,333
CO	12,145	9,918	8,585	7,781	6,834	6,671	6,280	6,155	5,762	5,406	5,134	4,907	4,634	4,484	4,317	4,201	4,006
NMVOC	3,768	3,203	2,930	2,689	2,210	2,094	2,005	1,969	1,932	1,777	1,613	1,524	1,451	1,390	1,402	1,385	1,349
NO_X	2,862	2,635	2,476	2,368	2,226	2,132	2,048	1,966	1,919	1,888	1,815	1,735	1,640	1,580	1,532	1,447	1,394
SO_2	5,353	3,934	3,212	2,865	2,399	1,724	1,448	1,207	969	796	637	641	601	605	582	574	558

Table 9: Changes in emissions of directly and indirectly acting greenhouse gases and SO_2 in Germany since 1990

Emissions Trends	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Changes compared to base year or 1990	(%)																
Net CO_2 emissions/removals	0.0	-3.9	-8.7	-9.7	-11.2	-11.4	-9.2	-12.3	-13.0	-15.7	-15.4	-13.7	-15.2	-13.8	-13.9	-16.3	-16.0
CO2 emissions (without LULUCF)	0.0	-3.7	-8.3	-9.2	-10.6	-10.8	-8.6	-11.6	-12.2	-14.8	-14.4	-12.7	-14.1	-12.7	-12.8	-15.1	-14.7
CH_4	0.0	-5.4	-9.6	-10.0	-14.6	-17.9	-21.0	-24.9	-30.2	-30.9	-34.8	-38.1	-41.7	-45.8	-50.1	-52.0	-53.8
N_2O	0.0	-5.2	-4.3	-8.4	-7.9	-8.4	-7.0	-10.7	-26.3	-30.3	-29.8	-28.7	-29.5	-26.4	-23.8	-22.0	-25.3
HFCs (CO_2 equivalent)						0.0	-9.6	-1.4	7.4	11.1	0.0	21.7	32.0	29.5	34.0	44.7	51.7
PFCs (CO_2 equivalent)						0.0	-2.0	-21.8	-15.8	-29.0	-55.1	-58.7	-54.6	-51.0	-52.5	-58.9	-66.7
SF_6 (CO_2 equivalent)						0.0	-4.0	-4.4	-7.2	-26.5	-29.7	-32.2	-41.9	-40.3	-37.9	-34.4	-26.1
Total GHG Emission and Removal trends																	
Total Emissions/Removals with LULUCF	0.0	-4.1	-8.4	-9.5	-11.1	-11.3	-9.7	-12.8	-15.0	-17.6	-17.8	-16.5	-18.1	-17.1	-17.3	-19.2	-19.3
Total Emissions without CO_2 from LULUCF	0.0	-3.9	-8.0	-9.1	-10.6	-10.8	-9.2	-12.2	-14.3	-16.9	-16.9	-15.6	-17.1	-16.1	-16.3	-18.1	-18.1
CO	0.0	-18.3	-29.3	-35.9	-43.7	-45.1	-48.3	-49.3	-52.6	-55.5	-57.7	-59.6	-61.8	-63.1	-64.5	-65.4	-67.0
NMVOC	0.0	-15.0	-22.2	-28.6	-41.3	-44.4	-46.8	-47.8	-48.7	-52.8	-57.2	-59.6	-61.5	-63.1	-62.8	-63.2	-64.2
NO_X	0.0	-7.9	-13.5	-17.3	-22.2	-25.5	-28.4	-31.3	-33.0	-34.0	-36.6	-39.4	-42.7	-44.8	-46.5	-49.5	-51.3
SO_2	0.0	-26.5	-40.0	-46.5	-55.2	-67.8	-72.9	-77.5	-81.9	-85.1	-88.1	-88.0	-88.8	-88.7	-89.1	-89.3	-89.6

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

Emissions Trends	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Changes compared to previous year	(%)																
Net CO2 emissions/removals	0.0	-3.9	-5.0	-1.1	-1.6	-0.2	2.5	-3.4	-0.8	-3.1	0.3	2.0	-1.7	1.6	-0.2	-2.7	0.4
CO_2 emissions (without LULUCF)	0.0	-3.7	-4.8	-1.0	-1.5	-0.2	2.4	-3.2	-0.8	-2.9	0.4	2.0	-1.6	1.6	-0.1	-2.6	0.4
CH_4	0.0	-5.4	-4.4	-0.5	-5.1	-3.9	-3.8	-4.9	-7.0	-1.0	-5.6	-5.1	-5.8	-7.1	-7.8	-3.8	-3.8
N_2O	0.0	-5.2	0.9	-4.3	0.5	-0.4	1.5	-4.1	-17.4	-5.4	0.7	1.6	-1.1	4.4	3.6	2.3	-4.2
HFCs (CO_2 equivalent)	0.0	-8.1	2.1	3.1	3.1	48.6	-9.6	9.1	8.9	3.5	-10.1	21.8	8.4	-1.9	3.4	8.0	4.8
PFCs (CO_2 equivalent)	0.0	-13.8	-9.9	-6.7	-15.9	6.1	-2.0	-20.1	7.6	-15.6	-36.8	-8.0	9.9	7.9	-3.2	-13.5	-18.9
SF_6 (CO_2 equivalent)	0.0	7.0	10.1	13.7	4.5	7.9	-4.0	-0.4	-2.9	-20.8	-4.4	-3.5	-14.3	2.7	4.0	5.5	12.7
Total GHG Emission and Removal trends																	
Total Emissions/Removals with LULUCF	0.0	-4.1	-4.5	-1.2	-1.7	-0.3	1.8	-3.5	-2.4	-3.2	-0.2	1.6	-1.9	1.3	-0.3	-2.3	-0.1
Total Emissions without CO_2 from LULUCF	0.0	-3.9	-4.3	-1.2	-1.6	-0.2	1.8	-3.3	-2.3	-3.0	-0.1	1.7	-1.8	1.3	-0.2	-2.2	0.0
CO	0.0	-18.3	-13.4	-9.4	-12.2	-2.4	-5.9	-2.0	-6.4	-6.2	-5.0	-4.4	-5.6	-3.2	-3.7	-2.7	-4.6
NMVOC	0.0	-15.0	-8.5	-8.2	-17.8	-5.3	-4.3	-1.8	-1.9	-8.0	-9.3	-5.5	-4.8	-4.2	0.9	-1.2	-2.6
NO_X	0.0	-7.9	-6.0	-4.4	-6.0	-4.2	-3.9	-4.0	-2.4	-1.6	-3.9	-4.4	-5.4	-3.7	-3.0	-5.6	-3.6
SO_2	0.0	-26.5	-18.4	-10.8	-16.3	-28.1	-16.0	-16.7	-19.7	-17.8	-19.9	0.6	-6.3	0.6	-3.7	-1.5	-2.6

2.1 Description and interpretation of the progress of aggregated greenhouse-gas emissions

By 2006, the above-described obligation to reduce greenhouse-gas emissions, in the framework of EU burden-sharing, had been largely fulfilled, via a reduction of 18.4 %. 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 14.7 % and CH_4 and N_2O emissions were reduced by over 53.8 % and by 25.3 %, respectively. The reasons for these reductions are found in an entire group of measures, including fuel changeovers, enhanced economic efficiency, changes in ways of keeping animals and reductions of numbers of animals kept. These measures 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 87.6 % 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 from 84.0 % to 87.6 % 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 4.6 % in 2006. Emissions of nitrous oxide, caused primarily by agriculture, industrial processes and transport, account for 6.3 % of greenhouse gas releases. The other relevant gases, the so-called "Kyoto" or "F" gases, together accounted for about 1.6 % 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

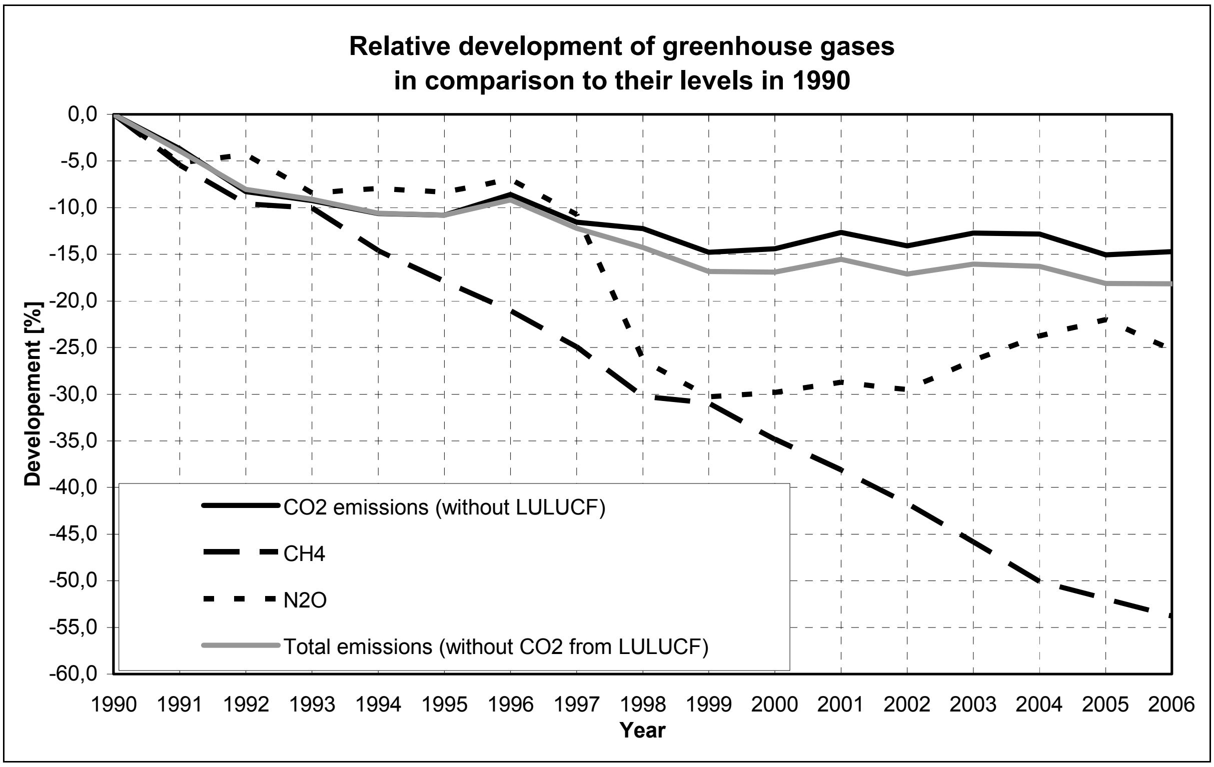


Figure 16: Relative development of greenhouse gases in comparison to their levels in 1990

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

2.2.1 *Carbon dioxide (CO_2)*

The reduction in CO_2 emissions is closely linked to trends in the energy sector. The sharp emissions decrease in the period 1990-1995 is due mainly to restructuring processes in the new German Länder, to related energy-efficiency increases, to changeovers to fuels with lower emissions and to decommissioning of obsolete facilities. As of 1995, CO_2 emissions began decreasing considerably more slowly. This slowdown was due to efficiency increases in power stations, as well as to other changes in the energy mix, including intensified use of low-emissions fuels and nascent use of renewable energies. CO_2 emissions from public power and district-heat generation decreased by 6 million tonnes since 1990. In the process, the mix of fuels used changed considerably – while energy-sector emissions from use of solid and liquid fuels sank by 6.6 % and 40.1 %, respectively, CO_2 emissions from use of gaseous fuels increased by 63.8 %. This trend is even more pronounced in the area of households and small consumers. In this area, emissions decreased by a total of over 17 %, between 1990 and 2006 – from 204 million tonnes of CO_2 to about 170 million tonnes of CO_2. Increasing use of renewable energies, along with efficiency increases and changeovers from coal to gas and oil, was responsible for these emissions decreases. In 1990, solid fuels were still contributing 36 % of these emissions. By 2006, their contribution had fallen sharply, however – to 14 %. The corresponding percentages for gaseous fuels, on the other hand, increased considerably, from 23 % to 51 %. Similar trends also occurred in the transport sector. In that sector, CO_2 emissions increased from 162 million tonnes in 1990 to over 186 million tonnes in 1999. Then, they decreased again to 160 million tonnes (i.e. to below their 1990 level), as a result of reduced consumption and shifting of consumption patterns, with a disproportionate increase in consumption of diesel fuel. In 1990, nearly 2/3 of all road-traffic emissions were still being caused by petrol consumption. In 2006, the balance between petrol-related (46 %) and diesel-related emissions (54 %) reversed. With respect to the previous year, total emissions in 2006 increased by 3.4 million tonnes (+ 0.4 %). While this increase was due especially to increased production in the iron and steel sector (+ 2 million tonnes CO_2), it also resulted from increasing energy use overall.

2.2.2 Nitrous oxide (N_2O)

N_2O emissions decreased by over 25 % in the period under consideration. The emissions decrease with respect to the previous year is the result of production-related decreases in the chemical industry, especially in production of nitric acid. The main sources were use of nitrogen-containing fertilisers in agriculture, industrial processes in the chemical sector, 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. Decreased fertiliser use in agriculture also contributed to the reduction of total emissions.

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 nearly 54 % 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 over 75 % 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 nearly 4 %. 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 17 shows emissions trends for so-called "F" gases for the period 1995-2006. HFC emissions increased, primarily as a result of intensified use of these substances as refrigerants. 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 soundproofed windows, for which production use of SF_6 has been reduced to one-tenth of its level in 1995. At the same time, increasing emissions must be expected in the next few years as a result of increasing disposal of old soundproofed 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. The increase in total SF_6 emissions in recent years is due primarily to use of pure SF_6 in aluminium production; in the 1990s, that gas was used solely as an additive.

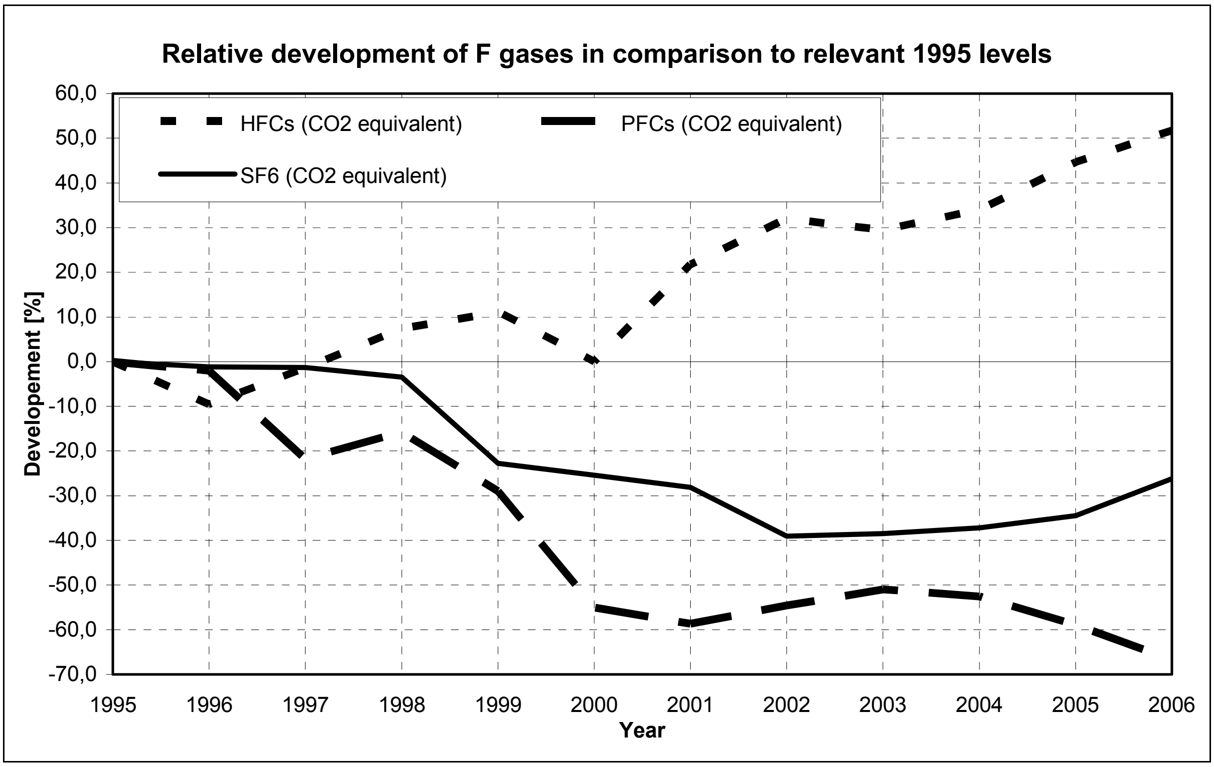


Figure 17: Relative development of F gases in comparison to relevant 1995 levels

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. The 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 17 % 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, CO_2-emissions contributions have been relatively constant in the lime and cement manufacturing sector and in the iron and steel industry. Reallocation of emissions from the iron and steel industry, to energy-related and process-related emissions, has cast a different light on this development, however. The trend for this source category, in which the reduction amounts to over 12 %, has been shaped primarily by emissions-reducing measures in adipic acid production, which have led to marked reductions in N_2O emissions. German producers' introduction of these technical measures, which began 1997, led to sharp reductions. In recent years, these have been offset by increasing emissions from the chemical industry (nitric-acid production), however. With respect to the previous year, emissions in this area have increased, especially as a result of increases in metals production.

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 is a finding of a balance taken 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 reduction of emissions from agriculture is due primarily to reductions in livestock herds. Herd reductions have led to an emissions decrease of over 24 %. In addition, decreasing use of mineral fertilisers has also reduced emissions (- 14.7 %). In comparison to their 1990 levels, emissions decreased by over 18 % overall.

The over 29 % increase in greenhouse-gas storage via "land-use changes and forestry" is due primarily to a reduction of CO_2 emissions from agriculturally cultivated soils and to an increase in forest area.

The most significant emissions reduction, nearly 68 %, occurred in the area of waste emissions. In this area, intensified recycling of recyclable materials ("yellow sack" for recyclable materials, Ordinance on Packaging, etc.) has reduced annual amounts of landfilled waste, thereby reducing landfill emissions by over 73 %. 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 44 %.

Table 11: Changes in emissions in Germany, by source categories, since 1990 / since the relevant previous year

Emissions Trends	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
compared to 1990 (without CO_2 from LULUCF)	**Changes in %**																
1. Energy	0.0	-3.5	-8.4	-9.1	-11.4	-11.8	-9.1	-12.8	-13.7	-15.9	-16.2	-14.1	-15.6	-14.4	-14.9	-17.0	-17.1
2. Industrial processes	0.0	-4.5	-4.5	-7.6	-0.7	1.2	-2.1	0.1	-11.5	-18.5	-15.8	-16.8	-16.7	-14.0	-10.6	-10.6	-9.7
3. Solvent and Other Product Use	0.0	-4.0	-8.0	-11.9	-15.9	-19.9	-23.9	-27.9	-31.8	-35.8	-39.8	-43.8	-43.8	-43.8	-43.8	-43.8	-43.8
4. Agriculture	0.0	-9.7	-12.3	-13.8	-16.4	-14.3	-14.3	-15.7	-15.4	-13.8	-13.6	-14.3	-16.8	-17.2	-17.7	-18.2	-18.2
5. Land Use, Land-Use Change and Forestry	0.0	3.0	5.4	7.1	9.4	10.3	11.9	13.3	14.2	15.8	20.2	22.9	23.7	25.5	26.9	27.7	28.9
CO_2 (Net-Sink)	0.0	3.0	5.4	7.0	9.3	10.2	11.7	13.1	14.0	15.6	20.1	22.8	23.5	25.4	26.7	27.5	28.7
N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5
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	-63.5	-65.9	-67.9
7. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Emission Trends	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
compared to previous year (without CO_2 from LULUCF)	**Changes in %**																
1. Energy	0.0	-3.5	-5.0	-0.8	-2.5	-0.5	3.0	-4.0	-1.0	-2.6	-0.3	2.5	-1.8	1.4	-0.5	-2.5	-0.1
2. Industrial processes	0.0	-4.5	0.0	-3.2	7.4	1.9	-3.3	2.3	-11.6	-7.9	3.3	-1.3	0.1	3.2	4.0	0.1	1.0
3. Solvent and Other Product Use	0.0	-4.0	-4.1	-4.3	-4.5	-4.7	-5.0	-5.2	-5.5	-5.8	-6.2	-6.6	0.0	0.0	0.0	0.0	0.0
4. Agriculture	0.0	-9.7	-2.9	-1.7	-3.0	2.5	0.0	-1.6	0.3	1.9	0.3	-0.8	-3.0	-0.5	-0.5	-0.6	0.0
5. Land Use, Land-Use Change and Forestry	0.0	3.0	2.3	1.6	2.1	0.8	1.4	1.3	0.8	1.4	3.7	2.3	0.6	1.5	1.1	0.7	0.9
CO_2 (Net-Sink)	0.0	3.0	2.3	1.6	2.1	0.8	1.4	1.3	0.8	1.4	3.8	2.3	0.6	1.5	1.1	0.7	0.9
N_2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	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	-6.5	-5.7
7. Other	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 indirectly acting greenhouse gases and of SO_2

The relative development of emissions of indirectly acting greenhouse gases and SO_2 are graphically depicted, in each case as time series since 1990, in Figure 18 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 were reduced by almost 90 %, those of CO were reduced by 67 %, those of NMVOCs were reduced by over 64 % and those of NO_X were reduced by over 51 %.

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 comparatively 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 the state of the art.
- 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 fuels has had an impact on emissions of indirectly acting 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.

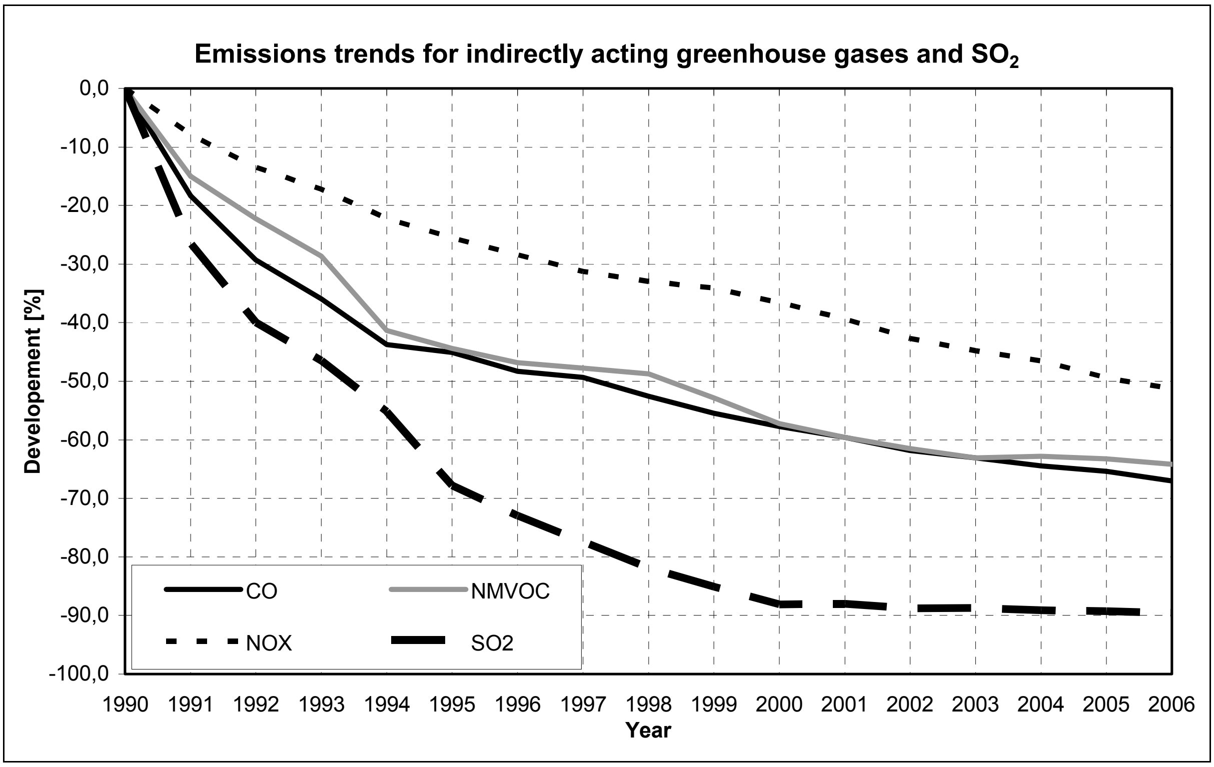


Figure 18: Emissions trends for indirectly acting greenhouse gases and SO_2

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 Emissions Causes" ("Bilanz der Emissionsursachen" – BEU). In both models, combustion-related activities are determined and then recorded in the "Central Database of Emissions" (CSE) 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 Emissions Causes" (BEU) model. The database for this model, which was developed by the Federal Environment Agency, consists of the Energy Balance of the Federal Republic of Germany. The Energy Balance is described in detail in Chapter 13.

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 1995. The model for all of Germany has been extensively revised in the years 2003-2006. Revisions have been documented in detail in reports of two research projects (FKZ 203 41 142 and 204 41 132). 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 13.

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

- Power plants in hard coal mining,
- Power plants in lignite mining,
- Power plants in petroleum processing (refinery power stations),
- Power plants 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 plants under 1A1a (EB line 11)),
- Industrial power plants (quarrying, other mining, manufacturing industry).

3. **Thermal power plants** (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 plants. The district heat generated is fed into the public heating grid. These plants also supply industrial customers with process heat.
4. **District heat plants** (line 16): here, the fuel input for the public district heat supply, from thermal power plants, is given. The plants are often used to cover peak loads in district heat networks in which the basic load is met by combined heating and 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 plants, 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 plants.
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 data in the Energy Balance are no longer sufficient to accommodate the diverse requirements of national and international energy and emissions reporting. For example, the Energy Balance combines fuel inputs which

- Are used in plants 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 plant 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 Causes (BEU) are disaggregated, using additional statistics as well as the Federal Environment Agency's own calculations. The following Figure 19 provides an overview of the relevant structure:

Balance of emission causes
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.
Plant types 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 19: Characteristics of the Federal Environment Agency's structure of the Balance of Emission Causes, for disaggregation of the Energy Balance

The BEU model is designed to provide a data structure that can be used in meeting a range of different reporting obligations. In particular, determination of "classical" air pollutants has 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, we have so far succeeded in fitting the data within the outlined basic structure, thereby facilitating the preparation of consistent time series. Data for the period 2003 to 2006 are provisional.

Figure 19 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. This information needs to be accompanied by the following explanations:

The number in the first column corresponds to the consecutive number in the table in the *Balance of Emission Causes*. The number in the third column is the line number of the Energy Balance from which the basic data for calculation in the *Balance of Emission Causes* table 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 refers directly to the database of the *Central System of Emissions (CSE)*.

Table 12: Structure of the Balance of Emissions Causes – public services

Nr.	Prozess, Brennstoff	EB-Zeile	Emissionsschutz-rechtliche Zuordnung	Anlagenart[1)]	Wirtschaftsbereich	SWK[2)]	Dateiname
Öffentliche Versorgung							
1	Stromerzeugung in GFA der Öffentlichen Kraftwerke	11	13. BImSchV	DTKW	Öffentliche Versorgung	S	OEKW13
2	Stromerzeugung in GFA öffentlicher Rohbraunkohlekraftwerke	11	13. BImSchV	DTKW	Öffentliche Versorgung	S	OEBKW13
2a	Stromerzeugung in GFA öffentlicher Hartbraunkohlekraftwerke	11	13. BImSchV	DTKW	Öffentliche Versorgung	S	OEHBKW13
3	Stromerzeugung in MVA der Öffentlichen Kraftwerke	11	17. BImSchV	DTKW	Öffentliche Versorgung	S	OEKW17
4	Stromerzeugung in Gasturbinen (TA Luft)der Öffentlichen Kraftwerke	11	TA Luft	GTKW	Öffentliche Versorgung	S	OEKWGTTA
4a	Stromerzeugung in GuD-Anlagen der Öffentlichen Kraftwerke	11	TA Luft	GuD	Öffentliche Versorgung	S	OEKWGUDT
4b	Stromerzeugung in GFA der Gasturbinen der Öffentlichen Kraftwerke	11	13. BImSchV	GTKW	Öffentliche Versorgung	S	OEKWGT13
4c	Stromerzeugung in GFA der GuD-Anlagen der öffentlichen Kraftwerke	11	13. BImSchV	GuD	Öffentliche Versorgung	S	OEKWGUD13
5	Stromerzeugung in Gasmaschinen der Öffentlichen Kraftwerke	11	TA Luft	GMKW	Öffentliche Versorgung	S	OEKWGM
6	Stromerzeugung in Dieselmotoren der Öffentlichen Kraftwerke	11	TA Luft	DMKW	Öffentliche Versorgung	S	OEKWDM
22	Wärmeerzeugung in GFA der öffentlichen Kraftwerke	15	13. BImSchV	DTKW	Öffentliche Versorgung	W	HEKW13
22a	Wärmeerzeugung in GFA öffentlicher Rohbraunkohlekraftwerke	15	13.BImSchV	DTKW	Öffentliche Versorgung	W	HEBKW13
23	Wärmeerzeugung in MVA der öffentlichen Kraftwerke	15	17. BImSchV	DTKW	Öffentliche Versorgung	W	HEKW17
25	Wärmeerzeugung in Gasturbinen (TA Luft) der öffentlichen Kraftwerke	15	TA Luft	GTKW	Öffentliche Versorgung	W	HEKWGTTA
25a	Wärmeerzeugung in GuD-Anlagen (TA Luft) der öffentlichen Kraftwerke	15	TA Luft	GuD	Öffentliche Versorgung	W	HEKWGuDTA
25b	Wärmeerzeugung in GFA der Gasturbinen der öffentlichen Kraftwerke	15	13. BImSchV	GTKW	Öffentliche Versorgung	W	HEKWGT13
25c	Wärmeerzeugung in GFA der GuD-Anlagen der öffentlichen Kraftwerke	15	13. BImSchV	GuD	Öffentliche Versorgung	W	HEKWGUD13
26	Wärmeerzeugung in Gasmaschinen der öffentlichen Kraftwerke	15	TA Luft	GMKW	Öffentliche Versorgung	W	HEKWGM
28	Wärmeerzeugung in GFA der öffentlichen Fernheizwerke	16	13. BImSchV	FHW	Öffentliche Versorgung	W	FEHW13
29	Wärmeerzeugung in MVA der öffentlichen Fernheizwerke	16	17. BImSchV	FHW	Öffentliche Versorgung	W	FEHW17
30	Wärmeerzeugung in TA Luft-Anlagen der öffentlichen Fernheizwerke	16	TA Luft	FHW	Öffentliche Versorgung	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 Emissions Causes – coal mining

Nr.	Prozess, Brennstoff	EB-Zeile	Emissionsschutz-rechtliche Zuordnung	Anlagenart[1)]	Wirtschaftsbereich	SWK[2)]	Dateiname
Kohlenbergbau							
7a	Stromerzeugung in GFA der Kraftwerke des Steinkohlenbergbaus	12	13. BImSchV	DTKW	Kohlebergbau	S	STKBKW 13
7b	Stromerzeugung in TA-Luftanlagen der Kraftwerke des Steinkohlenbergbaus	12	TA-Luft	DTKW	Kohlebergbau	S	STKBKWTA
8a	Stromerzeugung in GFA der Grubenkraftwerke (neu angelegt)	12	13. BIMSchV	DTKW	Übriger Kohlebergbau	S	GRKW13
8b	Stromerzeugung in MVA der Grubenkraftwerke (neu angelegt)	12	17. BIMSchV	DTKW	Übriger Kohlebergbau	S	GRKW17
33a	Wärmeerzeugung in GFA der Grubenkraftwerke	40	13. BImSchV	DTKW	Übriger Kohlebergbau	W	UEGK13
33b	Wärmeerzeugung in GFA der Kraftwerke des Steinkohlenbergbaus	40	13. BImSchV	DTKW	Kohlebergbau	W	UESTKB13
33c	Wärmeerzeugung in TA Luft-Anlagen der Kraftwerke des Steinkohlenbergbaus	40	TA-Luft	DTKW	Kohlebergbau	w	UESTKBTA
41	Direktantrieb durch Dieselmotoren der Zechen- und Grubenkraftwerke	40	TA Luft	DMKW	Kohlebergbau	K	UEKZDM
43	Herstellung von Steinkohlenkoks	40	TA Luft	PF	Kohlebergbau	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 Emissions Causes – other industrial power stations

Nr.	Prozess, Brennstoff	EB-Zeile	Emissionsschutz-rechtliche Zuordnung	Anlagenart[1)]	Wirtschaftsbereich	SWK [2)]	Dateiname
sonstige Industriekraftwerke							
12	Stromerzeugung in GFA der DB-Kraftwerke	12	13. BImSchV	DTKW	Deutsche Bahn AG	S	DBKW13
14	Stromerzeugung in GFA der übrigen Industriekraftwerke	12	13. BImSchV	DTKW	Übriger Bergbau und Verarbeitendes Gewerbe (ohne VAW)	S	UIKW13
14b	Stromerzeugung in GFA der Kraftwerke der Zellstoff- und Papierindustrie	12	13. BImSchV	DTKW	Zellstoff- und Papierindustrie	S	ZPKW13
15	Stromerzeugung in MVA der übrigen Industriekraftwerke	12	17. BImSchV	DTKW	Übriger Bergbau und Verarbeitendes Gewerbe	S	UIKW17
16	Stromerzeugung in TA Luft-Anlagen der übrigen Industriekraftwerke	12	TA Luft	DTKW	Übriger Bergbau und Verarbeitendes Gewerbe	S	UIKWTA
18	Stromerzeugung in Gasturbinen (TA Luft) der übrigen Industriekraftwerke	12	TA Luft	GTKW	Übriger Bergbau und Verarbeitendes Gewerbe	S	UIKWGT
18a	Stromerzeugung in GFA der Gasturbinen der übrigen Industriekraftwerke	12	13. BImSchV	GTKW	Übriger Bergbau und Verarbeitendes Gewerbe	S	UIKWGT13
18b	Stromerzeugung in GuD-Anlagen (TA-Luft-Anlagen) der übrigen Industriekraftwerke	12	TA-Luft	GuDKW	Übriger Bergbau und verarb. Gewerbe	S	UIKWGUDTA
18c	Stromerzeugung in GuD-Anlagen (GFA) der übrigen Industriekraftwerke	12	13. BImSchV	GuDKW	Übriger Bergbau und verarb. Gewerbe	S	UIKWGUD13
19	Stromerzeugung in Gasmaschinen der übrigen Industriekraftwerke	12	TA Luft	GMKW	Übriger Bergbau und Verarbeitendes Gewerbe	S	UIKWGM
21	Stromerzeugung in Dieselmotoren der übrigen Industriekraftwerke	12	TA Luft	DMKW	Übriger Bergbau und Verarbeitendes Gewerbe	S	UIKWDM
47	Wärmeerzeugung in GFA der IKW des verarb. Gewerbes und übr. Bergbaus	60	13. BImSchV	DTKW	Übriger Bergbau und Verarbeitendes Gewerbe	W	INKW13
48	Wärmeerzeugung in MVA der IKW des verarb. Gewerbes und übr. Bergbaus	60	17. BImSchV	DTKW	Übriger Bergbau und Verarbeitendes Gewerbe	W	INKW17
50	Wärmeerzeugung in TA Luft-Anl. der IKW des verarb. Gewerbes und übr. Bergbaus	60	TA Luft	DTKW	Übriger Bergbau und Verarbeitendes Gewerbe	W	INKWTA
51	Wärmeerzeugung in Gasturbinen der IKW des verarb. Gewerbes und übr. Bergbaus	60	TA Luft	GTKW	Übriger Bergbau und verarbeitendes Gewerbe	W	INKWGT
51 a	Wärmeerzeugung in GFA Gasturbinen der IKw des verarb. Gewerbes und übrigen Bergbaus	60	13. BImSchV	GTKW	Übriger Bergbau und verarbeitendes Gewerbe	W	INKWGT13
51b	Wärmeerzeugung in TA-Luftanlagen der GuD-Anlagen der IKW des verarb. Gewerbes und übrigen Bergbaus	60	TA Luft	GuDKW	Übriger Bergbau und verarbeitendes Gewerbe	W	INKWGUDTA
51c	Wärmeerzeugung der GFA der GuD-Anlagen der IKW des verarb. Gewerbes und übr. Bergbaus	60	13. BImSchV	GuDKW	Übriger Bergbau und verarbeitendes Gewerbe	W	INKWGUD13
52	Wärmeerzeugung in Gasmaschinen der IKW des verarb. Gewerbes und übr. Bergbaus	60	TA Luft	GMKW	Übriger Bergbau und verarbeitendes Gewerbe	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 heat stations, FA = combustion systems, PF = process furnaces

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

Table 15: Structure of the Balance of Emissions Causes – refineries, other energy producers, iron and steel industry

Nr.	Prozess, Brennstoff	EB-Zeile	Emissionsschutz-rechtliche Zuordnung	Anlagenart[1)]	Wirtschaftsbereich	SWK[2)]	Dateiname
Raffinerien							
13	Stromerzeugung in GFA der Raffineriekraftwerke	12	13. BImSchV	DTKW	Mineralölverarbeitung	S	UIKR13
13a	Stromerzeugung in TA Luft-Anlagen der Raffineriekraftwerke	12	TA-Luft	DTKW	Mineralölverarbeitung	S	UIKRTA
17	Stromerzeugung in Gasturbinen (TA Luft) der Raffineriekraftwerke	12	TA Luft	GTKW	Mineralölverarbeitung	S	UIKRGTTA
17a	Stromerzeugung in GFA der Gasturbinen der Raffineriekraftwerke	12	13. BImSchV	GTKW	Mineralölverarbeitung	S	UIKRGT13
34	Wärmeerzeugung in GFA der Raffineriekraftwerke	40	13. BImSchV	DTKW	Mineralölverarbeitung	W	UEKR13
34a	Wärmeerzeugung in TA Luft-Anlagen der Raffineriekraftwerke	40	TA-Luft	DTKW	Mineralölverarbeitung	W	UEKRTA
39	Wärmeerzeugung in Gasturbinen (TA Luft) der Raffineriekraftwerke	40	TA Luft	GTKW	Mineralölverarbeitung	W	UEKRGTTA
39a	Wärmeerzeugung in GFA der Gasturbinen der Raffineriekraftwerke	40	13. BImSchV	GTKW	Mineralölverarbeitung	W	UEKRGT13
42	Wärmeerzeugung in Dieselmotoren der Raffineriekraftwerke	40	TA Luft	DMKW	Mineralölverarbeitung	W	UEKRDM
44	Raffinerie-Unterfeuerungen (GFA)	40	13. BImSchV	PF	Mineralölverarbeitung	W	UEPFRG
44a	Raffinerie--Unterfeuerungen (TA Luft-Anlagen)	40	TA Luft	PF	Mineralölverarbeitung	W	UEPFRT
Sonstige Energieerzeuger des Umwandlungsbereichs							
31	Wärmeerzeugung in GFA (Industrie-Kessel) des übr. Umwandlungsbereichs	40	13. BImSchV	FA	Sonstige Energieerzeuger	W	UEUM13
36	Wärmeerzeugung in TA Luft-Anlagen (Industrie-Kessel) des übr. Umwandlungsber.	40	TA Luft	FA	Sonstige Energieerzeuger	W	UEUMTA
Eisenschaffende Industrie							
54	Herstellung von Roheisen (Prozessfeuerung)	60	TA Luft	Hochofen	Eisenschaffende Industrie	W	INPFHO
55	Herstellung von Sinter (Prozessfeuerung)	60	TA Luft	Sinteranlagen	Eisenschaffende Industrie	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 heat 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 Emissions Causes – other tables

Nr.	Prozess, Brennstoff	EB-Zeile	Emissionsschutz-rechtliche Zuordnung	Anlagenart[1)]	Wirtschaftsbereich	SWK[2)]	Dateiname
weitere Tabellen der BEU-Struktur							
36a	Gasturbinen (TA Luft) in Erdgasverdichterstationen	40	TA Luft	GT	Gaswirtschaft	K	GVKOMPTA
36b	GFA der Gasturbinen in Erdgasverdichterstationen	40	13. BImSchV	GT	Gaswirtschaft	K	GVKOMP13
46	Wärmeerzeugung in GFA (Industrie-Kessel) des verarb. Gewerbes und übr. Bergbaus	60	13. BImSchV	Dampf-/Warmwasserkessel	Übriger Bergbau und verarbeitendes Gewerbe	W	INDU13
49	Wärmeerzeugung in TA Luft-Anl. (Industrie-Kessel) des übr. Bergb. u. verarb. Gew. (Produktionswärme)	60	TA Luft	Dampf-/Warmwasserkessel	Übriger Bergbau und Verarbeitendes Gewerbe	W	INDUTAP
57	Herstellung von Walzstahl (Prozessfeuerung)	60	TA Luft	Erzeugung von Walzstahl	Stahlerzeugung	W	INPFWA
58	Herstellung von Eisen-, Stahl- und Temperguss (Prozessfeuerung)	60	TA Luft	Gießereien	Gießereiindustrie	W	INPFGU
59	Herstellung von Nichteisen-Schwermetalle (Prozessfeuerung)	60	TA Luft	NE-Metallgießereien	NE-Metallerzeugung	W	INPFNE
60	Herstellung von Kalk (Prozessfeuerung)	60	TA Luft	Kalkbrennofen	Kalkerzeugung	W	INPFKA
61	Herstellung von Zementklinker (Prozessfeuerung)	60	TA Luft	Zementöfen	Zementherstellung	W	INPFZK
62	Herstellung von Glas (Prozessfeuerung)	60	TA Luft	Glasschmelzofen	Glasherstellung	W	INPFGL
63	Herstellung von Zucker (Prozessfeuerung)	60	TA Luft	Zuckerraffinerie	Zuckerherstellung	W	INPFZU
64	Herstellung von keramikschen Erzeugnissen (Prozessfeuerung)	60	TA Luft	Brennofen	Ziegelherstellung	W	INPFZI
64a	Wärmeerzeugung in GFA der Kraftwerke der Zellstoff- und Papierindustrie	60	13. BImSchV	DTKW	Zellstoff- und Papierindustrie	W	INKWZP
66	übrige Prozessfeuerungen	60	TA Luft	Prozessfeuerung	Übriger Bergbau und Verarbeitendes Gewerbe	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 Emissions Causes – deleted structural elements

Nr.	Prozess, Brennstoff	EB-Zeile	Emissionsschutz-rechtliche Zuordnung	Anlagenart[1)]	Wirtschaftsbereich	SWK[2)]	Dateiname
6a	Stromerzeugung aus biogenen Brennstoffen	11	TA Luft / 1. BImSchV		Öffentliche Versorgung	S	OEKWBIO
27	Wärmeerzeugung in Dieselmotoren der öffentlichen Kraftwerke	15	TA Luft	DMKW	Öffentliche Versorgung	W	HEKWDM
7	Stromerzeugung in GFA der STEAG	12	13. BImSchV	DTKW	Kohlebergbau/STEAG	S	STEA13
8	Stromerzeugung in GFA der übrigen Zechenkraftwerke	12	13. BImSchV	DTKW	Übriger Kohlebergbau	S	ZGSK13
9	Stromerzeugung in Gasturbinen der Zechen- und Grubenkraftwerke	12	TA Luft	GTKW	Kohlebergbau	S	ZGKWGT
10	Stromerzeugung in Gasmaschinen der Zechen- und Grubenkraftwerke	12	TA Luft	GMKW	Kohlebergbau	S	ZGKWGM
11	Stromerzeugung in Dieselmotoren der Zechen- und Grubenkraftwerke	12	TA Luft	DMKW	Kohlebergbau	S	ZGKWDM
32	Wärmeerzeugung in GFA der STEAG	40	13. BImSchV	DTKW	Kohlebergbau /STEAG	W	UEST13
33	Wärmeerzeugung in GFA der übrigen Zechenkraftwerke	40	13. BImSchV	DTKW	Übriger Kohlebergbau	W	UEZK13
38	Wärmeerzeugung in Gasturbinen der Zechen- und Grubenkraftwerke	40	TA Luft	GTKW	Kohlebergbau	W	UEKZGT
40	Wärmeerzeugung in Gasmaschinen der Zechen- und Grubenkraftwerke	40	TA Luft	GMKW	Kohlebergbau	W	UEKZGT
43a	Herstellung von Steinkohlenkoks (17. BImSchV)	40	17. BImSchV	PF	Kohlebergbau	W	UEPFKO17
14a	Stromerzeugung in GFA der Vereinigten Aluminium Werke (VAW), Bonn	12	13. BImSchV	DTKW	Vereinigte Aluminium Werke (VAW)	S	VAW13
24	Wärmeerzeugung in TA Luft-Anlagen der übr. IKW (nur Einspeisung ins öff. Netz)	15	TA Luft	DTKW	Übriger Bergbau und Verarbeitendes Gewerbe	W	HEKWTA
35	Wärmeerzeugung in GFA der übr. IKW des Umwandlungsbereichs	40	13. BImSchV	DTKW	Sonstige Energieerzeuger	W	UEKI13
37	Wärmeerzeugung in TA Luft-Anlagen der IKW des Umwandlungsbereichs	40	TA Luft	DTKW	Sonstige Energieerzeuger	W	UEKITA
20	Stromerzeugung in Dieselmotoren der Raffineriekraftwerke	12	TA Luft	DMKW	Mineralölverarbeitung	S	UIKRDM
49a	Wärmeerzeugung in TA Luft-Anl. (Industrie-Kessel) des übr. Bergb. u. verarb. Gew. (Heizungsanlagen)	60	TA Luft	Dampf-/Warmwasserkessel	Übriger Bergbau und Verarbeitendes Gewerbe	W	INDUTAH
53	Wärmeerzeugung in Dieselmotoren der IKW des verarb. Gewerbes und übr. Bergbaus	60	TA Luft	DMKW	Übriger Bergbau und verarbeitendes Gewerbe	W	INKWDM
53a	Wärmeerzeugung in KFA (Industriekessel) des übr. Bergbaus und verarb. Gewerbes (Produktionswärme)	60	1. BImSchV	Dampf-/Warmwasserkessel	Übriger Bergbau und verarbeitendes Gewerbe	W	INDU01P
53b	Wärmeerzeugung in KFA (Industriekessel) des übr. Bergbaus und verarb. Gewerbes (Heizungsanlagen)	60	1. BImSchV	Dampf-/Warmwasserkessel	Übriger Bergbau und verarbeitendes Gewerbe	W	INDU01H
56	Herstellung von Siemens-Martin-Stahl (Prozessfeuerung)	60	TA Luft	Siemens-Martin-Ofen	Stahlerzeugung	W	INPFSM
65	Herstellung von Calciumcarbid (Prozessfeuerung)	60	TA Luft	Brennofen	Calciumcarbidherstellung	W	INPFCA

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

Nr.	Prozess, Brennstoff	EB-Zeile	Emissionsschutz-rechtliche Zuordnung	Anlagenart[1)]	Wirtschaftsbereich	SWK[2)]	Dateiname
67	Wärmeerzeugung in TA Luft-Anlagen der Landwirtschaft und Gärtnereien	67	TA Luft	Dampf-/Warmwasserkessel	Landwirtschaft	W	LAWITA
68	Wärmeerzeugung in KFA der Landwirtschaft und Gärtnereien	67	1. BImSchV	Dampf-/Warmwassererzeuger	Landwirtschaft	W	LAWI01
69	Wärmeerzeugung in TA Luft-Anlagen der übrigen Kleinverbraucher	67	TA Luft	Warmwasserkessel	Kleinverbrauch	W	UEKVTA
70	Wärmeerzeugung in KFA der übrigen Kleinverbraucher	67	1. BImSchV	Warmwasserkessel	Kleinverbrauch	W	UEKV01
71	Wärmeerzeugung in TA Luft-Anlagen der militärischen Dienststellen	67	TA Luft	Warmwasserkessel	Militärische Dienststellen	W	MILITA
72	Wärmeerzeugung in KFA der militärischen Dienststellen	67	1. BImSchV	Warmwasserkessel	Militärische Dienststellen	W	MILI01
73	Wärmeerzeugung in KFA der Haushalte	66	1. BImSchV	Wärmeerzeuger	Haushalte	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 category by level (l) / trend (t)		**Gas (HQG)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	26.35 %	31.42 %	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 category, 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 heat plants and electricity and heat production of public power plants.

Some 97 GW of net bottleneck capacity were in place in the public electricity generating sector in 2006. Of this amount, about 65 GW were operated with fossil fuels or with transformation products of fossil fuels. As a group, all fossil-driven plants generated some 337 TWh of electrical work. This corresponds to about 62 % of all public electricity generation (about 540 TWh). About 274 TWh of electricity were generated solely with lignite and hard coal (DESTATIS 2,006a).

In 2006, thermal power stations contributed about 11 GW of electrical power, and about 24 GW of net thermal bottleneck capacity, to the public electricity / heat supply. In 2006, they produced around 32 TWh of electricity and 224 PJ of district heat. District heating generation is supplemented by district heat plants (usually in peak-load operation) with thermal bottleneck capacity of about 22 GW and district-heat output of about 41 PJ (preliminary data, AGFW 2006/2007).

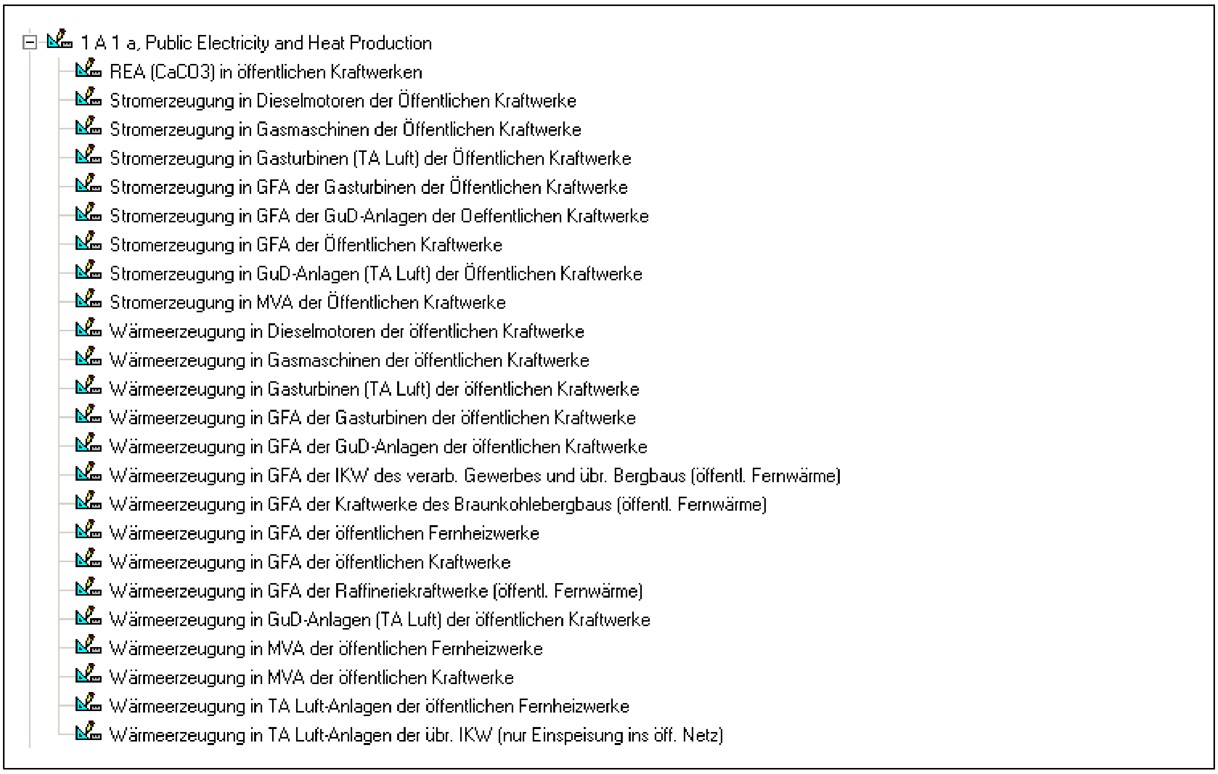


Figure 20: Structural allocation, 1.A.1a Public electricity and heat production

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

In the "Balance of Emissions Causes" model, the energy inputs listed in the Energy Balance are divided among several time series, with the help of statistical data. The aim of the calculations is to produce a database that is adjusted to the special technical characteristics of electricity and heat generation. 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 plants in the new German Länder for the year 1990").

In the case of electricity and heat generation in waste-incineration plants of public power plants, and of heat generation in waste-incineration plants of public district-heating plants, the Energy Balance values diverge considerably from those in the waste statistics of the Federal Statistical Office (DESTATIS, FS19 Reihe 1), with the latter statistics showing considerably higher values. 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 plants >/< 50 MW). The dividing line between these two categories is based on legal regulations pertaining to licensing of combustion plants in the Federal Republic of Germany.

Emission factors (except for CO_2)

The underlying data for the emission factors used is provided by the report on the research project "Ermittlung und Evaluierung von Emissionsfaktoren für Feuerungsanlagen in Deutschland für die Jahre 1995, 2000 und 2010" ("Determination and evaluation of emission factors for combustion plants in Germany for the years 1995, 2000 and 2010"; Rentz et al, 2002). The values for the intermediate years 1996 - 1999 and 2001 - 2006 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 generation of steam and hot/warm water. The research project was carried out by the Franco-German Institute for Environmental Research (Deutsch-Französischen 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 plants 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 plants subject to licensing requirements, and CH_4 for gas turbines and combustion plants 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 was available to permit systematic survey of N_2O emission factors in the research project. The relevant technological emission factors for large combustion plants, as determined in the research project, are summarised in Table 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 plants

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	-Staub	Dust combustion	≥ 5 MW	NBL	[3,2]
	-Brikett	n.i.	< 5 MW	NBL	0,4 - 3,7 [2,1]
	Roh-	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 Fuel Oil		n.i.	/	ABL	2 - 4 [3]
			/	NBL	2 - 4 [3]
Light Fuel 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 plants 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 plants in the new German Länder for the year 1990"). The relevant recalculation method is described in the Annex, Chapter 13.

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.

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 REA (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, produced 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 plants in Germany are not subject to monitoring of CH_4 emissions; for this reason, no systematic measurement data is available in this area. Consequently, individual items of data 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). Die The individual CH_4 emission factors, as determined in the research project (RENTZ et al, 2002), are summarised in Annex 14.1.2.3. Previously, the factors listed there, for hard coal fired in combustion plants < 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 is 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 this basis, for 2000 and 2010. With this approach, no changes result for most of these emission factors for the period from 1995 to 2006. 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 2006 were reviewed in this light and assessed as consistent overall. The time series of CH_4 emission factors for 1995 to 2006 were also reviewed and assessed as internally consistent.

Currently, source-category-specific review of N_2O and CH_4 emission factors is being carried out for the period from 1990 to 1994, with regard to consistency with pertinent values as of 1995. To date – as reported in the NIR 2007 – N_2O emission factors for use of natural gas and light heating oil in gas turbines have been reviewed and adjusted.

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

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

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 aspects (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 plants, 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 (after Figure 66). Their results were reported in the NIR 2005.

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

As a result of data updating (updating of the evaluation tables for the Energy Balance), the data reported for electricity generation from heating oil, in source category 1.A.2. + 1.A.1, differ from the corresponding data reported in the 2007 inventory. For 2005, the figures for heating oil have been lowered from 100 PJ to 52 PJ.

The 2005 values for fuel inputs of household waste / municipal waste were updated, since Fachserie 19, with the figures for 2005, did not become available in time for the NIR 2007. For this reason, the relevant data were estimated for the previous NIR. For the current greenhouse-gas inventory, the values for the year 2006 were again estimated. The 2006 values will be updated when FS 19 2007 (for the year 2006; FS = Fachserie, technical publication series) appears.

The CO_2 emission factors for the fuel Helmstedt raw lignite have been lowered, on the basis of recent findings of the Emissions Trading Agency (Emissionshandelsstelle), from 111 t/TJ to 99 t/TJ for the entire time series.

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

As mentioned in previous chapters, the time-series consistency of N_2O and CH_4 emission factors for the 1990-1994 period is currently being reviewed in light of the period as of 1995. Where necessary, changes will be made in the emission-factor figures for the 1990-1994 period.

Plans for the longer term call for further review, in the framework of systematic studies, of the N_2O-emissions behaviour of combustion and gas-turbine systems. In addition, the CH_4-emissions behaviour of gas turbines is to be determined more precisely, via measurements. This shifting of technical emphasis, with respect to the NIR 2007, is a result of the review process carried out in 2007.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	1.57 %	1.93 %	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 petroleum-refining source category is a key category for 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 the year 2006. Over this period, 112 Mt of crude oil, along with 12 Mt of intermediate products, were used for subsequent processing. Production of petroleum products totalled 122 Mt, 61 Mt of which consisted of fuels, about 31 Mt of which consisted of heating oils, about 9 Mt of which consisted of naphtha and about 21 Mt of which consisted of other products. (MWV, 2007).

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 provided 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 heat and power production of refinery power stations.

Figure 21: Structural allocation 1.A.1b Petroleum refining

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

Activity rates

Fuel inputs for electricity generation 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 generation) of refineries and used-oil-processing facilities. Fuel inputs for heat generation 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 generation 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 generation, energy inputs for heat generation (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 generation in refinery power stations and the fuel inputs for electricity generation in refinery power stations. This factor, in conjunction with fuel inputs for electricity generation 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 generation.

The activity rates for refinery-process bottom heating are obtained by subtracting fuel inputs in refinery power stations for heat generation 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)

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 in Annex 3. The cited project does not provide any emission factors for the bottom-heating systems that provide 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)

In the 2004 report year, uncertainties were determined for the activity rates, for the first time ever (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" (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. In addition, the pertinent comments made in Chapter 3.1.1.3.2 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 (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has not been carried out.

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)

As a result of data updating (updating of the evaluation tables for the Energy Balance), the data reported for electricity generation from heating oil, in source category 1.A.2. + 1.A.1, differ from the corresponding data reported in the 2007 inventory. For 2005, the figures for heating oil have been lowered from 100 PJ to 52 PJ.

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 planning described in Chapter 3.1.1.6 with regard to studies relative to emissions behaviour should also adequately improve the data for 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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	4.63 %	1.59 %	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 category, 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 21.4 Mt of usable hard coal (STATISTIK DER KOHLEWIRTSCHAFT 2006: for the year 2006, Übersicht (Overview) 1, and www.kohlenstatistik.de). Coke production in 2005 amounted to 8.3 Mt (STATISTIK DER KOHLENWIRTSCHAFT 2006, for the year 2005, p. 50, 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, 176.3 Mt of crude lignite was produced in Germany (www.kohlenstatistik.de). Combined production of lignite briquettes and other lignite products amounted to about 5.2 Mt (www.kohlenstatistik.de). From these plants, steam is drawn off for drying crude lignite for production of lignite products.

In 2006, German production of petroleum totalled just under 3.4 Mt (MWV, 2007), while production of natural gas totalled nearly 18,750 Mm³ (H_u = 31,736 kJ/m³) (BAFA, 2007). The fuel input needed for operation of the plants is included in the Balance of Emission Causes (BEU).

In the CSE, source category 1.A.1.c Manufacture of solid fuels and other energy industries includes electricity and heat generation in steam-turbine power stations, broken down by hard-coal mining and lignite mining (pit power stations), electricity and heat generation in gas turbines, gas engines and diesel engines of all pit (*Zeche* + *Grube*) power stations, other heat generation 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 plants" and "plants falling under the Technical Instructions on Air Quality Control" (TA Luft).

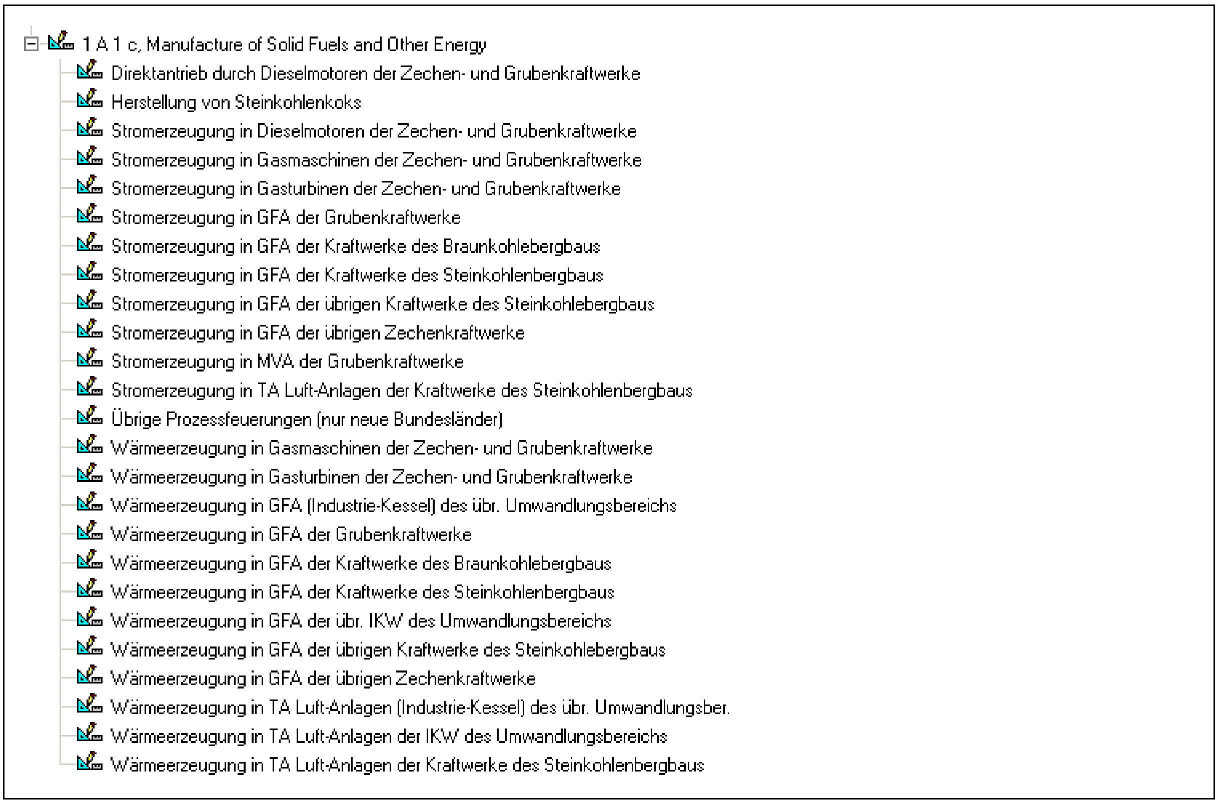


Figure 22: Structural allocation, 1.A.1c Manufacture of solid fuels and other energy industries

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 generation 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 generation 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 generation in power stations of the hard-coal mining sector are determined with the help of figures of the Federal Statistical Office (DESTATIS, 2006d). This is achieved by the adding the fuel-input fraction for electricity generation in CHP plants to the fuel input in electricity-only plants. The fuel-input fraction for electricity generation in CHP plants is equivalent to the relationship between electricity generation in CHP plants and heat/electricity generation in CHP plants. The activity rates for heat generation 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 generation 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 generation, 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"-use 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 generation 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.

Emission factors (except for CO_2)

The emission factors for power stations and other boiler combustion for production of steam and hot/warm water, in source category 1.A.1.c, have been taken from Rentz et al (2002). A detailed description of the procedure is presented in Chapter 3.1.1.2 and in Chapter 14.1.2 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)

In the 2004 report year, uncertainties were determined for the activity rates, for the first time ever (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, especially 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 (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has not been carried out.

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.

The results of Chapter 3.1.1.4 apply mutatis mutandis.

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

The results of Chapter 3.1.1.5 apply mutatis mutandis.

The activity data for lignite drying were recalculated for the year 2005, to take account of new data.

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

The planning described in Chapter 3.1.1.6 with regard to emissions-behaviour studies will also adequately improve the data situation for emission factors for power stations and other combustion plants within the mining sector.

Plans call for enhancing the quality of the data used as a basis for the sector-specific breakdown of fuel inputs for electricity generation in industrial power stations, i.e. for electricity generation in power stations of the hard-coal and lignite mining sectors. The Working Group on Energy Balances (AGEB) has agreed to provide the Federal Environment Agency with the relevant required data. With that data, we expect to be able to enhance the consistency among the various time series, since the AGEB data are likely to show much better consistency with the Energy Balance than the previously used data did.

Review of existing emission factors in the area of coking plants, and of the consistency of pertinent time series, is planned for next year. In the interest of broadening the database, plans also call for development, with the help of relevant associations, operators and monitoring authorities, of a strategy for future data deliveries and uncertainties estimates. One lignite coking plant is still in operation in Germany. That coking plant's relevance for emissions reporting remains to be studied.

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.

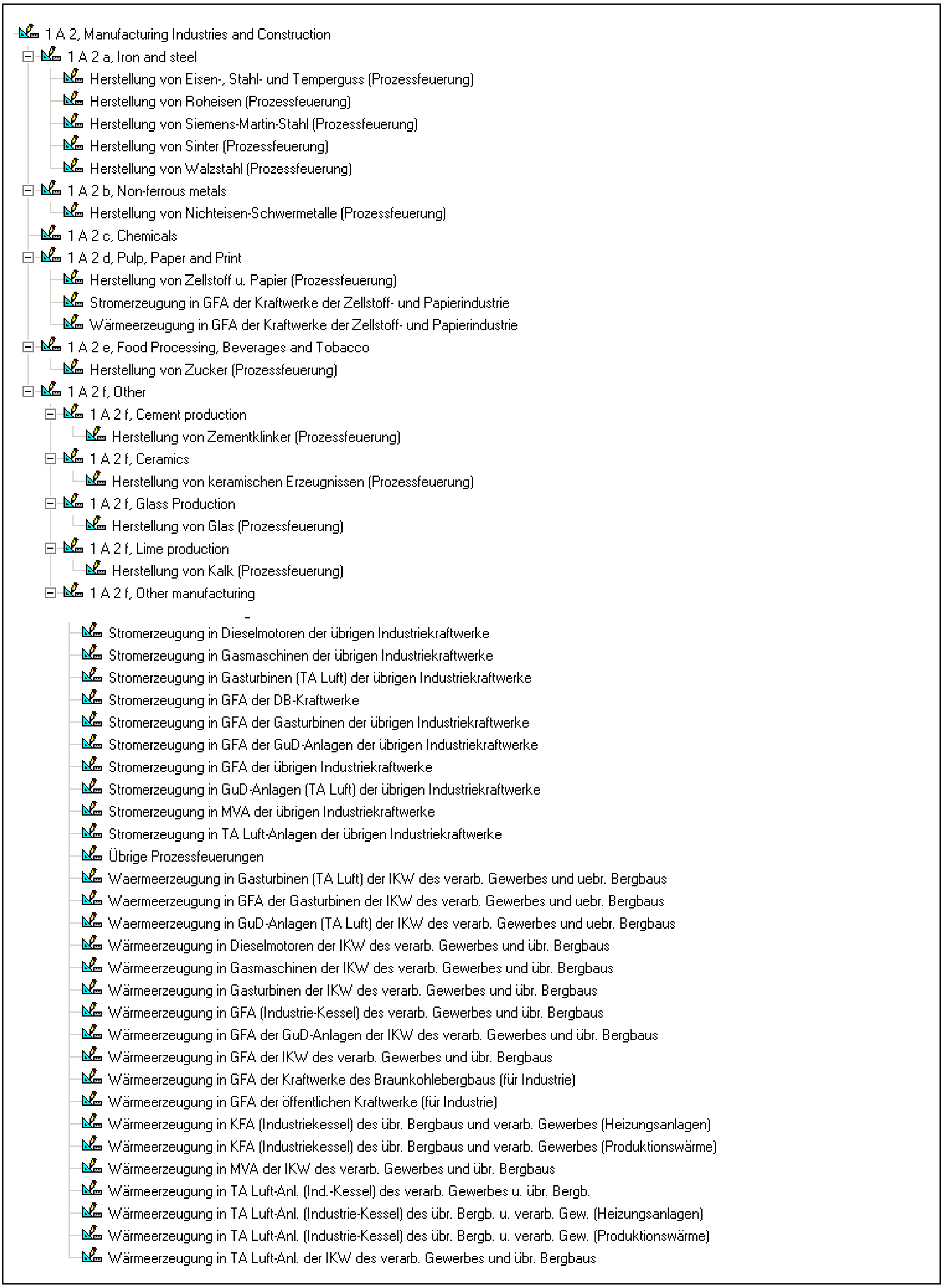


Figure 23: Structural allocation, 1.A.2 Manufacturing industries and construction

The following improvements over the last inventory have been made in source category 1.A.2:

The activity rates for the Federal Republic of Germany as of 1995 were determined in the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten"; FKZ 204 41 132), which was aimed at revising the BEU model.

Table 12 through Table 18 show the revised structure of the BEU model.

As a result of the revision, several BEU structural elements were combined for the period as of 1995 (small combustion plants are now reported under "TA-Luft" plants, since the data that would be required for separate listing are lacking), and several new BEU elements were created (gas and steam turbine plants are now also listed in the category of heat production in industrial power stations).

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.

In addition, a small number of experts' assessments were required in this area – primarily with regard to technology differentiation.

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

With respect to power and heat generation, industrial power stations and boiler systems were 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 are 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 generation in industrial power stations and boiler systems was carried out via Statistik 067 (Statistics 067; electricity-generation 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 leads to a jump in the activity rates for heat and electricity production. Until 2001, only the fuel inputs for electricity production in electricity generation 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 Causes* (BEU). In addition to the figures provided from the Energy Balance, in various sub- source categories substitute fuels have now been listed. The relevant amounts were determined in a research project (UBA 2005b, FKZ 204 42 203/02) and are now updated annually with the help of association data (see below). As these figures show, use of substitute fuels has been increasing. This has led to reductions in use of conventional fuels, via de facto fuel substitutions.

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

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

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

As a result of data updating (updating of the evaluation tables for the Energy Balance), the data reported for electricity generation from heating oil, in source category 1.A.2. (and in 1.A.1) differ from the corresponding data reported in the 2007 inventory. For 2005, the data for heating oil was lowered from 100 PJ to 52 PJ, on the basis of a recalculation, using updated figures of the petroleum industry association (Mineralölwirtschaftsverband), carried out by the Working Group for Energy Balances (Arbeitsgemeinschaft für Energiebilanzen).

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

CRF 1.A.2.a					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	0.99 %	1.11 %	rising

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

The source category Manufacturing industries and construction – iron and steel is a key category, 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 the year 1993. 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 Emissions Causes (BEU), the pertinent model in the research project "Substantiation of the data quality of activity rates" ("Dokumentation der Datenqualität von Aktivitätsraten" (FKZ 204 41 132) was revised, and the relevant calculation algorithms were described in detail.

This sub- source category comprises process combustion in the various production areas of the iron and steel industry. The relevant fuel-use amounts, including those for secondary fuels, are contained in the Balance of Emission Causes (BEU).

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 explained in Annex Chapter 13.6 of the NIR 2007 and in the 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.

In a research project (UBA 2005b, FKZ 204 42 203/02), the time-series data provided by the Wirtschaftsvereinigung Stahl steel-industry association for use of substitute reducing agents in the steel industry was subjected to intensive quality checks. In the process, the steel industry's total reducing-agent and fuel inputs from standard fossil fuels were determined and then compared with consumption of substitute reducing agents. In addition, the determined CO_2 emissions from regular and substitute reducing agents were assessed.

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

As a result of the methodologically based revision of activity rates, recalculations were carried out for the entire time series as of 1995. These had only a slight impact on the total-emissions figures for the source category, however.

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

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.

3.1.4.2 Manufacturing industries and construction – non-ferrous metals (1.A.2.b)

CRF 1.A.2.b					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 category.

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 Causes (BEU). The source for fuel inputs consists of statistics for the manufacturing sector (Statistik 060 – Energieverwendung des produzierenden Gewerbes (energy use in the manufacturing sector; 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 Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of such revision, production and initial processing of precious metals, aluminium and other non-ferrous metals are now taken into account in determination of activity data.

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

The 1990 activity rates for the new German Länder were revised and substantiated, with the help of new data, in the project "Base year and updating" ("Basisjahr und Aktualisierung" (UBA 2005c: FKZ 205 41 115); see Annex Chapter 14.1).

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 ever. 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)

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

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

As a result of the methodologically based revision of activity rates, recalculations were carried out for the entire time series as of 1995. These had a considerable impact on emissions levels for the entire source category.

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

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.

3.1.4.3 Manufacturing industries and construction – Chemicals (1.A.2.c)

CRF 1.A.2.c					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	IE	IE	IE	IE	IE

The chemical industry's process combustion and own power generation 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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 category.

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 generation, 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 fluctuating estimates, as well as on small numbers of measurements and analysis findings, and thus are widely distributed. 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)

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 amount flows 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)

Plans call for allocating regular fuels used in paper-industry power stations to the relevant structural elements, with the help of new Energy Balance data.

3.1.4.5 Manufacturing industries and construction – Sugar production (1.A.2.e)

CRF 1.A.2.e					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	- / t	CO_2	0.16 %	0.06	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										
Method of EF determination										

The Sugar production source category is a key category for CO_2 emissions in terms of trend.

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 Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

As a result of this revision, it was decided that all fuels of relevance for calculation of activity rates would be included as of Statistik 060 (Statistics 060; DESTATIS, 2006b).

The pertinent fuel inputs are contained in the Balance of Emission Causes (BEU). The fuel input data has been taken from manufacturing industry statistics (Statistik des produzierenden Gewerbes; Melde-Nr. (reporting no.) 15.83, sugar production). As of 2002, Meldenummer (reporting number) 15.8 (sonstiges Ernährungsgewerbe ohne Getränkeherstellung; other food industry, but without beverage production) will be used to calculate activity rates. This will be done in order to take account of different data availability; pursuant to the Federal Statistical Office, the fuel inputs recorded under that number can be allocated almost exclusively to the sugar industry. Statistik (Statistics) 067 (DESTATIS, 2006c) will be used for purposes of differentiation from heat and electricity production.

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

The 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).

The fuel inputs for the new German Länder in 1990 were recalculated on the basis of specific fuel consumption in 1989 and production in 1990.

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

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

As a result of the methodologically based revision of activity rates, recalculations were carried out for the entire time series as of 1995. These had a considerable impact on emissions levels for the entire source category.

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

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.

3.1.4.6 Manufacturing industries and construction – Other (1.A.2.f, sum)

CRF 1.A.2.f					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	10.85 %	8.45 %	falling

The source category Other (1.A.2.f), the sum of all other sub- source categories, is a key category, in terms of emissions level and trend, for CO_2 emissions. Key-category analysis was carried out only for the sum of sub- source categories in 1.A.2.f.

As a result of the pertinent inventory structure, the NIR 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 ceramic 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 emissions-dominant sub-source categories can be listed. 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 generation 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)

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									

Apart from the binding key-category analysis, this sub- source category must be considered particularly significant; it contributes nearly one percent to the total inventory.

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 Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

The pertinent inputs of conventional fuels are contained in the Balance of Emission Causes (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 generation 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 is now being reported 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, Zement)

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 fluctuating estimates, as well as on small numbers of measurements and analysis findings, and thus are widely distributed. 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).

They 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 13.

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

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.

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

Recalculations were carried out for the entire time series, to take account of the methodological revision of activity data.

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

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.

3.1.4.8 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 generation 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 pertinent fuel inputs are contained in the Balance of Emission Causes (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 ceramics).

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

The 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 were determined for all fuels, for the first time ever, for the year 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.

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

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.

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

As a consequence of the methodologically based revision of activity rates, recalculations were carried out for the entire time series as of 1995. These have led to an increase in the emissions for this source category.

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

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.

3.1.4.9 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 Emissions Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

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

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.

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

Recalculations were carried out for the entire time series as of 1995, to take account of the methodological revision of activity data.

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

3.1.4.10 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 Causes (BEU) were revised in the interest of standardisation, consistency and transparency.

The relevant inputs of regular fuels are contained in the Balance of Emission Causes (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 generate 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 "Use 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 ever, for the year 2004. The relevant method is described in Annex 13.6 of the NIR 2007.

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

In the framework of the research project "Inputs of secondary fuels" (UBA 2005b, FKZ 204 42 203/02), the uncertainties of the CO_2 emission factors derived for substitute fuels were determined using the Monte Carlo method. Such figures are based on fluctuating estimates, as well as on small numbers of measurements and analysis findings, and thus are widely distributed. 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 plants in the new German Länder for the year 1990"). The relevant recalculation method is described in the Annex, Chapter 13.

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

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 – as has been the procedure for 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.

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

Recalculations were carried out for the entire time series as of 1995, to take account of the methodological revision of activity data.

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. The available data does not permit such allocation, however. Since no delivery data are available for the gases in source category 1.A.2, these gases cannot be assigned to the various individual processes. They are thus reported here in sum form.

3.1.4.11.2 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)

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 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 ever, 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)

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 were 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 methodologically based revision of activity rates, recalculations were carried out for the entire time series as of 1995. These had a considerable impact on emissions levels for the entire source category.

As a result of updating of the evaluation tables for the Energy Balance, the data reported for electricity generation from heating oil, in source category 1.A.2. + 1.A.1, differ from the corresponding data reported in the 2007 inventory. For 2005, the figures for heating oil have been lowered from 100 PJ to 52 PJ.

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 results of Chapter 3.1.1.5 apply mutatis mutandis.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Jet Gasoline	l / t	CO_2	0.23 %	0.50 %	rising

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 air transport is a key category in terms of emissions levels and trend.

In terms of emissions origins, air transports differ considerably from land and water transports, since aircraft burn most of their fuel under atmospheric conditions that differ from those on the ground and that are not constant. The main factors that influence the combustion process in this sector include atmospheric pressure, environmental temperature and humidity – all of which are factors that vary considerably with 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 sulphur dioxide (SO_2), nitrogen oxides (NO_X, i.e. NO and NO_2), non-methane volatile organic compounds (NMVOC), methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O – laughing gas).

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

For aircraft operating in Germany, no data are available that are broken down by the various relevant flight phases.

For this reason, the requirements for the Tier 2 method, calling for differentiation of emission factors for the LTO cycle and cruising flight, cannot be met.

In the inventory, air transport emissions are still calculated via the Tier 1 method, pursuant to equation 2.7 of IPCC GPG p. 2.57 (IPCC, 2000):

Emissions = fuel consumption * emission factor

Activity rate:

The Energy Balance prepared on the basis of aircraft fuel sold in Germany provides the basis for the relevant activity data. The emission factor for carbon dioxide was derived on the basis of the carbon content of jet kerosene.

Emission factors:

In keeping with the derived mean carbon content of jet kerosene, a value of 3,150 g/kg (73,256 kg/kJ) is used.

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 jet kerosene 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 jet kerosene, a jet kerosene sulphur content of 210 mg/kg is 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.

From the study "Federal Environment Agency texts 17/01" (UBA-Texte 17/01 (Federal Environment Agency, 2001a), the ratio between national and international air transports was determined as 20 % to 80 %. The smaller percentage is based on the number of passengers, as a percentage of all passengers, who must be assigned to intra-German air transports (including transfers, base year 1995). In keeping with this relationship, 20 % of the total emissions determined are assigned to national civil air transports.

Table 24 shows the emission factors used to date (until NIR 2003). The first emission-factor column uses the units g/kg fuel, which are customarily used in the air-transport sector, while the second emissions-factor column uses the units kg/TJ, which are commonly used in the framework of reporting. For purposes of emissions reporting, the determined emission factors must be converted into the corresponding energy equivalents, taking the calorific value of jet kerosene into account. The Table shows the values used to date (until 2003). The conversion factor used is 44.985.

Table 24: Emission factors used until NIR 2003

Name	Emission factor [g/kg]	Emission factor [kg/TJ]
Sulphur dioxide	0.2	4.7
Nitrogen dioxide	17.4	390
Volatile organic compounds (without methane)	2.6	59
Methane	0.04	1
Carbon monoxide	17.4	390
Carbon dioxide	3,299.7	74000
Nitrous oxide (laughing gas)	0.1	1.5

(Conversion with factor 43,000 kJ/kg)

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

For scientific reasons, it is not possible to reliably determine the uncertainties for the emission factors used. Beginning next year, more precise emissions data, based on more precise calculation for Tier 2 methods (in some cases, even Tier 3), are expected from the EUROCONTROL European Organisation for the Safety of Air Navigation. As of that time, therefore, it will become possible to provide uncertainty ranges.

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

General and source-specific quality assurance (Tier 1 and Tier 2), in keeping with the requirements of the QSE manual and its co-applicable documents, was carried out. The current calculation procedures have been verified on the basis of more current data and findings. This applies to the various emission factors used and the energy content required for conversion into energy-related emission factors. No data is available to quantify a more accurate breakdown between national and international air transports. The IPCC's proposed emission factors were taken into account in the following considerations. On the other hand, it must be noted that the proposed emission factors were generated with an average fleet that does not reflect German air transports. 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 26. Determining the emission factor for 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 level 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 25).

Table 25: 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 Center (Deutsches Zentrum für Luft- und Raumfahrt e.V. – DLR) and that is oriented to temperatures and pressures at the combustion-chamber intake. Engines with higher bypass ratios have slightly lower specific nitrogen-oxide emissions (DLR, 1999).

Aircraft with "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 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 26).

Table 26: NO_X emission factors for 1992 and 2015, from NASA, ANCAT and DLR, without military air transports (all flight phases)

	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-chamber pressures and temperatures. The values determined in the DLR and ANCAT scenarios are likely to have been affected by the assumption that a large percentage of engines in 2015 will have lower specific nitrogen oxide emissions, and thus the zenith for the emission factor EF (NO_X) will have been passed by then.

On the basis of 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 (NO_X) 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 jet kerosene. They are emitted primarily at low load levels. As engine efficiencies have improved, a process that has involved increases in combustion-chamber temperatures and pressures, the specific emission factor for unburned hydrocarbons has decreased. For example, the EF (HC) for global airline transports in 1986, for all flight phases, is given as 1.34 g/kg, while that for 1989 is 1.25 g/kg and that for 1992 is 1.12 g/kg (DLR, 1999). Studies of emitted hydrocarbons have shown that the length of hydrocarbon chains in the hydrocarbon fractions formed in jet kerosene combustion decreases with increasing engine load. At an 80 % load level, primarily C1 and C2 fractions form, while at 7 % and 30 % thrust 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 jet kerosene. While the first sub-reaction involved, oxidation of carbon to carbon monoxide, is fast, the second sub-reaction, oxidation to carbon dioxide, determines the rate of the overall reaction. In combustion, part of the carbon monoxide is not completely converted.

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 quantities, care must be taken to obtain the most precise emission factor possible (DÖPELHEUER, 2002). The basis for determining the emission factor for jet kerosene consists of the average composition of this fuel. Jet kerosene consists of alkanes (about 35 % by volume), cycloalkanes (about 45 % by volume), aromates (about 17 % by volume) and alkenes (about 1 % by volume). As a rule, the fuel's composition varies widely by region. Among the lengths of the hydrocarbon chains involved, the fraction with 11 to 12 carbon atoms predominates by amount. Taking into account jet kerosene's average hydrogen content, and its average mol-weight of 167 g/mol, jet kerosene can be simply described via the sum formula $C_{12}H_{23}$. In complete combustion, in strict stoichiometric terms, one kg of jet kerosene produces 1.24 kg of water and 3.15 kg of carbon dioxide. **The average emission factor for carbon dioxide**

from jet kerosene may thus be assumed to be 3,150 g/kg. This value has also been confirmed in numerous publications (including IPCC, 1999).

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.

The breakdown used to date for determining the contribution made by domestic air traffic to total emissions (DESTATIS, Fachserie 8, Reihe 6) was obtained by allocating 80 % of determined total emissions to international air traffic. This breakdown is based on a study carried out by the TÜV Technical Control Association organisation under commission to the Federal Environment Agency (UBA, 1989). Since then, air traffic has become more and more international, and thus the domestic share of air traffic has become relatively smaller.

The breakdown must be based on the relevant IPCC guidelines' definition for preparation of national emissions inventories. Pursuant to those guidelines, domestic air traffic includes all passenger and cargo flights that start and end on the territory of a single country. International air traffic, on the other hand, comprises all civil air traffic that originates in other countries or that leaves domestic territory.

On the basis of the figure of 114 million passengers transported in 2002, of which 13.6 million fell within the category *domestic air traffic*, domestic air traffic accounted for a share of 11.9 % of all civil air traffic over Germany. Including all transfer passengers, however, a total of 19.8 million passengers, or 17.4 % of all passengers, flew on intra-German routes in 2002. Under the IPCC's definitions, transfer passengers must be included, as a rule.

In the area of cargo traffic, international flights accounted for 2.1 million of the total of 2.2 million t of freight transported in 2002. The relevant domestic share was thus 0.1 million t, or 4.5 %.

As to overall numbers of flights, in 2002 a total of 1.45 million flights were made in Germany, of which 0.339 million had destinations within Germany. This number represents a share of 23.4 %.

Another category that can be useful for calculating domestic shares of total transports, for purposes of calculating emissions, is that of *seat/tonne-km*. Here as well, no close correlation to fuel consumption may be assumed. The reasons for this include variances in fleet fuel consumption, and the relatively higher share of the LTO cycle, in which fuel consumption is greater, due to the take-off and climbing phases involved. Air freight accounted for 23.8 % of total transport performance (assuming 0.1 tkm to be equivalent to one seat-km). A total of 7.81 billion tonne-kilometres were found to have been completed in 2002. Domestic flights accounted for 21.4 % of all passenger seat-km in 2002. The combined figure for freight and passenger km together is smaller, since most freight transports – as described above – serve international destinations.

At present, no calculation procedure is available for converting existing data into fuel-consumption figures, and no data that would support such conversion is collected; consequently, a 20 % domestic air transport share will continue to be assumed for calculation purposes. The smaller percentage is based on the number of passengers, as a percentage of all passengers, who must be assigned to intra-German air transports (including transfers, base year 1995) (UBA, 2001a). While the data on passengers, flights and seat-km for 2002 also point to this share, no correlation with fuel consumption can be derived, and yet such a correlation should actually be used as a calculation basis.

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

In a review of the year 2007, the emission factor for CO_2 during the 1990-1999 period was recalculated in accordance with the EF for the period as of 2000. As a result, it was reduced from 74,000kg/TJ to 73,265kg/TJ.

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

EUROCONTROL, the European Organisation for the Safety of Air Navigation, maintains an extensive database with detailed information on all flights in European airspace. Using this database, EUROCONTROL has developed a model that makes it possible to calculate emissions from civil aviation pursuant to Tier 3 of the 2006 IPCC Guidelines. In a pilot project, Germany is currently reviewing the possibility of using the database data for reporting purposes. Following initial analyses, in all likelihood next year Germany will use the higher method to recalculate air-transport emissions, on the basis of the EUROCONTROL data, and then will recalculate the time series.

In a first step, the emission factors used until the year 2000 were used for calculations in the CSE. These emission factors are still valid at present.

The emission factors used for the last five years, and for the period prior to those years, are shown again in Table 27.

Table 27: Adjusted emission factors for civil air transports

Name **Year**	**New emission factor 2000-2005 [g/kg]**	**New emission factor 2000-2005 [kg/ TJ]**	**Old emission factor 1990-1999 [kg/ TJ]**
Sulphur	0.4	9.4	4.7
Nitrogen dioxide	14.00	325.58	390
Volatile organic compounds (without methane)	1.61	37.44	59
Methane	0.04	0.93	1
Carbon monoxide	9.20	213.95	390
Carbon dioxide	3,150.00	73,265	74,000
Nitrous oxide (laughing gas)	0.15	3.49	1.5

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	11.80 %	14.21 %	rising
All fuels	- / t	CH_4	0.10 %	0.01 %	falling

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 category for CO_2 emissions in terms of both emissions level and trend and a key category for CH_4 emissions in terms of trend.

Emissions from motorised road traffic in Germany are reported under this category. It includes traffic on public roads within Germany, excluding agriculture and forestry and excluding the military. 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 (cf. Table 28, p. 157).

The sharp reduction in the methane emission factor for gasoline and, thus, the sharp reduction in methane emissions between 1990 and 1993, is 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 to 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 2006, these emissions had decreased by 22.4 million t with respect to the corresponding figure in 2000. The likely reasons for this trend include reductions in specific fuel consumption, a marked shifting 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).

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 (except for Denmark), 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 "fuel-purchase tourism" ("Tanktourismus"). Although several detailed studies have been carried out, no reliable overall picture of the situation is yet available (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).

According to estimates of the German Institute for Economic Research (DIW), the total quantity of such imported fuel amounted to about 3.8 billion litres in 2005: 2.4 billion litres of diesel (the majority of which was imported in tanks of trucks), and 1.5 billion litres of petrol – or more than 6 % of Germany's nation-wide fuel consumption (2005: about 62 billion litres) (DIW, 2005).

Table 28: Emissions from road transports

[Gg]	CO_2	CH_4	N_2O	NO_X	CO	NMVOC	SO_2
1990	150,358.33	60.53	1.96	1,341.45	6,527.26	1,408.97	90.20
2000	171,289.61	15.68	4.81	996.24	2,451.76	278,33	19.64
2002	165,961.12	12.40	4.50	852.47	2,036.44	218,31	3.45
2003	159,828.29	10.53	4.19	776.86	1,848.61	186,21	0.83
2004	159,993.14	9.52	4.09	731.86	1,696.65	168,16	0.83
2005	152,230.94	8.34	3.79	655.62	1,523.25	147,88	0.80
2006	148,881.71	7.40	3.54	613.33	1,385.71	133,49	0.79

In source category 1.A.3.b Road transport, the CSE includes mopeds, motorcycles, diesel-powered automobiles, gasoline-powered automobiles, buses, light duty vehicles with diesel and petrol engines and heavy duty vehicles, broken down by emissions-reduction equipment.

- 1 A 3 b, Road Transport
  - Busse, Verbrauch insgesamt
    - Bremsabrieb bei Bussen
    - Busse mit Minderungstechnik, Verbrauch ausserorts
    - Busse mit Minderungstechnik, Verbrauch Autobahn
    - Busse mit Minderungstechnik, Verbrauch innerorts
    - Fahrleistung von Bussen
    - Konventionelle Busse, Verbrauch ausserorts
    - Konventionelle Busse, Verbrauch Autobahn
    - Konventionelle Busse, Verbrauch innerorts
    - Reifenabrieb bei Bussen
    - Straßenabrieb bei Bussen
  - Leichte Nutzfahrzeuge, Verbrauch insgesamt
    - Bremsabrieb bei leichten Nutzfahrzeugen
    - Fahrleistung von leichten Nutzfahrzeugen
    - Konventionelle leichte Diesel-Nutzfahrzeuge, Verbrauch ausserorts
    - Konventionelle leichte Diesel-Nutzfahrzeuge, Verbrauch Autobahn
    - Konventionelle leichte Diesel-Nutzfahrzeuge, Verbrauch innerorts
    - Konventionelle leichte Otto-Nutzfahrzeuge, Verbrauch ausserorts
    - Konventionelle leichte Otto-Nutzfahrzeuge, Verbrauch Autobahn
    - Konventionelle leichte Otto-Nutzfahrzeuge, Verbrauch innerorts
    - Leichte Diesel-Nutzfahrzeuge mit Minderungstechnik, Verbrauch ausserorts
    - Leichte Diesel-Nutzfahrzeuge mit Minderungstechnik, Verbrauch Autobahn
    - Leichte Diesel-Nutzfahrzeuge mit Minderungstechnik, Verbrauch innerorts
    - Leichte Otto-Nutzfahrzeuge mit Minderungstechnik, Verbrauch ausserorts
    - Leichte Otto-Nutzfahrzeuge mit Minderungstechnik, Verbrauch Autobahn
    - Leichte Otto-Nutzfahrzeuge mit Minderungstechnik, Verbrauch innerorts
    - Reifenabrieb bei leichten Nutzfahrzeugen
    - Straßenabrieb bei leichten Nutzfahrzeugen
    - Verdunstung, Konventionelle LNF, Verbrauch innerorts
    - Verdunstung, Otto-LNF mit Minderungstechnik, Verbrauch innerorts

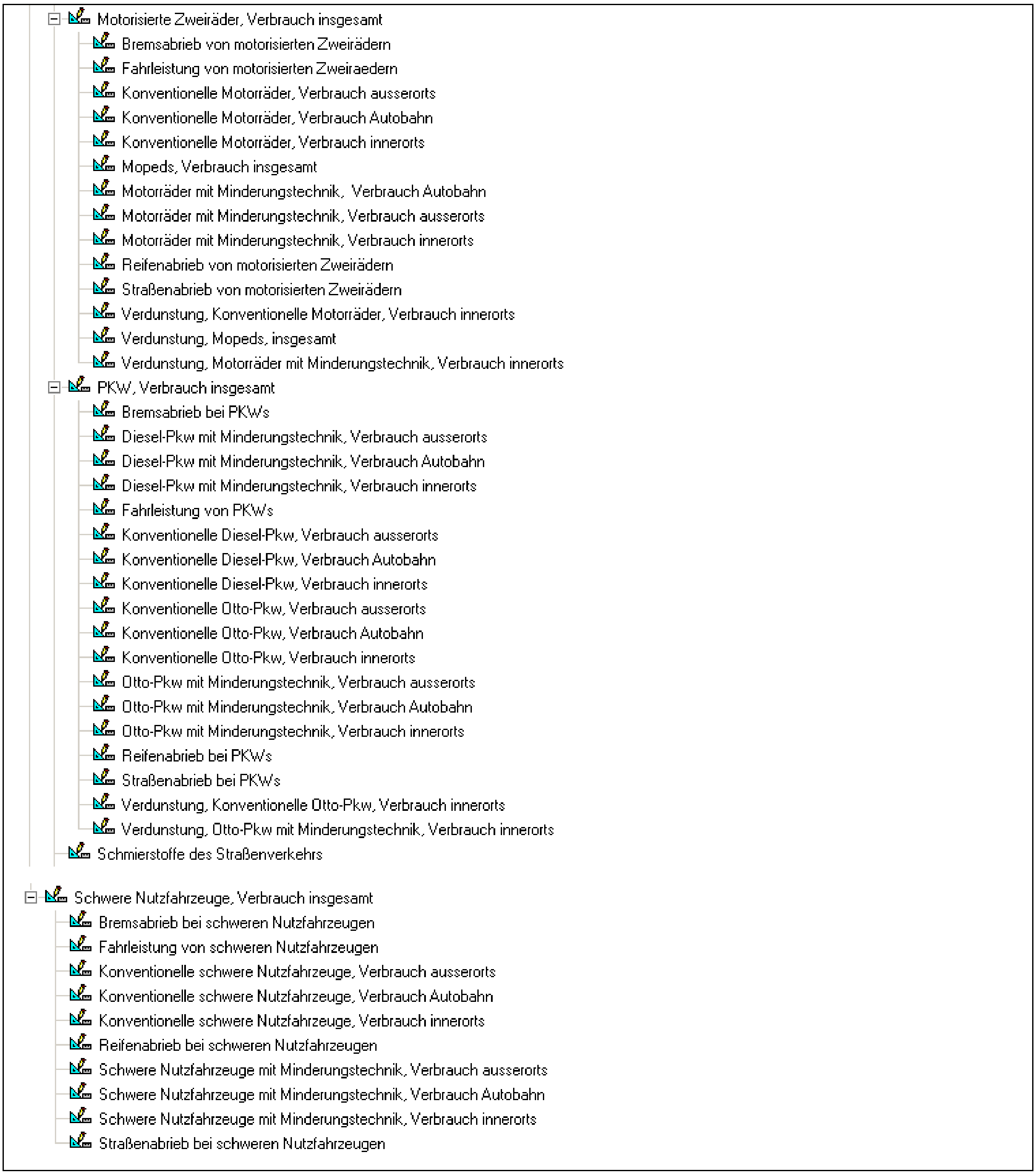


Figure 24: Structural allocation, 1.A.3.b Road transport

Calculation of CO_2 emissions from motorised road transports in Germany is based on 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 form of *Energy Balances*. In order to determine the CO_2 emissions, the individual fuel consumption figures (petrol, diesel (not including biodiesel), LP gas) are multiplied 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)[18]. That model adopts a "*bottom-up"* (Tier 3) approach

18 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.

whereby mileage of the individual vehicle layers is multiplied by region-specific emission factors. For passenger cars and light duty vehicles, in addition, a "*cold start surplus*" is added. The total consumption calculated on the basis of fuel type is compared with the consumption according to the Energy Balance. The emissions are 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 are derived (kg of emissions per TJ of fuel consumption) and then forwarded to the CSE via a relevant interface (cf. Chapter 17.3.2). 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 pollution-control equipment". The following differentiation is used in the area of pollution-control equipment:

	Without pollution-control equipment	**With pollution-control equipment**
Passenger cars / light commercial vehicles with petrol-burning engines	without 3-way catalytic converters	with 3-way catalytic converters
Passenger cars / light duty vehicles with diesel engines, buses, heavy commercial vehicles, motorcycles	prior to Euro 1	after Euro 1

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.

Real data for the years 1990-2000

These real data refer to:

- Motor-vehicle ownership:
  For western Germany from 1990 to 1993, and for Germany as a whole from 1994, car ownership was calculated on the basis of the officially published ownership and new registration statistics of the Federal Motor Transport Agency (Kraftfahrt-Bundesamt, 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.
- Emission factors:
  All emission factors are listed in the " Handbook Emission Factors for Road Transport 2.1" ("Handbuch für Emissionsfaktoren des Straßenverkehrs 1.2") (INFRAS, 2004). This manual was prepared in the framework of 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. These include fundamental surveys for the reference years 1989/1990. In these 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 "Handbook Emission Factors for Road Transport", which is used for the current emissions calculations, draws on findings of the EU working group COST 346 and the ARTEMIS research programme.

- Data for the years 2001 to 2006

These real data refer to:

- Development of the road traffic fleet:
  Fleet data for the TREMOD model, for the reference years 2001 through 2003, are the result of cross-checking with the database of the Federal Motor Transport Authority (Kraftfahrt-Bundesamt, KBA). Such cross-checking provides vehicle-fleet statistics for each reference year, broken down as is needed for emissions calculation – by the characteristics of engine type (gasoline, diesel, other), size class, vehicle age and basic emissions classification. 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 2006 were calculated with the help of a fleet-shifting module in TREMOD that extrapolates past fleet-growth trends.
- Emission factors:
  The emission factors are derived from the development of the various vehicle layers and from the data provided by the " Handbook Emission Factors for Road Transport 2.1". The emissions reduction achieved via the introduction of sulphur-free fuels was estimated by the Federal Environment Agency.
- Mileage:
  Vehicle mileage was updated on the basis of the "2002 vehicle mileage survey" ("Fahrleistungserhebung 2002"; IVT 2004).

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.

Quality checking of the data is achieved by comparing energy consumption based on the top-down approach (Energy Balance) and bottom-up approach (uncorrected TREMOD results). For petrol/gasoline, deviations of between 0.4 % and 3.7 % were calculated for the period 1994-2002. The deviations for diesel-fuel consumption ranged between 8.9 % and 17.7 %.

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

The presented emissions data was calculated with TREMOD version 4.17 (IFEU, 2005). With this version, no changes, with respect to the 2007 report year, were made in the database.

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

No improvements are planned at present.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	- / t	CO_2	0.23 %	0.12 %	falling

Gas	CO_2	CH_4	HFCH FC	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 category for 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[19]. 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 further description below.

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. Solid fuels are used for historic rail vehicles – in the main, steam locomotives are operated for demonstration and exhibition purposes. The amounts of hard-coal and lignite used in historic railway vehicles vary from year to year. As a result, the CO_2 emission factors for railway use of solid fuels also differ from year to year. Such fuels are of little significance, accounting for only 1.5 % of total energy inputs in the railway sector. Use of other fuels – such as vegetable oils or gas – in private narrow-gauge railway vehicles has not been included to date and may still be considered negligible.

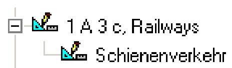


Figure 25: Structural allocation 1.A.3.c Railways

3.1.5.3.2 Methodological issues (1.A.3.c)

No specific information relative to this source category is found in IPCC Good Practice Guidance (2000: Chapter 2). The relevant emissions are thus calculated as the product of fuel consumption and the relevant country-specific emission factors. This procedure conforms to the general Tier 1 method and the basic calculation rule pursuant to equation 2.6 of the IPCC Good Practice Guidance (2000, p. 2.46).

Activity rate:

The energy-consumption data is taken from the *Energy Balance* (AGEB, 2003) and, for the years 2003-2006, from sales statistics of the Association of the German Petroleum Industry

[19] From Energiewirtschaftliche Tagesfragen, 54th year (2004), issue 3, p. 185

(Mineralölwirtschaftsverband, MWV). In particular, the fuel data have been taken from the following Energy Balance lines, for the following periods:

Table 29: Sources for AR in 1.A.3.c

Fuel type	Energy Balance line	Relevant years
Diesel fuel	74	until 1994
	61	since 1995
Lignite briquettes	61	since 1996
Raw lignite	61	since 1996
Hard coal	74	until 1994
	61	since 1995
Hard-coal coke	61	since 1995

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

Gas	Emission factor used [kg/TJ]	Default emission factor [kg/TJ]
CH_4	Diesel fuel: 1.6 – 3.2 Hard coal: 15.0 Lignite briquettes: 15.0 Raw lignite: 15.0 Hard-coal coke: 0.5	Oil: 5 Coal: 10
N_2O	Diesel fuel: 1.0 Hard coal: 4.0 Lignite briquettes: 3.5 Raw lignite: 3.5 Hard-coal coke: 4.0	Oil: 0.6 Coal: 1.4

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

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

No recalculations are required.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
	- / -				

Gas	CO_2	CH_4	HFCH FC	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 not a key category.

Navigation is broken down primarily into the categories "coastal and inland navigation" and "sea navigation". 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.

Figure 26: Structural allocation, 1.A.3.d Navigation

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:

The energy consumption data was taken from the *Energy Balance* (AGEB, 2003) and, for the period as of 2002, from official petroleum data of the Federal Office of Economics and Export Control (BAFA). In particular, the fuel data have been taken from the following Energy Balance lines, for the periods as listed:

Table 31: 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 following section breaks down the activity rates into the areas of domestic and international, taking account of sales – as listed in different Energy Balance lines – of different ship fuels subject to different taxation rates. The resulting amounts of fuel, in combination with the various relevant EF, make it possible to calculate and list 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.

Emission factors:

The emission factors are based, for each specific gas, on the results of various Federal Environment Agency research projects and on 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's study "Air Quality Control '88" ("Luftreinhaltung '88"; (UBA, 1989b)). This value is lower than the IPCC default value for heavy fuel oil in sea 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-reduction 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 fuel 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 not been carried out completely.

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

No recalculations are required.

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 category nach Level 8l) / Trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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	--	--	--	--
EF uncertainties in %	--	--	--	--	--	--				
Distribution of uncertainties	--	--	--	--	--	--				
Method of EF determination	T1	T1	--	--	--	T1				

The source category Other Transport is not a key category.

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.

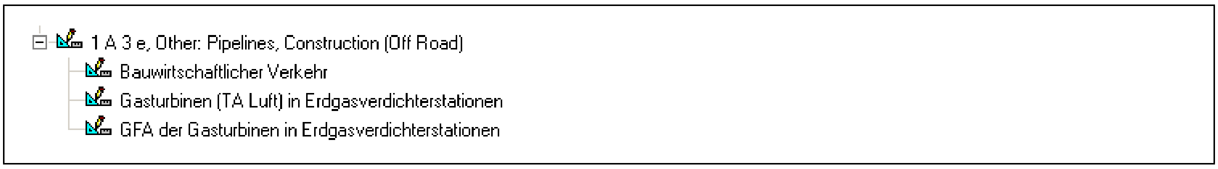


Figure 27: Structural allocation, 1.A.3.e Other Transport

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 rate – construction-sector transports:

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 (until 1994 and as of 1995) (cf. Chapter 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 category, the calculation procedure used for this category should be as detailed as possible. At present, due to a lack of detailed data, only the above-described Tier 1 method can be used, however.

Emission factors – construction-sector transports:

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 13.7 on 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 an UBA 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-reduction equipment.

Activity rate – natural-gas compressor stations:

The area of *natural-gas compressor stations* accounts for the smaller share of energy inputs. The natural-gas consumption data are provided in a revised form for the 2007 report. The relevant values, along with natural-gas inputs in coking plants and city-gas plants, are provided in the 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.

Emission factors – natural-gas compressor stations:

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 13.7 on 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 plants (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)

In the 2004 report year, uncertainties were determined for the activity rates, for the first time ever (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 (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has not been carried out.

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)

Natural-gas compressor stations: The results of Chapter 3.1.1.5 apply mutatis mutandis.

Recalculation back to the year 1995 was carried out for methane emissions of construction-sector transports. Since the emissions factors used until the 2007 report year do not reflect the relevant technical development, recalculation with the updated emissions factors yields slightly lower methane-emissions figures (cf. the following Table).

Table 32: Reduction of CH_4 emissions in the 2008 report, in comparison to the relevant figures in the 2007 report

Year	1995	2000	2003	2004	2005
Reduction of CH_4 emissions [in Gg]	0.09	0.12	0.13	0.14	0.15

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

Plans call for using updated, country-specific emission factors.

Natural-gas compressor stations: The planning described in Chapter 3.1.1.6 could further improve the already good data for 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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
CRF 1.A.4.a (commercial/institutional)					
All fuels	l / t	CO_2	5.02 %	4.39 %	falling
All fuels	- / t	CH_4	0.10 %	0.01 %	falling
CRF 1.A.4.b (residential)					
All fuels	l / t	CO_2	10.16 %	11.18 %	rising
CRF 1.A.4.c (agriculture, forestry and fishing)					
All fuels	l / t	CO_2	0.86 %	0.62 %	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 % - liguid fuels		-25/ +50	-	-	-	± 35				
EF uncertainties in % - gaseous fuels		-50 / +100	-	-	-	± 35				
EF uncertainties in % - solid fuels		-50/ +100	-	-	-	± 50				
Distribution of uncertainties		L	-	-	-	N				
Method of EF determination		Tier 2	-	-	-	Tier 2				

The source category 1.A.4 Other is a key category, in terms of both emissions level and trend, in all of its sub - source categories. Furthermore, the source category 1.A.4.a (*Commercial/Institutional*) is a key category, in terms of trend, for CH_4 emissions.

Source category 1.A.4 comprises combustion systems in the areas Residential, Commercial and Institutional and Agriculture, along with various mobile sources.

Heat-generation systems in small combustion systems of small commercial and institutional users are reported in sub- source category 1.A.4.a. Commercial and institutional.

1.A.4.b comprises energy inputs in households (the Residential sector). This refers primarily to combustion systems. In addition, source category 1.A.4.b includes residential mobile sources (not including road transports).

Sub- source category 1.A.4.c comprises the areas of agriculture, forestry and fisheries. Reporting under this category includes emissions from heat generation in small and medium-sized combustion systems and emissions from agricultural transports. Pursuant to the IPCC structure, 1.A.4.c also includes emissions from mobile sources in fisheries and in forestry. 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 in which these emissions are calculated.

The following Figure 28 shows relevant allocations within the Central System of Emissions.

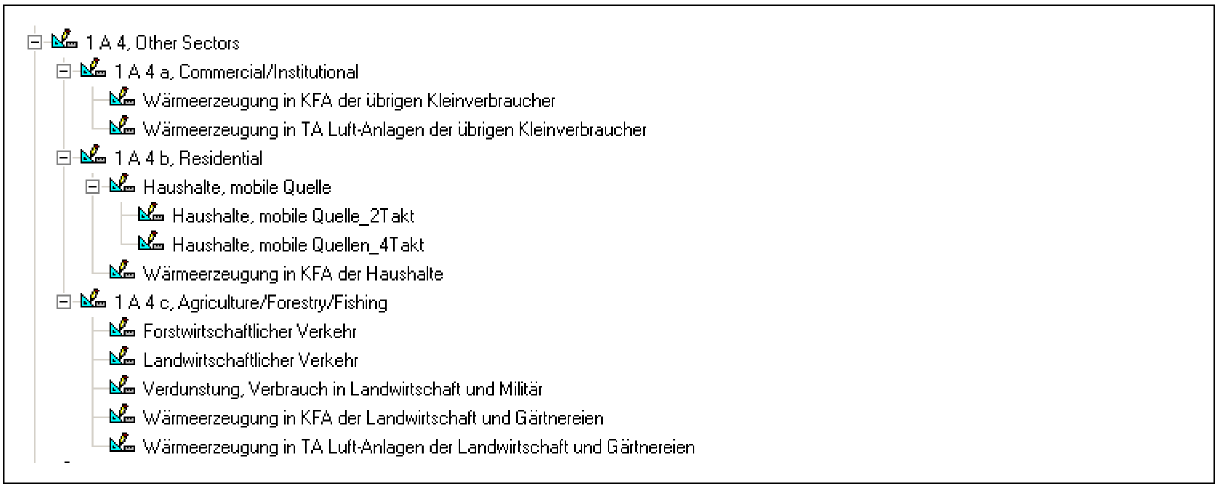


Figure 28: Structural allocation, 1.A.4 Other sectors

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 2000, more than 36 million combustion systems were in place in Germany in the Residential and Commercial/Institutional sectors (UBA, 2003d: p. 10). Combustion systems for solid fuels accounted for a majority of these systems, or some 14.6 million, while the group of gas-fired furnaces accounted for some 13.5 million systems and that of oil-fired furnaces accounted for some 7.9 million. The great majority of these systems (over 95 %) are in place in private households (UBA, 2000a and UBA, 2003d).

Official statistics regarding wood fuels used in this source category tend to be incomplete; a large amount of fuel in this category consists of privately sold fuel and of fuel grown in users' 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 is used in the sector "Commercial, institutional 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 (commercial, institutional 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. This study provides an estimate of agricultural combustion systems' share of total energy inputs in line 67. This share was assumed to be constant for the years until 2006.

The data source for the **emission factors** used is UBA, 2000a. Within the context of this 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 1995.

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 corresponds to the Tier 2 method of the IPCC-GPG (2000: p. 2.39).

The emission factors are structured in accordance with the relevant fuels involved in final energy consumption in Germany:

- Fuel oil EL
- Fuel oil S/SA
- Natural gas,
- Lignite (raw lignite, briquettes from the Rhine, Lausitz and central German regions, imported briquettes),
- Hard coal (coke, briquettes, anthracite) and
- Wood (natural wood, residual wood).

In addition, emission factors for combustion systems are determined in accordance with device design, age class, output category and typical mode of operation. In the commercial/institutional area, additionally, a distinction was made between installations not subject to licensing within the scope of the 1st Ordinance on the Execution of the Federal Immission Control Act (*BImSchV*) (Ordinance on small and medium-sized combustion systems) and licensable installations that are subject to the requirements of the Technical Instructions in Air Quality Control (Clean Air Directive – *TA Luft*). 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. This work was supplemented with experiments conducted on furnaces using solid fuels, both on the test bench and via measurements in the field.

The description of the plant structure for installed furnaces was prepared using statistics on residential and other buildings, statistics from the chimney-sweeping trade, and surveys by the researchers themselves in selected chimney-sweep districts of Baden-Wuerttemberg, North-Rhine Westphalia and Saxony. These data were used to estimate the energy inputs for various system types, an approach that, in turn, yielded sectoral emission factors that are weighted by energy inputs. Table 33 shows the sectoral emission factors obtained.

Table 33: Sectoral emission factors for combustion systems in the residential, commercial and institutional areas

Residential	**CH_4 [kg/TJ]**	**N_2O [kg/TJ]**
Hard coal and hard-coal briquettes	273	11
Hard coal	259	12
Briquettes	293	10
Hard-coal coke	7.1	0.8
Lignite briquettes	105	4.4
Untreated wood	123	1.5
Heating oil EL	0.06	0.61
Natural gas	1.1	0.31
Commercial and institutional, residential (commerce, trade services; small consumers)		
Hard coal and hard-coal briquettes	9.2	4.9
Hard coal	9.2	4.9
Briquettes	-	-
Hard-coal coke	20	0.81
Lignite briquettes	248	0.47
Untreated wood	96	0.99
Heating oil EL	0.02	0.56
Natural gas	0.12	0.34

On the basis of the emissions data calculated for the year 1995, the subsequent development of emission factors in 5-year stages up until the year 2020 was estimated using two scenarios.

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

Calculating reliable emission factors in this plant sector is possible only via a complex procedure. Apart from emission figures, it is also necessary to obtain other information e.g. in order to make allowance for the relevant mode of operation (load situations), plant 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 plants 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 plant types, moreover, only inadequate data or no data at all was available on emissions behaviour when using certain fuels. In this respect, it is important to bear in mind that for furnaces belonging to residential and commercial/institutional users, there is no statutory obligation to measure the greenhouse-gas emissions under consideration. 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. In some of these cases, the data gaps were closed by adopting emission factors from comparable furnace designs or by using emissions data from other studies.

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). This assessment, which is based on the emissions data obtained for the aforementioned research project, was carried out by experts from the Federal Environment Agency, in co-operation with the University of Stuttgart's Institute of Process Engineering and Power Plant Technology (Institut für

Verfahrenstechnik und Dampfkesselwesen). 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 plant data used (overall group structure in terms of type, age and performance and fuel consumption)

For all of these influencing factors, it proved useful to differentiate between systems burning liquid and gaseous fuels and systems burning solid fuels. All uncertainties, with the exception of the measuring error in N_2O measurement, must be considered greater for systems burning solid fuels than for systems burning liquid or gaseous fuels. One reason for this is that the group of solid fuels comprises many different fuels, with different emissions behaviours (e.g. various types of lignite, hard coal and wood, from various different origins and with various different characteristics); in systems burning gaseous or liquid fuels, on the other hand, almost all emissions result from use of natural gas or light heating oil.

In gas-fired systems in particular, 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 3.2.2.6 (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, in a first approximation, a normal distribution is assumed for N_2O emission factors. Given the considerably larger uncertainties for CH_4 (up to 100%), on the other hand, it must be assumed that deviations toward larger values in this area are considerably more pronounced than those toward smaller values. For this reason, a log-normal distribution must be assumed for CH_4, for all fuels.

In the aforementioned research project, the emission factors for CH_4 and N_2O were determined in five-year steps for the period 1995 (reference year) through 2020. With this approach, no changes result for most of these emission factors for the period until 2003. The CH_4 emission factors were forecast to decrease slightly only in the area of use of some solid fuels (lignite, wood). This is due primarily to modernisation of existing systems (replacement of old systems with new systems with lower emissions) and, in part, to changes in fuel-consumption structures (sharply decreasing use of eastern German lignite since 1990). In a good approximation, constant emission factors for this period may be assumed for N_2O, which is largely fuel-dependent in small combustion systems.

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 not been carried out completely.

For the purposes of quality assurance, in the context of the aforementioned research and development project, all the input data obtained from literature and from the research company's own investigations were examined with a view to validity. The review included comparisons with confirmed data and plausibility checks. As a general principle, in description of the emissions behaviour of combustion systems, emissions data were included in subsequent calculations only if the relevant literature sources contained complete, undisputed data on the fuel used, the design of the furnace, and the furnace's operating mode during measurements. All resources of significance for inventory preparation were substantiated by the research company.

In a quality review carried out by Federal Environment Agency experts, pursuant to IPCC-GPG (2000: Chapter 2.2.3 and 8), the country-specific emission factors for CH_4 and N_2O, as determined pursuant to Tier 2, were compared with the IPCC Tier 1 default factors of the IPCC Reference Manual (1996b). For most fuels, the values agreed well (discrepancies within one order of magnitude), although the default values for CH_4 tended to be higher, and those for N_2O lower, than the country-specific values. Larger discrepancies occurred only for fuel oil; they are due to the very high Tier 1 default value (10 kg/TJ CH_4 for "oil"). A comparison with the relevant Tier 2 default value (0.7 kg/TJ CH_4 for "distillate fuel oil") produces considerably smaller discrepancies with the country-specific values.

Furthermore, data was compared with relevant data for Austria, whose plant and fuel-consumption structures are similar to those of Germany (UBA Wien, 2004, 2004). The results included good agreement of emission factors, with lower discrepancies overall than seen in the default-value comparison.

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

Recalculations were carried out for the years 2004 and 2005, for all activity rates, to take account of updated evaluation tables of the Working Group on Energy Balances (AGEB).

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

Further study is required, with the aim of creating create a broader database for calculating certain emission factors (particularly for CH_4 in connection with use of solid or gaseous fuels). Such study is underway in a research project currently in progress. Similar study requirements apply for activity rates for combustion of biomass (especially wood and wood fuels).

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*".

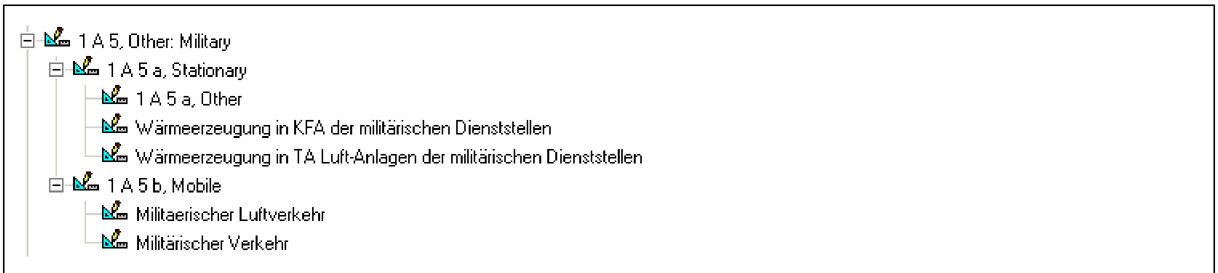


Figure 29: Structural allocation, 1.A.5 Other

3.1.7.1 Source-category description (1.A.5)

CRF 1.A.5					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
All fuels	l / t	CO_2	0.93 %	0.15 %	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 in %		25								
Distribution of uncertainties		N								
Method of EF determination		CS								

The source category 1.A.5 Other is a key category, in terms of emissions level and trend, for 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 "commercial, institutional and other consumers" – additional sources of energy statistics had to be found for source category 1.A.5.

For source category 1.A.5.a, use is made of data of the Federal Ministry of Defence (BMVg, 2007), which has reported the "Energy input for heat generation in the German Federal Armed Forces", by fuels and for 1995-2006, to the Federal Environment Agency. These figures are deducted from the figures in Energy Balance line 67 (commercial, institutional) and are reported in 1.A.5, rather than in 1.A.4.

For source category 1.A.5.b, military fuel and aircraft-fuel consumption for 1995-1999, in TJ, was drawn from a special analysis of the Working Group on Energy Balances (AGEB). The following source was used for the years 2000-2004: Association of the German Petroleum Industry (Verband der Mineralölwirtschaft; MWV; 2007), Mineralöl-Zahlen 2006, p. 52. The consumption figures, which are given in 1,000-t units, are converted into TJ on the basis of the relevant heating statistics listed for 2002.

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 (UBA, 2000a). Within the context of this 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 1995. The method used to determine the factors conforms to that described for source category 1.A.4. Table 34 shows the sectoral emission factors used.

Table 34: Sectoral emission factors for combustion systems of military agencies

Military	CH_4 [kg/TJ]	N_2O [kg/TJ]
Hard coal and hard-coal briquettes	2.4	4.8
Hard-coal coke	19	0.8
Lignite briquettes	242	0.37
Raw lignite	368	
Heating oil EL	0.02	0.56
Natural gas	0.02	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 recalculations (1.A.5)

Recalculations were carried out for the activity rates of solid, liquid and gaseous fuels for the year 2005, to take account of data updating in the evaluation tables of the Working Group on Energy Balances (AGEB).

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. By way of a comparative approach, the *Intergovernmental Panel on Climate Change* (IPCC) has developed the *Reference Approach*, which is based on the level of 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 2004 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 shown in Table 35. In Figures 31 and 32, they are compared with the various relevant data records. In an average for all years in question, the discrepancy between the results obtained with the Reference Approach and those obtained with the sectoral calculation approach is 1.8 %. The discrepancies vary throughout a range of – 0.7 to + 3.2 %.

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, this 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 detail last year in Annex 2, Chapter 13.9 of the Inventory Report.

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 sea 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 IPCC Good Practice Guidance (IPCC, 2000: p. 2.57) they are not reported as part of national total inventories.

German energy statistics do not yet provide an official breakdown of fuel consumption relative to international air-traffic emissions. To make it possible to differentiate national and international consumption nevertheless, these fuel-consumption statistics are broken down into shares of 20 % for domestic air transports and 80 % for international air transports. This relation was confirmed via a research project for the year 1996. Overall, this estimate must be considered very conservative, since it breaks down the strong growth in air transports into consistent shares for national and international air transports. In actual practice, this strong growth, over the last 12 years, has most likely taken place very predominantly in the international air transports sector.

Currently, R&D activities are being prepared for a joint project of the European Community (European Commission, EUROSTAT, EUROCONTROL and EEA) for calculation of emissions, from national and international air transports, for the levels of the individual Member States and the entire European Union. This project is expected to be able to solve the aforementioned problems.

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

Figure 30: Structural allocation, 1.BU.1 civil aviation (international)

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 category.

International sea transports include international blue-water fisheries and sea navigation, categories which are also listed as such in the CSE.

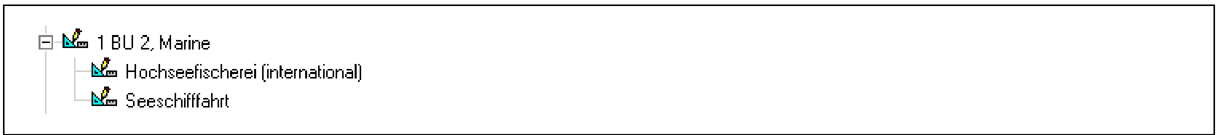


Figure 31: Structural allocation 1.BU.2 Navigation (international)

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.

In 1997, a total of 97,248 ships called at Germany's 19 ports on the North and Baltic sea. These ships spent a total of 902,057 hours in the sea areas of Germany's continental shelf, and they took on 715,537 tonnes of fuel, comprising heavy fuel oil and marine diesel oil.

Consumption of heavy fuel 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 fuel 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 bunkerung are taken directly from the Energy Balance of the Federal Republic of Germany. The reason why these rates are listed separately is that fuel purchased in ports is taxed differently. Current data from the Energy Balance of the Federal Republic of Germany are available for the period until 2001. For the period since then, statistics from the Association of the German Petroleum Industry (MWV; www.mwv.de) have been 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 a) heavy fuel oil and b) marine diesel oil.

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

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 that point, to the default emission factors. The verification was carried out in keeping with the MARION method.

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

No recalculations are required.

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 last year's inventory report.

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 these actions 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, 2007).

In the CSE, source category 1.A.5 includes, under stationary sources, heat production of military agencies; under mobile sources, it includes military agencies' 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 35 presents the results of the various CO_2 calculation approaches for comparison. For visualisation purposes, the data is also presented graphically, on a comparative basis over time, in Figure 32. This approach reveals the key development trends in all calculation approaches, including the Reference Approach, albeit at differing levels. In Figure 33, 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 Approach. This also applies to comparisons with the results of the Länder.

Table 35: 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
Results, discrepancy	[Gg] / [%]																
Comparative analysis (energy-related emissions)	**948.2**					**840.6**	**866.9**	**831.4**	**824.4**	**801.3**	**800.2**	**822.7**	**808.1**	**822.3**	**816.3**	**795.2**	**797.3**
Discrepancy between DIW's figures and UBA's figures	0.0					0.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.1	-0.3	-0.5	-0.3
IEA Statistics (Sectoral approach)	**967.6**	**941.5**	**892.6**	**884.9**	**871.8**	**880.5**	**908.4**	**879.7**	**867.6**	**837.7**	**827.0**	**846.3**	**836.4**	**845.5**	**849.8**	**813.5**	**NE**
Discrepancy between IEA's figures and UBA's figures	2.0	2.8	2.5	2.5	3.3	4.6	4.6	5.5	4.9	4.3	3.2	2.8	3.4	2.8	3.6	1.8	NE
IEA Statistics (Reference Approach) (IEA RA)	**972.2**	**937.5**	**897.5**	**883.7**	**870.7**	**877.8**	**895.5**	**870.4**	**869.9**	**833.9**	**843.7**	**868.4**	**846.3**	**848.5**	**842.8**	**819.1**	**NE**
Discrepancy between IEA RA figures and UBA's figures	-3.2	-2.9	-2.1	-2.5	-2.4	-1.3	-1.8	-1.2	-0.4	-1.5	-0.6	0.2	-0.6	-1.9	-2.5	-2.6	NE
Discrepancy between IEA RA figures and UBA RA figures	-0.8	-0.4	0.1	-0.8	0.3	2.2	1.1	1.8	2.7	1.5	2.8	3.1	2.2	2.2	3.0	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**	**859.8**	**845.3**	**NE**	**NE**
Discrepancy between the Länder figures and UBA's figures	3.4	5.0	5.1	5.5	5.3	6.0	5.2	6.7	7.1	7.1	7.3	7.3	6.5	4.4	3.1	NE	NE
Reference Approach, UBA (RA)	**979.5**	**941.7**	**896.9**	**890.5**	**868.2**	**858.8**	**886.0**	**854.5**	**846.3**	**821.6**	**819.9**	**841.4**	**827.5**	**829.8**	**817.7**	**793.3**	**797.2**
Discrepancy between RA figures and UBA's figures	3.2	2.8	3.0	3.1	2.9	2.2	2.2	2.7	2.5	2.4	2.4	2.2	2.3	1.0	-0.2	-0.7	-0.3
Sectoral approach, UBA (1 A)	**948.0**	**915.1**	**870.3**	**862.6**	**843.3**	**840.0**	**866.8**	**831.2**	**825.1**	**801.5**	**800.4**	**822.7**	**808.2**	**821.8**	**819.1**	**798.9**	**799.4**

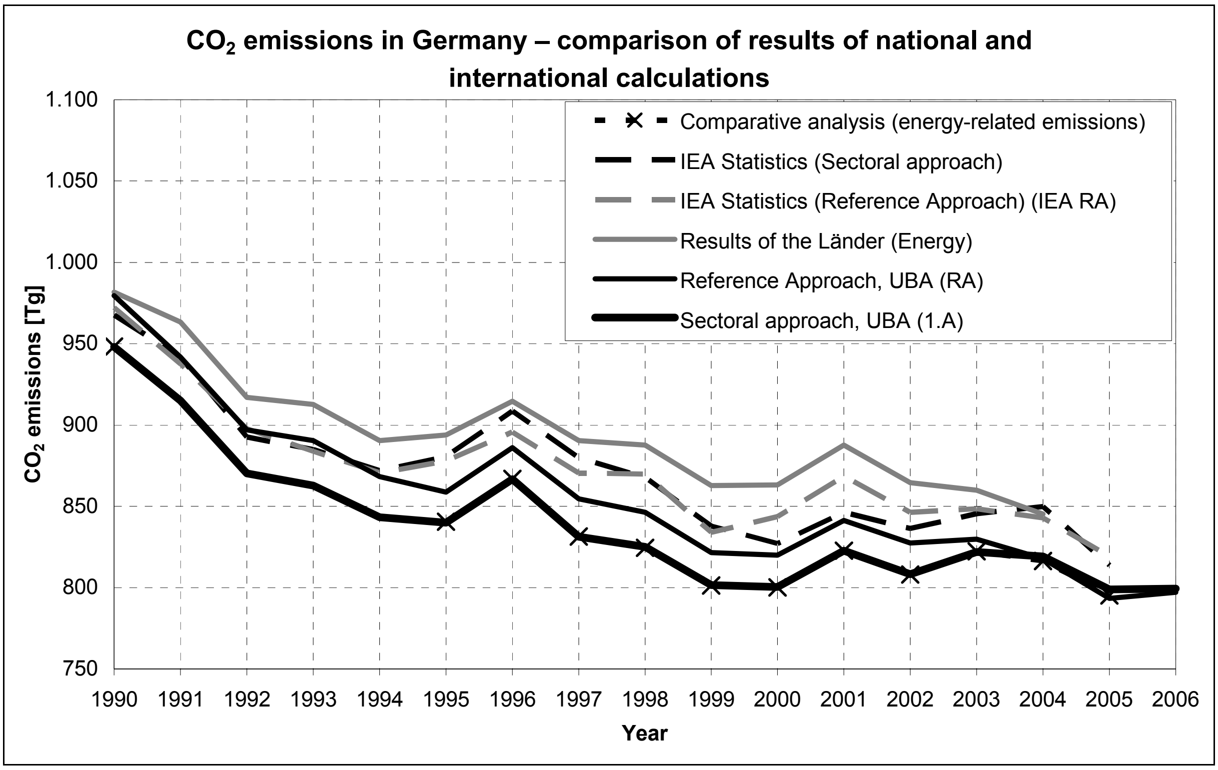


Figure 32: CO_2 emissions in Germany – comparison of results of national and international calculations

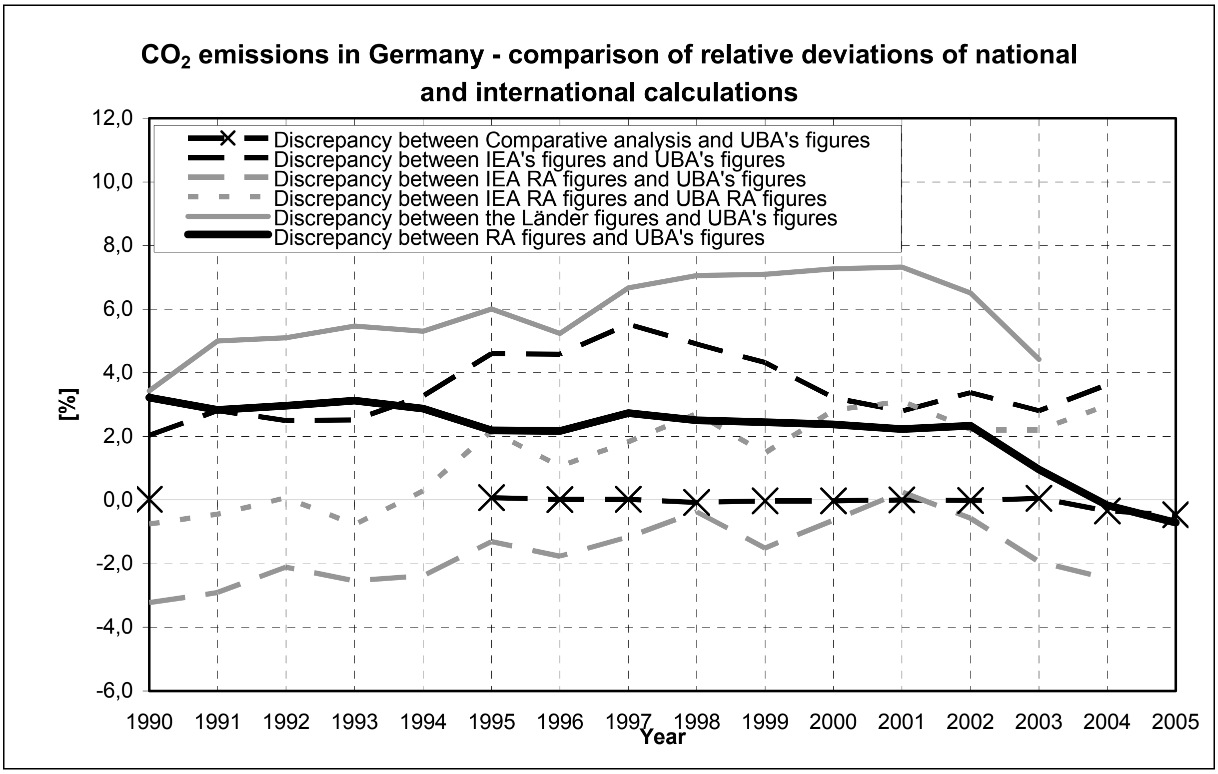


Figure 33: CO_2 emissions in Germany – comparison of relative deviations of national and international calculations

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 (2007). 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 differences between the figures produced by the two calculation approaches are very small – some 0.1 % – for all years in question. The only differences worthy of mention are seen for the years since 2003. The largest difference, amounting to 0.5 % (about 4 million t), occurs for 2005. This difference can be attributed to the differences in assumptions underlying energy-data updates for years in which a detailed Energy Balance has not yet appeared. The 2004 Balance had not yet appeared at the time of data publication.

3.1.12.2 Comparison with the IEA results

Comparison with the IEA results is included here for reasons of completeness. Annually updated, internationally published data (most recently: OECD/IEA 2007) 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: 3.2 %; fluctuation between 1.8 and 5.5 %).

The results of the reference approach used by the IEA differ from those of the reference approach carried out in Germany by 1.4%, over a 17-year average. Excellent agreement (>1 %) is seen for the early 1990s. The differences grow over time, however. For years after 2000, they amount to about 3 %.

The reasons for the discrepancies between the results of the two calculation approaches need to be analysed, especially in light of the recent extensive changes made in emissions-calculation methods. 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 principle 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[20].

20 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.

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 likewise 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 2004, 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 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.

Table 36: Comparison of the results of the CO_2 calculations of individual *Länder* with the national inventories for the years 1990 to 2004

State (Land)	1990	1992	1994	1996	1998	2000	2001	2002	2003	2004
	[Gg CO_2]									
Baden-Württemberg	74,374	78,036	74,535	81,759	80,080	74,940	80,108	76,549	75,536	74,863
Bavaria	84,544	87,041	87,871	92,265	92,708	88,705	90,377	84,578	83,783	*81,719*
Berlin	26,941	25,234	25,531	24,726	22,876	23,661	24,068	21,281	21,249	20,381
Brandenburg	81,894	58,894	54,011	50,312	59,255	60,564	60,928	61,537	57,910	58,659
Bremen	13,422	12,891	13,341	14,256	13,857	14,079	14,137	14,031	14,667	13,057
Hamburg	12,743	13,116	13,361	14,572	*13,940*	*13,940*	*13,940*	*13,940*	12,206	11,590
Hesse	50,338	53,267	56,201	59,935	57,156	56,011	57,817	54,897	55,528	*54,971*
Mecklenburg – West Pomerania	15,539	9,360	9,510	11,636	10,413	10,256	10,718	10,908	10,451	10,961
Lower Saxony	77,138	*82,276*	78,192	78,475	80,405	74,228	*73,145*	72,061	*71,040*	70,019
North Rhine – Westphalia	299,028	306,287	295,874	312,345	304,784	293,987	299,969	295,293	295,885	291,555
Rheinland-Palatinate	27,394	28,914	30,274	31,463	31,167	28,853	29,574	27,793	26,787	26,432
Saarland	23,708	24,398	24,313	23,852	23,795	23,459	23,260	22,964	23,278	*23,031*
Saxony	91,465	64,059	62,988	56,223	37,167	41,552	48,842	49,038	50,024	48,476
Saxony-Anhalt	50,863	31,892	26,307	25,652	25,261	26,301	26,840	27,518	28,171	27,145
Schleswig-Holstein	24,200	24,082	24,191	23,517	22,426	21,378	22,737	21,455	21,401	20,592
Thuringia	28,098	18,687	13,992	13,641	12,713	12,059	12,339	12,066	11,924	11,812
Total for all German Länder	**981,688**	**918,433**	**890,493**	**914,629**	**888,002**	**863,973**	**888,799**	**865,910**	**859,840**	**845,263**
Result for the nation as a whole	**948,015**	**870,283**	**843,265**	**866,762**	**825,080**	**800,409**	**822,664**	**808,224**	**821,829**	**819,110**
Difference	33,673	48,150	47,228	47,867	62,921	63,563	66,135	57,685	38,012	26,153
Difference [%]	3.4	5.2	5.3	5.2	7.1	7.4	7.4	6.7	4.4	3.1

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 5.6 % higher than the Federal result. The pertinent discrepancies reached extremes of 3.1 % in 2004 and 7.3 % in 2001. Taking account of the annual reallocations of about 35 to 45 million tonnes of CO_2, which are now being reported in the area of metal production, the discrepancies between the Länder results and the federal result decrease to about 1.5 to 2 %. This change in methods has not yet been applied in the Länder.

On the whole, these comparisons confirm the CO2 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).

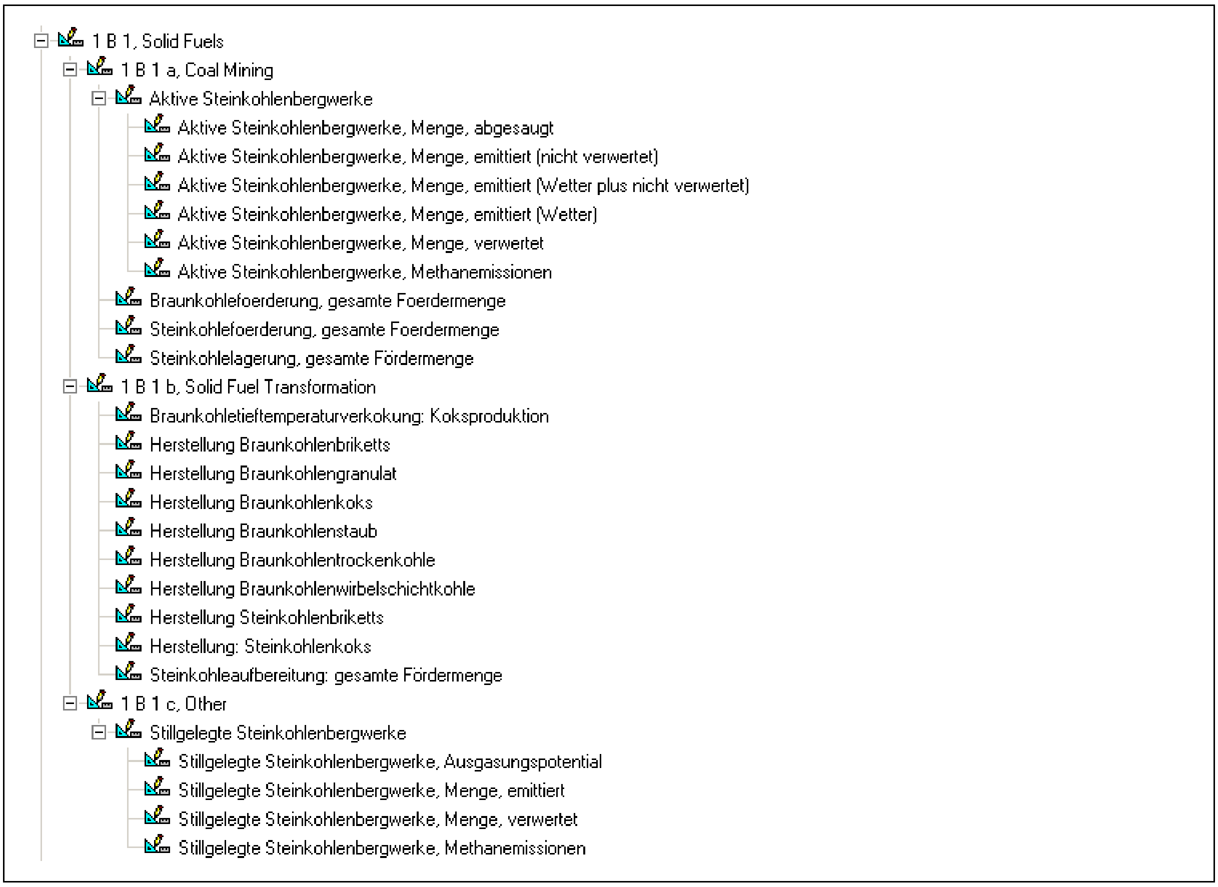


Figure 34: Structural allocation, 1.B.1 Solid fuels

Table 37 presents the scheme for source category allocation, while (Table 38) presents the relevant calculation methods.

Table 37: 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 38 presents calculated values for 2006 activity data, along with information regarding the origin of the data.

Table 38: Calculation of methane emissions from coal mining for 2006

			Activity data [Mt]	CH_4 emissions [Gg]
1.B.1.a. Coal mining			**197.20** (= 1.B.1.a.i + 1.B.1.a.ii)	(= 1.B.1.a.i + 1.B.1.a.ii) = 228.42+1.94 **= 230.36**
	i.	**Underground mining**	**20.674**[21] Hard-coal production 1)	= **mining and follow-up mining-related activities** = 216.39 + 12.03 **= 228.42**
		Mining activities		= AR * EF = 20.674 * 10.47 **= 216.39**
		Follow-up mining activities		**= 12.03**
	ii.	**Open-pit mining**	**176.32** Lignite mining 1)	= **mining activities** **= 1.94**
		Mining activities		= AR * EF = 176.32 * 0.011 **= 1.94**
		Follow-up mining activities		(included in 1.B.1.a.ii) IE
1.B.1.b. Coal transformation – processing			**14.09** Total for processed products 2) 1)	$AR_{H\text{-coal production}} * EF_{H\text{-coal production}}$ + $AR_{lignite\ production} * EF_{lignite\ production}$ = 8.47 * 0.049 + 5.62 * 0 **= 0.41**
1.B.1.c. Other				= **Decommissioned coal mines** **= 3.9**
		Decommissioned coal mines	**NO**	Potential emissions, minus gas usage **= 3.9**

1) pursuant to STATISTIK DER KOHLENWIRTSCHAFT (2006)

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

[21] Not including small mines

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Solid fuels	l / t	CH_4	1.44 %	0.46 %	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 category for CH_4 emissions in terms of both emissions level and trend.

For the source category Coal mining and handling (1.B.1.a), the only truly significant emissions tend to be those from ongoing extraction (coal-seam methane, CSM). Emissions from hard-coal processing are listed in source category 1.B.1.b, while emissions from 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 6 coal fields, primarily with the open-pit method (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 2006 amounted to some 21 million t of marketable production. Lignite production in 2006 totalled 176 million t (STATISTIK DER KOHLENWIRTSCHAFT, 2006). As a result, hard-coal production increased by about 16.3 % over the previous year, while lignite production increased by about 0.9 %.

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. On 10 November 2003, the Federal Government approved a financial framework for further support of the hard-coal sector, including support for further adjustment of production, from 26 million tonnes in 2005 to 16 million tonnes in 2012 (BMWA 2003). As a result, further decreases in methane emissions from hard-coal mining can be expected.

With regard to the international coal sector, an important aspect of lignite mining in Germany is that it has relied mainly on the open-pit method. What is more, since 2003 all lignite mining in Germany has been open-pit mining. One small underground lignite pit remained in operation until 2002. That pit was decommissioned in November 2002. Hard coal is mined only underground in Germany.

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 are used to determine levels of methane emissions. The association of the German hard-coal mining industry (Gesamtverband des deutschen Steinkohlebergbaus) aggregates the individual measurements to determine total methane amounts. It then makes the resulting statistics available for the inventory (STATISTIK DER KOHLENWIRTSCHAFT 2006). Expert review is carried out by the competent state supervisory authority (the mining authority – Bergamt).

An implied emission factor (IEF) of 10.47 kg/t (2006) 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 are 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 (raw lignite) has been taken from the STATISTIK DER KOHLENWIRTSCHAFT (2006). According to the DEBRIV German lignite-industry association (Deutscher Braunkohlen-Industrie-Verein e.V; DEBRIV 2004), an average emission factor of 0.015 m³ CH_4/t (corresponds to 0.011 kg CH_4/t) is assumed. This emission factor is based on a 1989 study RWE Rheinbraun AG (DEBRIV, 2004) and is documented by publications of the Öko-Institut e.V. Institute for Applied Ecology and of the DGMK (German Society for Petroleum and Coal Science and Technology; research report / Forschungsbericht 448-2, 1992). This value is considerably lower than the emission factor used prior to 2005, 0.11 m³ CH_4/t, which was derived from the EF for American hard lignite. Such American EF cannot be applied to German soft lignite, since the latter's temperature did not exceed 50°C during the coal-formation 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/$10^6 m^3$ (pursuant to IPCC Reference Manual, 1996b: at 20° C, 1 atmosphere) yields the individual values listed in Table 39. 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 39: Emission factors for CH_4 from coal mining, for 2006

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	26.43	17.71	0.016	0.011
CH_4 from extraction, minus pit gas used	15.46	10.36	-	-
CH_4 from storage	0.87	0.58	-	-
CH_4 from mining (extraction and storage, minus pit-gas use)	16.33	10.94	0.016	0.011

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

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

In the framework of verification for the 2005 report, various data sources for activity rates in coal mining, and the relevant EF used, were compared with the corresponding sources and EF of other countries.

A by-country comparison of specific emission factors for underground coal mining shows a broad range, with Germany in the lower part of the range, in a position comparable to that of the Czech Republic. France's EF lies considerably higher within the range, while Poland's is considerably lower. Both of these countries' EF lie outside of the UNFCCC's default values.

A by-country comparison of specific emission factors for open-pit coal mining shows that Poland, France (where production was discontinued in 2002) and Germany have relatively low emission factors that are below the default values. The reason for this is that the relevant coal in these countries has very low methane content, as a result of its degree of coalification and its geological history. Consequently, suitably low emission factors have to be applied to it. The comparison value for the Czech Republic is considerably higher, since its coal is not the "lignite" found in Germany, which has a low degree of coalification; instead, its coal is largely "sub-bituminous coal", which has a higher degree of coalification and higher methane content.

3.2.1.1.5 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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 category.

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 (2006) 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 (2006).

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

In consideration of emission factors, the IPCC conversion factor of 0.67 Gg/$10^6 m^3$ 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 Nm^3 into m^3.

Conversion factor, normal cubic metres ⇔ kilogrammes:

0.717 Nm³/kg (1.01325 bar, 0°C) **= 0.67 Gg/10⁶m³** (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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 category for 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 CH4 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 234.5 million m³ in 2006.

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)

3.2.1.3.3 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

3.2.1.3.4 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.

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

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

In consideration of 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.

3.2.1.3.6 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 des deutschen Steinkohlenbergbaus – 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 2005.

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.

3.2.1.3.7 Planned improvements (source-specific) (1.B.1.c)

No precise information is available regarding fugitive methane emissions from decommissioned mine segments. To date, experts have placed these emissions at 200 million m³. 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.

3.2.2 Oil and natural gas (1.B.2)

The overarching category 1.B.2 comprises a total of 13 source categories. In a first major division, by states of matter, 1.B.2 is divided into three intermediate categories. These categories are further subdivided, in keeping with oil and gas industry criteria, and in keeping with the industry's process chains. Only at this level of division are the source categories named. "Other emissions" and "Other leaks" are listed as separate source categories in their own right.

In the CSE database, data on fugitive emissions from oil and natural gas are included with data for the pertinent source categories and sub- source categories. Aggregated information and emissions data are included in the CRF tables (1(s2), "2. Oil and natural gas", and 1.B.2 "Fugitive emissions from oil, natural gas and other sources").

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). The calculation procedures used to this end, procedures which fulfill the relevant methodological requirements, are outlined in the sections on the various source categories.

To improve emissions reporting, and in order to fulfill 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. Under a **working title of "logistics"**, this emissions-calculation approach was used systematically to improve calculation procedures. The approach facilitates gradual changeover of calculation procedures for fulfillment of requirements pertaining to the IPCC and EMEP methods.

In the 2008 inventory report, efforts to improve relevant methods continued, building on the pertinent efforts made in 2007.

To improve emissions reporting, and in order to fulfill 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. Under a working title of "logistics", this emissions-calculation approach was used systematically to improve calculation procedures. The approach facilitates gradual changeover of calculation procedures for fulfillment of requirements pertaining to the IPCC and EMEP methods.

- 1 B 2, Oil and Natural Gas
  - 1 B 2 a Oel
    - 1.B.2.a.i Erkundung
    - 1.B.2.a.ii Foerderung und Vorbehandlung
    - 1.B.2.a.iii Weiterleitung
      - Umschlag und Transport von Rohoel gesamt
    - 1.B.2.a.iv Verarbeitung und Lagerung
      - Entschwefelung von Rohöl in Raffinerien
      - Verarbeitung von Rohöl und Mineralölzwischenprodukt in Raffinerie
        - Verarbeitung von Mineralölzwischenprodukt in Raffinerie
          - Verarbeitung von Mineralölzwischenprodukt in Cracker einer Raffinerie
        - Verarbeitung von Rohöl in Raffinerie
    - 1.B.2.a.v Verteilung
      - Tank eines Strassentankwagen
      - Verteilung von Ottokraftstoff
    - 1.B.2.a.vi Sonstige
      - Tank, mobil/beförderbar
        - Reinigung von Tank eines Binnentankschiff
        - Reinigung von Tank eines Eisenbahnkesselwagen
        - Reinigung von Tank eines Strassentankwagen
      - Tank, stationär/ortsfest
        - Reinigung von Tank einer Raffinerie
        - Reinigung von Tank eines Hafen
        - Reinigung von Tank eines Zwischenlager

Figure 35: Structural allocation, 1.B.2.a Oil

- 1 B 2 b Gas
  - 1.B.2.b.i Erkundung
    - Erkundung von Erdgas
    - Erkundung von Floezgas
  - 1.B.2.b.ii, Foerderung, Vorbehandlung und Verarbeitung
    - Entschwefelung von Erdgas
    - Foerderung von Erdgas
    - Foerderung von Floezgas
    - Verabeitung von Kokerei-/Stadtgas
    - Verarbeitung von Erdgas und Erdoelgas
    - Verarbeitung von Sauergas
  - 1.B.2.b.iii, Weiterleitung
    - Hochdruck-Netz aus Kunststoff/übr. (Durchleitung von Erdgas)
    - Hochdruck-Netz aus Kunststoff/übr. (Durchleitung von Stadtgas)
    - Hochdruck-Netz aus Stahl/Duktylguß (Durchleitung von Erdgas)
    - Hochdruck-Netz aus Stahl/Duktylguß (Durchleitung von Stadtgas)
    - Rohrleitungen zu Behälter zu Rohrleitung
  - 1.B.2.b.iv Verteilung
    - Mitteldruck-Netz aus Grauguß (Verteilung von Erdgas)
    - Mitteldruck-Netz aus Grauguß (Verteilung von Stadtgas)
    - Mitteldruck-Netz aus Kunststoff/übr. (Verteilung von Erdgas)
    - Mitteldruck-Netz aus Kunststoff/übr. (Verteilung von Stadtgas)
    - Mitteldruck-Netz aus Stahl/Duktylguß (Verteilung von Erdgas)
    - Mitteldruck-Netz aus Stahl/Duktylguß (Verteilung von Stadtgas)
    - Niederdruck-Netz aus Grauguß (Verteilung von Erdgas)
    - Niederdruck-Netz aus Grauguß (Verteilung von Stadtgas)
    - Niederdruck-Netz aus Kunststoff/übr. (Verteilung von Erdgas)
    - Niederdruck-Netz aus Kunststoff/übr. (Verteilung von Stadtgas)
    - Niederdruck-Netz aus Stahl/Duktylguß (Verteilung von Erdgas)
    - Niederdruck-Netz aus Stahl/Duktylguß (Verteilung von Stadtgas)
  - 1.B.2.b.v Sonstige
    - Erdgasanwendung in HH und KV fuer Erdgas Erdoelgas
    - Stadtgasanwendung in HH und KV fuer Kokerei- Stadtgas

Figure 36: Structural allocation, 1.B.2.b Gas

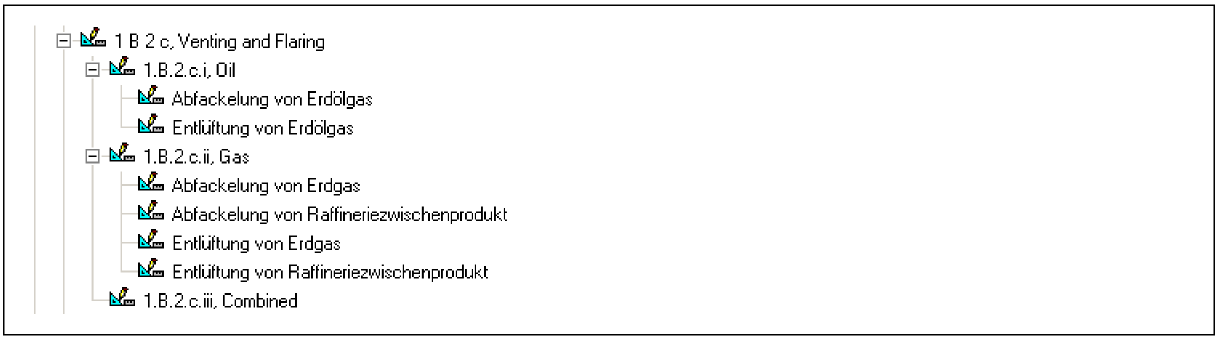


Figure 37: Structural allocation, 1.B.2.c Venting and flaring (oil & gas)

3.2.2.1 Methodological issues (1.B.2)

Under the logistics approach to emissions-calculation methods (including IPCC and EMEP methods), calculation-procedure steps were defined in keeping with levels of precision ("Tier 1 to 3" of the IPCC; "Simpler methodology" and "Detailed methodology".

The methods used conform to the various transparency requirements resulting from operational obligations under the UN Framework Convention on Climate Change and the UN ECE Geneva Convention on Long-range Transboundary Air Pollution. A synopsis (comparative summary) of all requirements, covering the various codes and subdivisions of the aforementioned reporting obligations, was prepared. It shows that CRF and NFR are on largely the same level of division. A breakdown of the NFR, using SNAP, leads to further subdivision, supporting determination of the emissions for these source catetories in keeping with materials, equipment and activities (cf. the CSE, Dimensions and descriptors).

Calculation procedure

Under the logistics approach, activity rates and emission factors (or emissions) are determined for handling, storage and applicable operational states. Such states include normal operation, as well as maintenance; repairs; accidents and operational disruptions (combined, in a larger sense, as "incidents"); and the operational state "cleaning" (not in operation).

Table 40: The seven emitter groups of source categories under CRF 1.B.2

Source categories	Emitter groups Normal operation	Emitter groups Disruptions	Emitter group Cleaning
Transfer (relation)	+	+ (IE)	-
Storage (containers)	+	+	+
Production (plants)	+	+	-

For transfer (relation), emissions are determined from normal operation. Disruptions occurring in connection with handling are allocated to the containers being filled, are designated "IE" in the inventory and are taken into account in storage. Cleaning is not considered an emissions source in connection with transfer.

For storage (containers), emissions are determined from normal operation, disruptions and cleaning. Emissions occurring in disruptions of transfer are allocated to the relevant containers being filled.

For production (plants), emissions are determined from both normal operations and disruptions. Cleaning is not considered an emissions source in the context of production.

Currently, for purposes of inventory preparation and source-category-related co-operation in the NaSE, the source categories are grouped as shown below.

Where no data are available, structural-element aggregates are formed, in the CSE database, that make it possible to determine the relevant emissions. These levels can be correlated with levels of precision.

Table 41: Levels of the logistics approach

Logistics approach	Aggregation	IPCC Tier	EMEP Method	Description
Level 1	aggregated	1	simpler methodology	Like level 2, but also includes some or all fugitive emissions from production and processing ("extraction" and "processing" with the notation "IE").
Level 2	aggregated	1	simpler methodology	Transfer from and to a container (pipeline, tank), along with storage in a tank and tank transport (also applies to pipelines), but with no differentiation of operational states.
Level 3	aggregated	2	simpler methodology	Transfer to or from a container (pipeline, tank), along with storage in a tank and tank transport (also applies to pipelines), in a normal operational state. Storage during transport of a tank (any type of transport) in the operational states "disruption" or "cleaning".
Level 4	disaggregated	2/3	detailed methodology	Transfer to or from a container (pipeline, tank), along with storage in a tank and tank transport (also applies to pipelines), in all operational states (normal operations, disruptions and cleaning). Storage during transport of a tank (any type of transport) in all operational states (normal operation, disruption, or cleaning).
Level 5	disaggregated	3	detailed methodology	Transfer to or from a container, relative to all individual margins (for the various products) under the pertinent logistics Storage (including transport) of a tank (with or without the relevant means of transport) for the logistics infrastructure (disaggregated) and oriented to normative specifications and to rules for the relevant operational states (normal operation, disruption and cleaning)
Level 6	disaggregated	3	detailed methodology	Like level 5, but also with emissions-reduction equipment, and oriented to equipment

For emissions-reporting purposes in 2008, the structural elements in the CSE database correspond largely to level 3 and, thus to the Tier 2 method pursuant to IPCC (1996a: Chapter 1.6, Methane emissions from oil and natural gas activities) and to the simpler methodology pursuant to the Emission Inventory Guidebook (EMEP, 2005a: Group 5, Group 6, Group 9). The activity rates used have been taken from highly precise association statistics that are broken down finely. The emission factors were obtained via measurements and modelling. They were allocated to the structural elements via final estimates of National System experts or via research projects.

Some of the published default emission factors in the guidelines or guidebooks were used, following validation (with adjustments as necessary) by national experts. The emissions data varies widely in quality and covers a spectrum ranging from measured values to estimated values.

In the NaSE, where possible, emissions-data experts were included in emissions determination or at least contacted (natural gas association; WEG Oil/gas production industry association (Wirtschaftsverband Erdöl- und Erdgasgewinnung) and gas statistics; annual reports of the natural gas industry, of storage-tank operators, of the TÜV technical testing organisation; reports of individual operators and databases (including database of disruptive incidents).

In support of QC measures, and in order to substantiate the quality of German emissions reporting, the sections on the various source categories outline the manner in which "good practice" principles were fulfilled. Table 42 lists the text passages with information on good practice.

Table 42: Passages with information relative to good inventory practice in the area of CRF 1.B.2

Good inventory practice
p. 2.79: If a rigorous bottom-up approach is chosen, then it is good practice to involve technical representatives from the industry in the development of the inventory.
p. 2.79: Good practice is to disaggregate the industry into the applicable segments and subcategories indicated in Table 2.15, Major Categories and Subcategories in the Oil and Gas Industry, and then evaluate the emissions separately for each of these parts.
p. 2.84: It is good practice to use the Tier 3 approach which will produce the most accurate emissions estimate.
p. 2.84 (EF):, Nonetheless, it is good practice to consider the impact of regional differences before adopting a specific set of factors.
2.91 (Completeness): Smaller individual sources, when aggregated nationally over the course of a year, may often be significant total contributors. Therefore, good practice is not to disregard them unless their collective contribution to total fugitive emissions is proven to be negligible.
2.92 It is good practice to document and archive all information required to produce the national emissions inventory estimates as outlined in Section 8.10.1 of Chapter 8, Quality Assurance and Quality Control.
2.93: (QA/QC): It is good practice to conduct quality control checks as outlined in Chapter 8, Quality Assurance and Quality Control, Table 8.1, Tier 1 General Inventory Level QC Procedures, and expert review of the emission estimates.

Source: IPCC GPG (2000)

The QC measures for demonstrating the quality of German emissions reporting thoroughly fulfill the various required aspects of good inventory practice pursuant to the Guidelines. All references to good inventory practice will be considered in the course of further improvements.

For inventory preparation in 2006, the "logistics" approach was implemented, in a first pertinent phase, and calculation procedures were carried out with the data in the CSE database. Where possible, new data were collected.

The necessary improvements were not listed in the inventory plan. The accomplished improvements led to the implementation of planned improvements pursuant to the improvement plan.

The initial check carried out by the FCCC Secretariat turned up no deficiencies, nor did it call for improvements on the basis of the submitted Synthesis and Assessment, Part 1 and Part 2. Furthermore, individual reviews (centralised review, desk review, in-country review) also found no need for improvements. To date, no individual review – such as a cross-country review or review by independent experts – has yet been carried out. Nonetheless, it would be wrong to conclude, from these quality assurance results, that no need for action exists, since previous descriptions in the national inventory reports did not permit any reviews focussed on the improvements now planned.

3.2.2.2 Uncertainties and time-series consistency (1.B.2)

For much of the emissions data, the source-category uncertainties are given as 20 %. These figures are based on estimates of WEG experts and NaSE members, and they lie within the range listed for a number of default emission factors, + 25 % to + 50 % (IPCC GPG, 2000: Kapitel 2.7.1.6, Energy - Uncertainty Assessment, p. 2.92).

3.2.2.3 Source-specific quality assurance / control and verification (1.B.2.)

Source-specific quality control

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

Source-specific quality assurance

The results of quality assurance (see the 2004 and 2005 centralised reviews and the 2004 in-country review) were taken into account in emissions determination and substantiation.

Verification

It has not yet been possible to verify the source-category sections via comparisons, synopses or analysis of other countries' inventories. Verification of source categories is hampered in that the pertinent required figures in other countries' inventories are not published, in the various national inventory reports, in a form and manner suitable for evaluation.

3.2.2.4 Source-specific recalculations (1.B.2)

No recalculations are required. Even though the calculation procedure was fundamentally modified, in keeping with the introduction of the logistics approach for the source categories, recalculations are useful only for the overarching levels within 1.B.2..

3.2.2.5 Planned improvements (1.B.2)

For improvement of the inventory, additional emission factors need to be determined under the logistics approach. Where adequate specific emission factors cannot be determined, the possibility of deriving default values from the IPCC Guidelines should be considered.

3.2.2.6 Oil (1.B.2.a)

3.2.2.6.1 Oil, Exploration (1.B.2.a.i)

CRF 1.B.2.a.i					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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	Mmt.	Mmt.				Mmt.				

Pursuant to the classification for the aggregated source category 1.B.2.a Oil, the source category 1.B.2.a.i Oil exploration is not a key category.

The source category's status results from the classification for the overarching category 1.B.2.a, for which emissions are to be determined using the Tier 2 or Tier 3 methods (cf. IPCC GPG, 2000: Figure 2.13, Decision Tree for Crude Oil Production and Transport, page 2.81; here, "Box 2“ = Tier 2, while "Box 3" could = Tier 3).

The emissions of source category 1.B.2.a.i Oil, exploration are currently not determined (notation: "NE").

The Guidelines call for reporting of emissions for the gases methane, carbon dioxide (non-combustion-related) and nitrous oxide (cf. the aforementioned source: page 2.79; here, 2.7.1. Methodological issues).

According to the Emission Inventory Guidebook, emissions of volatile organic compounds (VOC = CH_4 + NMVOC) are to be reported (source: RYPDAL 1999 in EMEP 2005).

3.2.2.6.1.1 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 2006, 346m of exploration wells were drilled, while a total of 10,185 m of new pool tests were drilled (WEG, 2006: Table on Balance of drilling success). The underlying exploration statistics do not differentiate between drilling for oil and drilling for gas.

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

No significant intermediate results from the changeover of calculation procedures are yet available for this source category (cf. 1.B.2).

For 1.B.2.a.i Oil exploration and 1.B.2.b Gas exploration, the default EF from IPCC GPG (2000: p. 2.86, Table 2.16, line 5), and for fugitive emissions from activities relevant to oil and gas, the default emission factor for CO_2, 0.000095 Gg per number of producing and capable wells, was used, on the basis of North American data for the category "Wells", sub-category "Servicing", emissions type "all", in connection with the AR from the annual report of the Wirtschaftverband Erdöl und Erdgasgewinnung e.V. (WEG) for 2004 (WEG 2004, p. 50, Table "Balance of drilling success" (Bohrerfolgsbilanz) – here, the line "Production wells", Total, with 12 strikes for 2004). The advisability of retaining this calculation procedure is currently being reviewed.

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

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

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

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

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

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

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

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

See 1.B.2 regarding planned improvements.

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

CRF 1.B.2.a.ii					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 category.

The source category's status results from the classification for the overarching category 1.B.2.a, for which emissions are to be determined using the Tier 2 or Tier 3 methods (cf. IPCC GPG, 2000: Figure 2.13, Decision Tree for Crude Oil Production and Transport, page 2.81; here, "Box 2" = Tier 2). Calculation pursuant to Tier 3 is not planned, since less than 20 % of the pertinent oil gas is flared or released into the atmosphere (see the aforementioned source: page 2.81; here, "estimation of total associated and solution gas volumes"). Emissions of source category 1.B.2.a.ii Oil, production are determined pursuant to the Tier 2 method.

The Guidelines call for reporting of emissions for the gases methane, carbon dioxide (non-combustion-related) and nitrous oxide (loc. cit.: page 2.79; here, 2.7.1. Methodological issues).

According to the Emission Inventory Guidebook, emissions of volatile organic compounds (VOC = CH_4 + NMVOC) are to be reported (EMEP 2005a: Group 5, B521, Extraction, first treatment and loading of liquid & gaseous fossil fuels, p. 1).

3.2.2.6.2.1 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, 2006), German petroleum extraction in 2006 amounted to some 3,514,519 million tonnes. Production in that year was thus slightly lower than the previous year's production. Petroleum extraction took place at 1097 producing oil wells, in a total of eight oil fields (loc. cit.).

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.

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

No significant intermediate results from the changeover of calculation procedures are yet available for this source category (see 1.B.2, Chapter 3.2.2).

The annual report of the WEG association of oil and gas producers (Wirtschaftsverband Erdöl- und Erdgasgewinnung - WEG 2006) shows the following emission factors:

Table 43: Emission factors for oil extraction

	CO_2	SO_2	NO_X	CH_4
Petroleum [kg/t]	64	0.14	0.06	0.1

The pertinent emission factors are calculated by establishing relationships between measured emissions and pertinent extraction quantities.

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

3.2.2.6.2.3 Uncertainties and time-series consistency (1.B.2.a.ii)

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

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

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

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

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

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

See 1.B.2 regarding planned improvements.

3.2.2.6.3 Oil, transport (1.B.2.a.iii)

CRF 1.B.2.a.iii					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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.

Emissions of source category 1.B.2.a.iii Oil, transport are determined pursuant to the Tier 2 method.

The Guidelines call for reporting of emissions for the gases methane, carbon dioxide (non-combustion-related) and nitrous oxide (loc. cit.: page 2.79; here, 2.7.1. Methodological issues).

Pursuant to the reporting rules set forth by the Emission Inventory Guidebook, by analogy to technical document B521 (EMEP 2005a: Group 5, B521, Extraction, first treatment and loading of liquid & gaseous fossil fuels, Chapter 2, p. B521-1), emissions may be determined pursuant to B541. That view takes account of the fact that this source category has emissions of volatile organic compounds (VOC = CH_4 + NMVOC).

3.2.2.6.3.1 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 2006, 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 105.1 million tonnes of crude oil (MWV, 2006: p. 38 ff). 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.

Currently, Germany has 11 crude oil pipelines with diameters ranging from 8 to 24 inches and 16 crude oil pipelines with diameters ranging from 12 to 40 inches. The following table lists the petroleum and crude-oil pipelines in place in Germany.

Table 44: Long-distance high-pressure pipelines in Germany

High-pressure pipelines in Germany
BSL, Rostock - Böhlen (RRB)
DEA, Heide – Brunsbüttel
FBG, NATO - Netz (CEPS/NEPS)
MIDER, Spergau – Hartmannsdorf
OMV, Burghausen – Feldkirchen
OMV, Feldkirchen – Munich
PCK, Schwedt – Seefeld
Rhein-Main-Rohrleitung (RMR), Grenze (NL) - Ludwigshafen/Raunheim
Rhein-Main-Rohrleitung (RMR), Pernis - Grenze DS (RRP)
Rohrleitung Rostock-Böhlen (RRB)
RUHR OEL, Gelsenkirchen - Duisburg
DEA, Brunsbüttel – Heide
MERO, Vohburg (TAL) - Nelahozeves (CZ)
Mineralölverbundleitung (MVL), Grenze (PL) - Schwedt
Mineralölverbundleitung (MVL), Rostock - Schwedt
Mineralölverbundleitung (MVL), Schwedt - Rostock
Mineralölverbundleitung (MVL), Schwedt - Spergau
Norddeutsche Ölleitung (NDO)
Norddeutsche Ölleitung (NDO), Wilhelmshaven - Hamburg
Nord-West-Oelleitung (NWO), Wilhelmshaven - Cologne
OMV, Steinhöring (TAL) – Burghausen
Rotterdam-Rijn-Pijpleiding (RRP), Venlo - Cologne
Rotterdam-Rijn-Pijpleiding (RRP), Venlo - Wesel
Rotterdam-Rijn-Pijpleiding (RRP); Rotterdam - Venlo
RUHR OEL, Wesel - Gelsenkirchen
Société du Pipeline Sud-Européen (SPSE)
SPSE, Lavéra (F) – Karlsruhe

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.

3.2.2.6.3.2 Methodological issues (1.B.2.a.iii)

Pursuant to the applicable calculation procedure, the lack of country-specific emission factors in the area of pipeline oil transports makes it necessary to use the default values 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/(10³m³ oil transported via pipeline)].

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.

No significant intermediate results from the changeover of calculation procedures are yet available for this source category (see 1.B.2, Chapter 3.2.2).

All emissions from transport facilities, such as pipelines, are reported in source category 1.A.3.e. All emissions of tank-transport vehicles fall under source categories 1.A.3.b, 1.A.3.c or 1.A.3.b or, proportionally, in source category 1.A.5.. Activities involved in offloading of crude oil, petroleum and intermediate petroleum products, along the relevant emissions, are reported in 1.A.3.d.

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

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

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

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

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

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

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

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

See 1.B.2 regarding planned improvements.

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

CRF 1.B.2.a.iv					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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										

Pursuant to the classification for the aggregated source category 1.B.2.a Oil, the source category 1.B.2.a.iv Oil, processing, refinery is not a key category.

Emissions were determined using the methods set forth in IPCC GPG (2000: Figure 2.14, Decision Tree for Crude Oil Refining and Upgrading, page 2.82; here, "Box 1" (Tier 1) and "Box 2" (Tier 3).

For certain areas of the CSE database, emissions of source category 1.B.2.a.iv Oil, processing, refinery are determined via the Tier 1 or Tier 3 methods.

The Guidelines call for reporting of emissions for the gases methane, carbon dioxide (non-combustion-related) and for the group of volatile organic compounds (CH_4 + NMVOC = VOC) (loc. cit.: page 2.84; here, 2.7.1.2 choice of emission factors).

Pursuant to the reporting specifications in the EMEP Emission Inventory Guidebook, figures for the gases SO_2, VOC, NO_X and CO are to be reported (2005a: Group 4, B410, Processes in Petroleum Industries, p. 2). In document B410 (loc. cit.: p. 1), the instructions relative to the refinery refining processes are to be understood in connection with NFR key 1.B.2.a.iv. This additional information for inventory preparation is provided in an overview of reporting requirements (cf. in this regard also IPCC 1996a: Chapter 1.6, Methane Emissions from Oil and Natural Gas Activities. p. 1.27 3, and Chapter 1.7 Ozone Precursors and SO_2 Emissions from Oil Refining, p. 1.31; IPCC 1996b: Chapter 1.8, Fugitive Emissions from Oil and Natural Gas Activities, p. 1.114ff). At this juncture, requirements-conformal inventory preparation is hampered in that the "IPCC Guidelines" (1996a) and the "Guidebook" (EMEP 2005a: Group 4, B410, Processes in Petroleum Industries) are not linked with each other in any pragmatic way.

Table 45 Overview of documents of the EMEP/CORINAIR Emission Inventory Guidebook - 2005 relative to NFR key 1.B.2.a.iv for petroleum-industry processes (crude-oil refining in refineries)

No.	Process	SNAP	Description
1.	Feed Stock handling and storage	**050401**	Marine Terminals
		050402	Other Handling and Storage
2.	Separation Processes	**040101**	Petroleum Products Processing
3.	Petroleum Conversion Processes	**040101**	Petroleum Products Processing
4.	Petroleum Treating Processes	**040101**	Petroleum Products Processing
		060310	Asphalt Blowing
5.	Product Blending	**040101**	Petroleum Products Processing
6.	Product Storage and Handling	**040104**	Storage and Handling of Products in Refinery
		050501	Refinery Dispatch Station
7.	Auxiliary Facilities	030104	Combustion
		030105	Combustion
		010306	Process Furnaces
		040103	Sulphur Recovery Plants
		0405	Organic Chemical Production
		091001	Waste Water Treatment in Industry
		091002	Waste Water Treatment In Residential /Commercial
		090202	Incineration of Industrial Wastes
		090203	Flaring in Oil Refinery
		090205	Incineration of Sludges From Water Treatment
		090400	Landfills
		k.A.	Cooling Towers
		k.A.	Vapour Recovery and Blowdown Systems

Consequently, the SNAP keys 040101, 040103, 040104, 050401, 050402, 050501 and 060310, pursuant to the EMEP/CORINAIR Emission Inventory Guidebook (2005a), are to be used for reporting in source category 1.B.2.a.iv.

3.2.2.6.4.1 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 124.6 million t in 2006. (MWV, 2006: p. 47).

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

The relevant activity rates are provided by the Federal Energy Balance of the Working Group for Energy Balances (Arbeitsgemeinschaft für Energiebilanzen), by annual special publications of the Mineralölwirtschaftsverband e.V. petroleum industry association (in the present case, "Mineralöl-Zahlen 2006") and by annual reports of the WEG association of oil and gas producers (Wirtschaftsverband Erdöl- und Erdgasgewinnung; in the present case, "Jahresbericht Zahlen & Fakten 2006" (WEG, 2006)).

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

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; cf. Table 41). 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 VOC is not sufficiently well substantiated.

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

For purposes of substantiating the quality of German emissions reporting, pursuant to "good practice", the seven criteria given by the "good practice" guidelines for the source category were studied. It was found that existing calculations procedures (i.e. procedures in place) fulfill the criteria.

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

3.2.2.6.4.3 Uncertainties and time-series consistency (1.B.2.a.iv)

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

3.2.2.6.4.4 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.

For source category 1.B.2.a.iv (in the present case, with 1.B.2.a.ii, iii and v), a comparison with the IPCC default values (IPCC 1996b) shows good agreement. Table 1.62 (loc. cit.: p. 1.130) lists emission factors for this area, as a whole, ranging from 110 to 1660 kg/PJ. Conversion of the German emission factor for 2004, 0.02 kg CH_4 / t crude oil, using the lower net calorific value of crude oil (42.7 MJ/kg), produces an emission factor of 468.4 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.

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

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

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

See 1.B.2 regarding planned improvements.

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

CRF 1.B.2.a.v					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 in source category 1.B.2.a.v Oil, distribution are determined, in the CSE database, pursuant to the Tier 2 or Tier 3 methods (cf. source category 1.B.2.a.iii, Chapter 3.2.2.6.3).

The Guidelines call for reporting of emissions for the gases methane, carbon dioxide (non-combustion-related) and for the group of volatile organic compounds (CH_4 + NMVOC = VOC) (loc. cit.: page 2.84; here, 2.7.1.2 choice of emission factors).

The reporting guidelines in the EMEP Emission Inventory Guidebook call for reporting of NMVOCs. Document B551 provides information relative to determination of significant NMVOC emissions (EMEP 2005a: Group 5, B551, Gasoline Distribution). Not all sub-categories of this SNAP key can be applied to reporting specifications pursuant to the CRF key, since the IPCC describes relevant inventory preparation in the Chapter on refineries (IPCC 1996b: Chapter 1.8.9 Refineries, p. 1.134; here, Storage and handling (SNAP 40104)). Document B541 provides no further information on relevant emissions determination, due to the emissions' insignificance (EMEP 2005a, Group 5, B541, Liquid Fuel Distribution (Except Gasolines, p. 1).

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

Petroleum products are transported via ships, product pipelines, railway tank cars and tanker trucks, and they are transferred from tanks to other tanks. Germany's domestic sales of petroleum products totalled 119,378,000 t (MWV, 2006) in 2006. Pursuant to the Association of the German Petroleum Industry (MWV; loc. cit.), domestic petrol consumption amounted to 22,604,000 tonnes in 2006. 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 88 % 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 20^{th} and 21^{st} 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 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.

The IPCC Synthesis and Assessment Report Part I (IPCC, 2004) noted that the IEF of the source category Refining / storage is lower than those of other 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.

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

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

The calculation procedure developed under the "logistics" approach was developed in keeping with emissions-reporting requirements pursuant to the UN Framework Convention on Climate Change (in the present case, pursuant to the Tier 2 method), and the UN ECE Geneva Convention on Long-range Transboundary Air Pollution (in the present case, pursuant to the simplier method).

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

The results of quality assurance (see the 2004 and 2005 centralised reviews and the 2004 in-country review) are taken into account in emissions determination and substantiation.

The criteria for "good practice" pursuant to the Guidelines are explained in general in 1.B.2 (cf. Chapter 3.2.2).

3.2.2.6.5.3 Uncertainties and time-series consistency (1.B.2.a.v)

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

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

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

NMVOC emissions from filling, within refineries, of vehicles for road, railway and waterway transports (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.

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

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

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

See 1.B.2 regarding planned improvements.

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

CRF 1.B.2.a.vi					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 (cf. the following source: IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 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).

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

Emissions can occur in cleaning of containers, an operational state outside of normal operations. Work is currently underway to take clearning 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) from the determined level of 36.5 t/a (without adsorption).

3.2.2.6.6.2 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.

The criteria for "good practice" pursuant to the Guidelines are explained in general in 1.B.2 (cf. Chapter 3.2.2).

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

Information regarding uncertainties is currently being added to the inventory description. See 1.B.2. for additional explanations of uncertainties and time-series consistency.

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

No further verification results are available at present.

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

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

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

See 1.B.2 regarding planned improvements.

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

CRF 1.B.2.b					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Natural gas	l / t	CH_4	0.53	0.64	rising

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

The source categories in the overarching group of fugitive emissions from natural gas (gaseous fuels) 1.B.2.b Natural gas comprise all sources, including exploration, first treatment and processing of natural gas, oil gas and coal-seam gas, gas transports and distribution of gas products and use of such products by customers. In contrast to the procedure followed for source categories in the other overarching group of fugitive emissions, 1.B.2.a Oil, first treatment and processing are not separated in the source categories under 1.B.2.b Natural gas. Distinctions between transport, distribution and storage play an important role in the various source categories.

Fugitive emissions from 1.B.2.b Natural gas are listed in the CSE database along with data for the various source categories and sub - source categories (cf. Figure 36).

3.2.2.7.1 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 category 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, p. 2.80; here, "Box 4", or "Box 3" if applicable).

Emissions of source category 1.B.2.b.i Natural gas, exploration are currently determined pursuant to the Tier 2 method.

The Guidelines call for reporting of emissions for the gases methane, carbon dioxide (non-combustion-related) and for the group of volatile organic compounds (CH_4 + NMVOC = VOC) (loc. cit.: page 2.84; here, 2.7.1.2 choice of emission factors).

The reporting guidelines in the EMEP Emission Inventory Guidebook call for reporting of NMVOCs relative to the aforementioned pollutants (EMEP 2005a: Group 5, B561 gas distribution networks, p. 1). Table 8.31 (and 8.32) of those guidelines provide natural gas profiles for fugitive emissions relative to extraction stations. This information implies that, depending on the gas concerned, the components N_2, CO_2, H_2S and other NMVOC can also play a significant role (loc. cit.: B521 Extraction, first treatment and loading of liquid & gaseous fossil fuels, p. 24).

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

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

3.2.2.7.1.2 Methodological issues (1.B.2.b.i)

The approach used for the calculation procedures corresponds to those used for source category 1.B.2.a.i. That section provides further relevant information (Chapter 3.2.2.6.1).

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

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

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

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

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

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

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

See 1.B.2 regarding planned improvements.

3.2.2.7.2 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 Natural gas, production and processing is a key category.

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).

Emissions of the source category 1.B.2.b.ii Natural gas, exploration are currently being determined in keeping with the Tier 2 method.

The Guidelines call for reporting of emissions for the gases methane, carbon dioxide (non-combustion-related) and for the group of volatile organic compounds (CH_4 + NMVOC = VOC) (loc. cit.: page 2.84; here, 2.7.1.2 choice of emission factors).

The reporting guidelines in the EMEP Emission Inventory Guidebook call for reporting of NMVOCs, in addition to the aforementioned gases (EMEP 2005a: Group 5, B561, gas distribution networks, p. 1).

3.2.2.7.2.1 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.

Anlagen zur Vorbehandlung

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

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

The approach used in the calculation procedures is largely equivalent to that used for source category 1.B.2.a.ii. For further information, see Chapter 3.2.2.6.2).

3.2.2.7.2.3 Uncertainties and time-series consistency (1.B.2.b.ii)

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

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

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

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

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

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

See 1.B.2 regarding planned improvements.

3.2.2.7.3 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 Natural gas, transmission is a key category 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).

Emissions of the source category 1.B.2.b.iii Gas, transmission are currently being determined in keeping with the Tier 2 method.

The Guidelines call for reporting of emissions for the gases methane, carbon dioxide (non-combustion-related) and for the group of volatile organic compounds (CH_4 + NMVOC = VOC) (loc. cit.: page 2.84; here, 2.7.1.2 choice of emission factors).

The reporting guidelines in the EMEP Emission Inventory Guidebook call for reporting of NMVOCs, in addition to the aforementioned gases (EMEP 2005a: Group 5, B561, gas distribution networks, p. 1).

3.2.2.7.3.1 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, gas (natural gas and oil gas) is transported from production and processing companies/plants to gas suppliers and other processors. Until 1997, significant amounts of city gas were transported via pipelines. In practice, such transportation included logistics operations involving both pipelines (high-pressure pipelines) and containers (tanks).

Gas is moved via high-pressure pipelines 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). Germany's gas-pipeline network currently has a total length of 6,362 km. 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 3.2.2.7.4).

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).

3.2.2.7.3.2 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).

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

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

3.2.2.7.3.4 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.

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

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

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

See 1.B.2 regarding planned improvements.

3.2.2.7.4 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 Natural gas, distribution is a key category 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.

Emissions of the source category 1.B.2.b.iv Natural gas, distribution are determined in keeping 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.

3.2.2.7.4.1 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 transmitted/distributed via low-pressure, medium-pressure and high-pressure pipelines made of special plastics, steel / ductile cast iron and grey cast iron.

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 by over 98 %, via replacements with 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 46: Gas-distribution network and its emissions

Parameter	1990	1995	2000	2005	2006
Total length of pipeline network [km]	295,304	366,985	417,354	415,065	414,065
Total methane emissions [t]	206,806	219,007	202,151	176,901	171,081
Emission factor [kg/km]	729.8	596.8	484.4	426.2	413.2
Change in the emission factor with respect to the base year	0 %	18 %	34 %	42 %	43 %

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, medium-pressure and high-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 this 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. The following results stand out in particular in the Table: the plastic-pipeline network has been expanded by over 210 % in the medium-pressure sector and by over 330 % in the high-pressure sector.

Table 47: Structure of the gas-distribution network

Gas-distribution network		Length of the distribution network			Emission factors [kg/km]		
Pressure level	Material	1990 [km]	Pressure level	Material	1990 [km]	Pressure level	2006 (Erdgas)
Low pressure	Grey cast iron	17,260	300	-98.3	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
High pressure	Plastic	904	3,898	331.2	11	44	44
	Steel and ductile cast iron	35,956	45,073	25.4	60	241	241
Total		**295,304**	**414,065**	**40.2**			

Distribution via containers

Gas in containers (small tanks, flasks) is distributed via filling plants. Filled tanks are transported via inland ships, railway tank cars and tanker trucks. Gas in containers (flasks) is also transported by customers, prior to being used (it is not transported on a unit-load basis, however). To a small extent, gas consumers also store gas temporarily before using it (cf. the consumption information, for the various source categories, provided under 1.A).

Storage reservoirs

Medium quantities of gas are stored in man-made above-ground reservoirs. Germany uses spherical tanks for this purpose.

No further significant intermediate results from this year's changeover of calculation procedures are yet available for this source category (see 1.B.2).

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

3.2.2.7.4.2 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 3.2.2.6.5).

3.2.2.7.4.3 Uncertainties and time-series consistency (1.B.2.b.iv)

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

3.2.2.7.4.4 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.

3.2.2.7.4.5 Source-specific recalculations (1.B.2.b.iv)

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

3.2.2.7.4.6 Planned improvements (source-specific) (1.B.2.b.iv)

See 1.B.2 regarding planned improvements.

3.2.2.7.5 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 Natural gas, other is a key category 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.

3.2.2.7.5.1 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.

3.2.2.7.5.2 Methodological issues (1.B.2.b.v)

Methodological issues cannot yet be explained.

3.2.2.7.5.3 Uncertainties and time-series consistency (1.B.2.b.v)

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

3.2.2.7.5.4 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.

3.2.2.7.5.5 Source-specific recalculations (1.B.2.b.v)

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

3.2.2.7.5.6 Planned improvements (source-specific) (1.B.2.b.v)

See 1.B.2 regarding planned improvements.

3.2.2.7.6 Venting and flaring (1.B.2.c)

CRF 1.B.2.c.i					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
	- / -				

The source category 1.B.2.c Venting and flaring is not a key category.

The source categories in the overarching group of fugitive emissions from 1.B.2.c Venting and flaring cover emissions that are vented and flared directly into the atmosphere.

In this source category, venting and flaring are differentiated on the basis of the pollutants concerned. Components of relevant plants that carry out venting and flaring for safety reasons, when oil-/gas- industry production processes are disrupted, are reported separately from the other two overarching groups of fugitive emissions (1.B.2.a "Oil" and 1.B.2.b "Natural gas"). This division must be taken into account in analyses of industry sub-sectors.

Fugitive emissions from 1.B.2.c Venting and flaring are listed in the CSE database along with data for the various source categories and sub - source categories (cf. Table Figure 37.

3.2.2.7.7 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	Mmt.	Mmt.				Mmt.				

Pursuant to the classification of the aggregated source category 1.B.2.c Venting and flaring, the source category Venting and flaring, oil is not a key category.

The source category's status results from the classification of the overarching group 1.B.2.c or of 1.B.2. No methods for determining relevant emissions are prescribed (cf. IPCC GPG, 2000); only the decision tree for refineries (cf. 1.B.2.c.iii) includes venting and flaring as a criterion.

Currently, emissions in the source category 1.B.2.c.i Venting and flaring, oil either are not determined or are taken into account, proportionally, in another source category of 1.B.2 (notation: "NE" and "IE").

3.2.2.7.7.1 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 should be burned in process combustion. Where such use is not possible, the gases are to be piped to a flare. Flares used for flaring of such gases must fulfill at least the requirements for flares for combustion of gases from operational disruptions and from safety valves. For refineries (1.B.2.c.iii) 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.

3.2.2.7.7.2 Methodological issues (1.B.2.c.i)

In conjunction with the logistics approach, review is currently underway to determine whether this approach for development of calculation procedures is a suitable one, in light of emissions-reporting requirements under the UN Framework Convention on Climate Change (Tier 2/3 method) and the UN ECE Geneva Convention on Long-range Transboundary Air Pollution (in keeping with the simple / precise method). No significant intermediate results for this source category are yet available from ongoing inventory preparation.

It remains to be determined whether only emissions of the gases CH_4, N_2O and CO_2 have to be reported, in keeping with the CRF-Reporter or the CRF inventory tables, or whether the entire spectrum of combustion-related gases, including CH_4, CO, CO_2, N_2O, NH_3, NMVOC, NO_X, and SO_2, must be determined.

The results of quality assurance (see the 2004 and 2005 centralised reviews and the 2004 in-country review) are taken into account in emissions determination and substantiation. General information relative to fulfillment of good inventory practice, pursuant to the Guidelines, is provided in the section for 1.B.2 (cf. Chapter 3.2.2).

3.2.2.7.7.3 Uncertainties and time-series consistency (1.B.2.c.i)

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

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

No explanations relative to source-specific quality assurance / control and verification are required. Verification is not possible at present (cf. 1.B.2).

3.2.2.7.7.5 Source-specific recalculations (1.B.2.c.i)

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

3.2.2.7.7.6 Planned improvements (source-specific) (1.B.2.c.i)

See 1.B.2 regarding planned improvements.

3.2.2.7.8 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	Mmt.	Mmt.				Mmt.				

Pursuant to the classification of the aggregated source category 1.B.2.c Venting and flaring, the source category Venting and flaring, gas is not a key category.

The source category's status results from the classification of the overarching group 1.B.2.c or of 1.B.2. No methods for determining relevant emissions are prescribed (cf. IPCC GPG, 2000); only the decision tree for refineries (cf. 1.B.2.c.iii) includes venting and flaring as a criterion.

Currently, emissions in the source category 1.B.2.c.ii Venting and flaring, gas either are not determined or are taken into account, proportionally, in another source category of 1.B.2 (notation: "NE" and "IE").

3.2.2.7.8.1 Source-category description (1.B.2.c.ii)

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

3.2.2.7.8.2 Methodological issues (1.B.2.c.ii)

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

3.2.2.7.8.3 Uncertainties and time-series consistency (1.B.2.c.ii)

No explainations of uncertainties and time-series consistency are required.

3.2.2.7.8.4 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 (see "planned improvements"). Verification is not possible at present (cf. 1.B.2).

3.2.2.7.8.5 Source-specific recalculations (1.B.2.c.ii)

No recalculations are required.

3.2.2.7.8.6 Planned improvements (source-specific) (1.B.2.c.ii)

See 1.B.2 regarding planned improvements.

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),
- Asphalt 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 explained, as necessary, in the relevant sub-chapters.

Figure 38: Structural allocation, 2.A Mineral products

4.1.1 *Mineral products: Cement (2.A.1)*

4.1.1.1 Source-category description (2.A.1)

CRF 2.A.1					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Cement production	l / -	CO_2	1.19 %	1.26 %	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 Mineral products: Cement is a key category, in terms of emissions level, for CO_2 emissions from cement production.

In 2005, a total of 61 furnaces for burning of cement clinkers, with a total capacity of 113,820 t/d, were in operation throughout Germany. In a breakdown by furnace types, the largest group of these consisted of furnaces with cyclonic preheaters (42), followed by furnaces with grid preheaters (11) and shaft furnaces (8) (BDZ, 2006a). A total of 22 companies, with 58 cement plants in Germany (of which 38 have their own clinker production), are members of the Association of the German Cement Industry (*Bundesverband der Deutschen Zementindustrie* - BDZ, 2006b, p. 48).

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 separately from the quantities 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, 2007) clinker production in 2006 amounted to 24,921 kt[22]. Raw-material-related CO_2 emissions are calculated with a country-specific emission factor, as determined by the *German Cement Works Association* (VDZ) from plant-specific data, of 0.53 t CO_2/t cement clinkers. Clinker production produced raw-material-related CO_2 emissions of 13,208 kt CO_2 in 2006.

[22] Provisional value.

Table 48: Production and CO_2 emissions in the German cement industry

Year	Clinker production	Emission factor	Raw-material-related CO_2 emissions
	[kt/a]	[t CO_2/t]	[kt/a]
1990	28,577		15,146
1991	25,670		13,605
1992	26,983		14,301
1993	27,146		14,387
1994	28,658		15,189
1995	29,072		15,408
1996	27,669		14,664
1997	28,535	0.53	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

Source: VDZ, 2007

4.1.1.2 Methodological issues (2.A.1)

Activity data

Activity rates are determined via summation of figures for individual plants (until 1994, activity rates were determined on the basis of data of the BDZ). As of 1995, following optimisation of data collection within the association, activity rates 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, 2007).

Table 48 summarises the activity rates, 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 German emission factor's (small) deviation from the prescribed default value, 0.5071 t CO_2 / t clinker, results from German clinkers' frequently higher lime content (64 % to 67 % CaO) and from inclusion of an average MgO content of 1.5% (which the default value does not include). The procedure used corresponds to the Tier 2 method of the IPCC-GPG (IPCC, 2000), and it is considered to be more precise than utilisation of default emission factors. The aforementioned emission factor of 0.53 t CO_2 / t cement clinkers is also used in the German industry's CO_2-monitoring reports and in calculations in the framework of greenhouse-gas emissions trading. The emission factor of 0.53 t CO_2 / t cement clinkers was applied to the entire time series.

Raw-material-related CO_2 emissions in the cement industry are determined, in accordance with the *IPCC-GPG*, via the following equation:

$$CO_2 \text{ emissions} = \text{emission factor } (EF_{clinkers}) \text{ x clinker production}$$

(Table 48 shows calculated CO_2 emissions for the German cement industry for the years 1990 to 2006.)

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

There are some uncertainties in determination of activity rates, since some of the data can only be estimated, using plant data of the VDZ.

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).

The uncertainty for the activity rates used was estimated as +/– 7 %. This experts' assessment took account of the following error sources:

- Uncertainty in collecting and transferring data,
- Uncertainties in determination of activity rates, since some of the data can only be estimated, using plant data of the VDZ.
- The uncertainty for the emission factors used was estimated as +/– 5 %. This experts' assessment took account of the following error sources:
- The uncertainty relative to the average fractions 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.

For purposes of quality assurance, all data used, including data from the BDZ, VDZ and from the literature, were checked for plausibility. The determined emission factor for raw-material-related CO_2 emissions has been compared with the relevant figures of other countries. Good agreement was found with figures from Australia, Canada, Denmark, France, Ireland, Spain, the UK and the U.S.. The small deviation (< 5 %) from the IPCC Tier 1 default factor of the IPCC Reference Manual (IPCC 1996b: Chapter 2.3.2, p. 2.6) results from the somewhat higher average carbonate content of clinker raw materials in Germany (see above).

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 system, 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. Use of a standard approach, for all relevant years, is the result of an expert assessment.

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)

The emission factor used for the entire time series, 0.53 t CO_2 / t clinkers, is currently being reviewed, especially in light of the following aspects:

- Plant-specific data relative to the carbonate content of clinker raw materials and to the metal-oxide content of produced clinkers,
- Recommendation, resulting from the initial review, to the effect that the country-specific emission factor regularly be reviewed in terms of CaO concentrations,
- New legal provisions in the ETS context.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Lime production	l / -	CO_2	0.48 %	0.52 %	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[23]	--	--	--	--	--				
Distribution of uncertainties	L	--	--	--	--	--				
Method of EF determination	D	--	--	--	--	--				

The source category Lime production is a key category for CO_2 emissions in terms of emissions level.

Lime results from burning of limestone. The primary component of limestone is calcium carbonate. Dolomite lime is produced via burning of dolomite. Chemically, dolomite is a mixture of calcium carbonate and magnesium carbonate. No plants for burning pure magnesium carbonate (*dead-burned magnesia*) are operated in Germany.

Lime and its secondary products (such as lime hydrate) and dolomite lime are used in many areas, including the steel industry, the chemical industry, environmental protection (for example, in flue-gas desulphurisation in power stations and in wastewater treatment) and agriculture.

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).

[23] Weighted uncertainty for the areas lime and dolomite (for individual uncertainties, see the CSE)

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 last five years, 2002-2006, were relatively small (with a range of 6.36 – 6.55 million t).

Table 49: Production and CO_2 emissions in the German lime industry

Year	Lime		Dolomite lime	
	Production [t]	CO_2 emissions [millions of t]	Production [t]	CO_2 emissions [millions of t]
1990	7,129,000	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	5.111	458,520	0.419
2005	6,359,666	4.992	463,174	0.423
2006 [24]	6,472,397	5.081	461,366	0.421

Source: BV KALK, 2007

From 1990 (the base year) through 2006, production decreased by about 9 %.

Dolomite-lime production, of which significantly smaller amounts are produced, basically exhibits similar fluctuations. On the other hand, production in the years 2003 to 2006 was considerably lower than in 2002 and the years before then (in 2003, production decreased by about 15 %). From 1990 (the base year) through 2006, 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

[24] Values for 2006 are provisional.

$EF_{dolomite\ lime}$: 0.913 t CO_2/t dolomite lime.

Here, it is assumed that the 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).

Since the NIR 2007, the CSE includes separate figures for lime production and dolomite-lime production, along with a stoichiometric CO_2-emission factor for each area. The total emissions for source category 2.A.2 are obtained by adding the separate emissions for each of these two areas. While this approach does not produce emissions values that differ from those in previous reports, it provides added transparency and involves fewer preliminary calculation steps. In the CSE, therefore, two different structural elements for the area of "lime" are used. A distinction is made between the activity rates and emission factors for lime and those for dolomite.

Activity data

The figures for lime and dolomite-lime production are collected by the German Lime Association (BVK) on a per-plant basis and then provided annually in aggregated form. For the years until 1994, no separate dolomite-lime production figures are available for the old and new German Länder; the relevant figures were estimated from the dolomite lime's share of total lime production and from the known total activities in the old and new German Länder. This artificial breakdown has no impact on the CO_2 emissions to be calculated, since the same emission factors (derived stoichiometrically) are used for both old and new German Länder.

No details are available as to the impurities in the raw materials and the pertinent degrees of deacidification. To permit comparison with other required reporting areas in which the same assumptions are applied, a CaO / CaO • MgO content of 100 % is assumed (= no impurities, complete deacidification).

Emissions from hydraulic-lime production play an insignificant role in Germany and are not estimated.

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 and thus their quality is 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 %, for 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.

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)

No specific improvements are planned at present. Continuous verification of the entire source category is being carried out, however.

4.1.3 Mineral Products: Limestone and dolomite use (2.A.3)

4.1.3.1 Source-category description (2.A.3)

CRF 2.A.3					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 sheet" ("Kalksteinbilanz"), all use of limestone and dolomite has been systematically tabulated (cf. Table 50). In addition, suitable, annually available data sources have been selected for reporting, and the relevant calculations have been integrated within the national reporting system. In this source category, all production and use of limestone and dolomite are being considered via a balance-sheet approach, 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 sheet" 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 50: 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
REA 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 research project also identified a significant gap, via the so-called "auxiliary balance sheet": The natural limestone fraction found in raw materials used to make bricks was estimated. That fraction is not included in limestone production and thus had not been taken into account in the limestone balance sheet.

Table 51: 2.A.3: Auxiliary balance sheet 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 sheet" project ("Kalksteinbilanz"; UBA 2006); cf. 4.1.8.

4.1.3.2 Methodological issues (2.A.3)

The "limestone balance sheet" research project (UBA 2006) modelled input quantities for all significant limestone-using source categories. As this approach implies, the original data on limestone use were not available in pertinent statistics. The data can usually be calculated with production data, however, and thus obtained for the limestone balance sheet. In addition, via an auxiliary balance sheet, the natural limestone fraction in raw materials for brick production was determined.

The prepared balance sheet clearly shows what errors the emissions inventory had contained: On this basis, the following balance items were added to the emissions inventory in 2006:

- 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 conformance with the requirements of the QSE manual and its associated applicable documents has been carried out.

The limestone-balance-sheet activity data and the emission factors are verified in the relevant source categories.

The data surveys from the limestone-balance-sheet 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)

The entire source category is subject to ongoing verification – for example, with data from European emissions trading.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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)	0 / 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 category.

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 Techniques 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.

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.

Emissionsfaktor

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 DESTATIS, 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.

Emissionsfaktor

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.

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: Asphalt roofing (2.A.5)

CRF 2.A.5					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 Asphalt roofing produces no greenhouse-gas emissions and is thus not a key category.

4.1.5.1 Source-category description (2.A.5)

Asphalt is used in production and laying of roofing and tar paper.

In 2006 some 181 million m^2 of roofing and tar paper were produced in Germany. In such production, liquid asphalt 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). Such emissions can be minimised via extensive enclosure and collection of exhaust gases.

Roofing and waterproofing materials are 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 roofing and tar paper produced (**activity rate**) has been taken from communications of the Verband der Dachbahnenindustrie asphalt roofing manufacturers association (VDD, 2006). 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 roofing and tar paper.

The **emission factor** for production of roofing and tar paper has been taken from the literature (IKP, 1996). The emission factor for laying of roofing and tar paper 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 52: Production and laying of asphalt roofing and waterproofing/sealing materials (rolls), and relevant activity rates and emission factors

	Produced or used area in 2006 [millions of m^2]	**EF [kg/ m^2]**
Production of asphalt roofing and waterproofing/sealing rolls	181	NMVOC 0.018
Laying of asphalt roofing and waterproofing/sealing rolls	181	VOC 0.043

4.1.5.3 Uncertainties and time-series consistency (2.A.5)

Since the total surface area of produced roofing paper and waterproofing/sealing materials is not calculated from asphalt consumption, and is determined and reported directly by the association, the relevant error is reduced considerably, to 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)

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

Until the NIR 2007, production quantities (activity rates) of roofing and waterproofing materials were determined via the pertinent asphalt inputs. In the process, it was assumed that between 1.3 and 4 kg asphalt/m^2 are consumed, depending on the nature of the roofing and waterproofing materials produced, and on the nature of the pertinent production process. The average consumption rate is estimated to be 3 kg/m^2. While the resulting calculated production quantity, about 233 million m^2, is higher than the VDD's statistical figure, the relevant possible range includes that figure and, thus, seems plausible.

4.1.5.5 Source-specific recalculations (2.A.5)

As a result of use of the new activity data, new, slightly lower NMVOC emissions result for the entire time series.

4.1.5.6 Planned improvements (source-specific) (2.A.5)

Plans call for reviewing the emission factors, especially those for laying of roofing paper and waterproofing/sealing materials. To this end, the relevant shares for "cold"-laid roofing and waterproofing/sealing materials (rolls) must be determined.

4.1.6 Mineral Products: Road paving with asphalt (2.A.6)

CRF 2.A.6					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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	NE	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 category.

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 57 million t of asphalt (DAV, 2007) was produced in Germany, in a total of some 750 asphalt-mixing plants. Asphalt is used primarily in road construction, where it competes directly with concrete. Following a considerable increase of production in 1991, production quantities have been decreasing again since 2000, although this decreasing trend is currently seen has having been halted (DAV, 2007).

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 in asphalt (proportional process emissions). CO occurs primarily in incomplete combustion processes. CO emissions are calculated solely in connection with fuel inputs.

Table 53: 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)

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

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 Glas)

CRF 2.A.7 Glas					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 category.

4.1.7.1 Source-category description (2.A.7 Glass production)

Germany's glass industry produces a wide range of different glass types that differ in their chemical compositions. Germany's glass sector comprises the following sub-sectors: container glass, flat glass, domestic glass, special glass and mineral fibres (glass and stone wool). The largest production quantities, by percentage, are found in the sectors of container glass (about 54.4 % of total glass production in 2006) and flat glass (about 23.6 % of total glass production in 2006). Together, these sectors account for 78.0 % 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, homogeneously mixed 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 furnace. 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 Glass production)

The currently valid IPCC Good Practice Guidance 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, 2007). "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 2006:

Table 54: Glass: Activity rates for the various industry sectors

Industry sector	Activity rate for 2006 [1,000 t]
Container glass	3,887.6
Flat glass	1,689.0
Special glass	357.1
Domestic glass	335.1
Glass fibre and wool	344.7
Stone wool	529.2

Source: BV Glas, 2007

The applicable cullet percentage, apart from the areas of container and flat glass, is considered to be 0 %. For this reason, it is possible that the emissions are being overestimated. The cullet percentage for container and flat 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 1995. Therefore, 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). These figures have been used to calculate emission factors for the following sub-sectors of the glass industry:

- Container glass
- Flat glass
- Domestic glass (consisting of crystal and lead-crystal glass)
- Special glass (consisting of lamp glass, display screen glass, apparatus glass and optical glass)
- Glass fibre
- Stone wool

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 55: 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 / 68 - 86	171 - 229
Flat glass	208 / 173 - 190	210
Domestic glass	120 / -	-
Special glass	113 / -	0 - 178
Glass fibre	198 / -	0 - 470
Stone wool	299 / -	238 - 527

4.1.7.3 Uncertainties and time-series consistency (2.A.7 Glass production)

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 as of 1995, 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. That company keeps precise records of all relevant quantities. For the new German Länder, an uncertainty of 20 % was assumed.

The figures on cullet use for flat glass are considerably less precise, however, since only estimates are available for that area. An uncertainty of 20 % was thus assumed.

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 production)

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

The calculated emission factors were compared with several different sources, including the CORINAIR manual and the "Baden-Württemberg 2004 emissions declaration" ("Emissionserklärung 2004 Baden-Württemberg"; UMEG 2004). According to this comparison, the calculated emission factors may be considered accurate.

The calculated emissions were also compared with data for the emissions trading system (ETS) in Germany; such comparison showed extensive agreement. In the case of container glass, a discrepancy was seen. As a result, the pertinent calculation was reviewed and corrections were made in the inventory.

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 production)

Recalculations have been carried out to take account of revised cullet inputs in container-glass production; these have yielded higher emissions figures for the period as of 1995. For the source category as a whole, the increases amount to about one-fourth as of 1995 and, thus, produce a slighlty increasing trend.

4.1.7.6 Planned improvements (source-specific) (2.A.7 Glass production)

The cullet inputs continue to be reviewed, and comparison with ETS data continues.

4.1.8 Mineral Products: Ceramics (2.A.7 Ceramics)

CRF 2.A.7 Keramik					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 is not a key category.

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 "wall 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); "wall brick" product: Production of wall 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 56: Activity rates and process-related CO_2 emissions in the ceramics industry (CRF 2.A.7.b)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
						[kT]					
Ceramics products	21595	20772	22769	24534	30458	24730	22663	22939	22798	22395	21199
of which:											
Wall bricks	16524	15691	17302	18827	23925	18827	16965	17298	17048	16591	15383
Roof tiles	1758	1946	2216	2349	2611	2466	2598	2521	2658	2849	2924
Process-related CO2 emissions											
Wall 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**				
						[kT]					
Ceramics products	21199	18003	16500	16443	16796	14643	16019				
of which:											
Wall bricks	15383	12771	11686	11631	11697	9881	10883				
Roof tiles	2924	2642	2381	2383	2601	2485	2648				
Process-related CO2 emissions											
Wall bricks	448	372	340	338	340	288	317				
Roof tiles	84	76	68	68	74	71	76				
Total	**531**	**447**	**408**	**407**	**415**	**359**	**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 is available and because this source category is not a key category.

Activity data

Official statistics are of limited use in determining actual production trends in the brick industry, in terms of weights, since such statistics list production of wall bricks and blown-clay products in cubic metres, and production of tiles in square metres and production of roof times in numbers of tiles. Produced weight quantities can be determined only via conversion factors. The conversion factors used for wall 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 wall 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 wall bricks account for about half of all wall 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 wall bricks (29.1 kg CO_2/t wall 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 56. 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 wall 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 wall bricks and roof tiles, and the related CO_2-emission factors are consistent as well. Some changes were made, throughout the time series, with regard to 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 wall 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 been carried out. 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 Chemische Industrie (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.

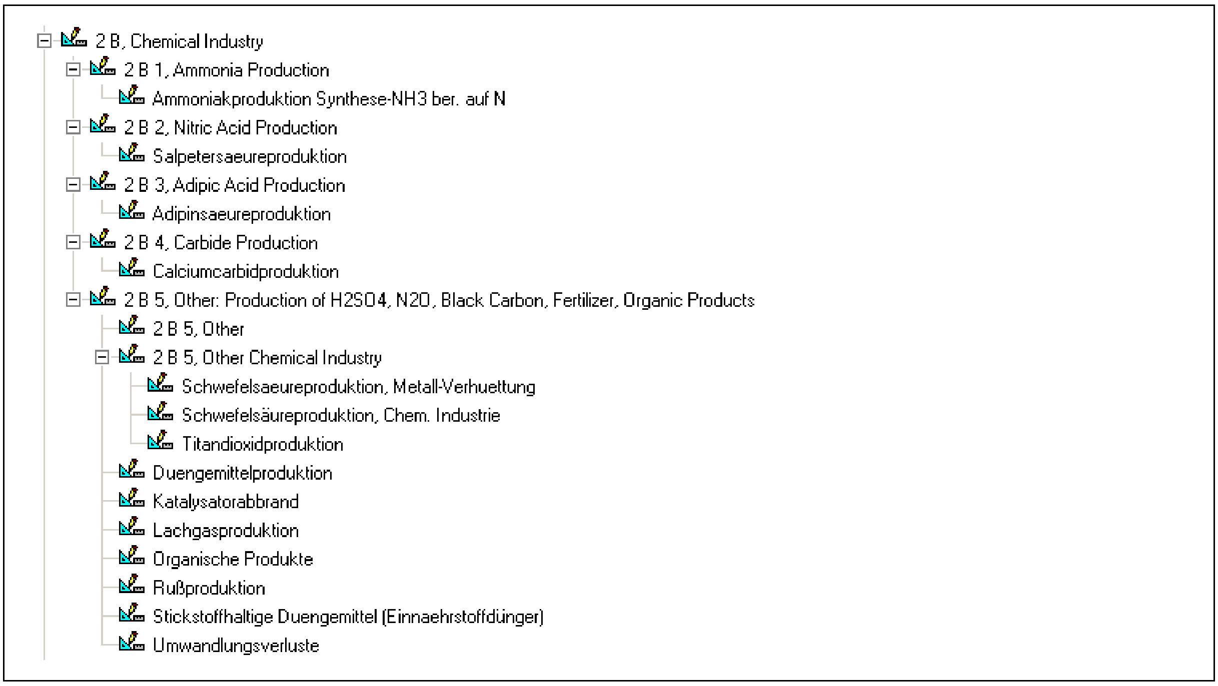


Figure 39: Structural allocation, 2.B Chemical industry

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Ammonia production	l / t	CO_2	0.36 %	0.49 %	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 category for CO_2 emissions in terms of emissions level and trend.

Ammonia is produced from 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 process 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 more than 15 % decrease in production (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, although it may be due to a change in statistical survey methods. 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)

Due to a lack of plant-specific data, an emission factor of 1500 kg CO_2 /t NH_3 – the proposed default factor – is used.

The amount of ammonia produced in Germany is determined by the Federal Statistical Office (DESTATIS, Fachserie (technical series) 4 Reihe 3.1, 1991-2006). 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).

The CSE thus uses an emission factor of 1815 kg CO_2 / t N for calculations.

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).

Pursuant 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. .

The emission factor for NO_X depends on the type of production in question. The Federal Environmental 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)

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 4 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.

In keeping with the 2006 IPCC Guidelines, an uncertainty of ±5 % was assumed for the activity rate.

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.

4.2.1.5 Source-specific recalculations (2.B.1)

No recalculations have been carried out.

4.2.1.6 Planned improvements (source-specific) (2.B.1)

At the end of 2006, the University of Utrecht completed a research project that, using the NEAT model (Non-energy Emission Accounting Tables; WEISS et al), studied the extent to which CO_2 emissions occur during non-energy-related consumption during product use and within industrial processes. Current work is reviewing findings relative to the figures in the Energy Balance for the Federal Republic of Germany for non-energy-related consumption of natural gas in ammonia production.

Since ammonia production is a key category with regard to CO_2 emissions, and since there are only five ammonia producers in Germany, efforts are being made to have plant-specific data reported directly (Tier 3).

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Nitric acid production	l / t	N_2O	0.37 %	0.81 %	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 category 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 plants for the production of nitric acid.

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:

$$4\ NH_3 \quad + \quad 5\ O_2 \quad \rightarrow \quad 4\ NO \quad + \quad 6\ H_2O$$

Simultaneously, nitrogen, nitrous oxide and water are formed by the following undesired secondary reactions:

$$4\ NH_3 \quad + \quad 3\ O_2 \quad \rightarrow \quad 2\ N_2 \quad + \quad 6\ H_2O$$

$$4\ NH_3 \quad \mathbf{+} \quad \mathbf{4\ O_2} \quad \rightarrow \quad \mathbf{2\ N_2O} \quad \mathbf{+} \quad \mathbf{6\ H_2O}$$

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)

The **activity data** are taken from the Federal Statistical Office (DESTATIS, Fachserie 4, Reihe 3.1, 1991-2006: 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. In 2003, production increased by nearly 2/3 over the 2002 level. Upon enquiry, the Federal Statistical Office attributed this extraordinarily large production increase to the appearance of two additional producers. In 2004, significant growth of 14 % took place from this high level. With respect to 2004, production rates in 2005 increased again by 47 %. Pursuant to DESTATIS, this increase was due to the aforementioned conversion of a data-collection system. In 2006, the production rate decreased by 23 % with respect to the 2005 level.

As a result, from 1990 through 2006, nitric acid production increased by 81 %.

The existing data for N_2O are based on measurements. The **emissions** depend on the technological situation and operating conditions, vary extensively from one plant to another, and 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.

Table 57: N_2O and NO_x emission factors from nitric acid production

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N_2O [kg/Mg]	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
NO_X [kg/Mg]	7.9	6.6	5.0	3.7	3.0	2.5	2.1	1.8	1.6	1.5	1.4	1.35	1.29
Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
N_2O [kg/Mg]	5.5	5.5	5.5	5.5									
NO_X [kg/Mg]	1.24	1.19	1.13	1.06				0.75					

Table 58: N_2O and NO_x emissions from nitric acid production

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
N_2O [Gg]	15.1	12.0	11.0	11.0	11.1	12.7	12.1	12.1	12.0	12.5	13.4	11.8	12.9
NO_X [Gg]	21.7	14.3	10.1	7.3	6.1	5.8	4.6	4.0	3.5	3.4	3.4	2.9	3.0
Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
N_2O [Gg]	21.3	24.3	35.7	27.4									
NO_X [Gg]	4.8	5.2	7.3	5.3									

4.2.2.3 Uncertainties and time-series consistency (2.B.2)

The emissions-determination process normally requires not only the produced amount sold; it also requires the entire produced amount, including amounts directly processed further within the plant. On the basis of the supposition that a significant portion of production is not sold, it must be determined whether production statistics include produced amounts that do not enter the market. Furthermore, it must be verified whether the Federal Statistical Office takes all plants into account. The Federal Statistical Office's combined listing of nitric acid and nitrating acid as of 2002 should be reviewed.

In keeping with the 2006 IPCC Guidelines, an uncertainty of ±2 % was assumed for the activity rate.

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.

4.2.2.5 Source-specific recalculations (2.B.2)

No recalculations have been carried out.

4.2.2.6 Planned improvements (source-specific) (2.B.2)

Nitric acid production is a key category for N_2O emissions. In the interest of reporting plant-specifically (Tier 3), in keeping with the IPCC Guidelines, initial steps for institutionalising delivery of plant-specific data have been taken. 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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Adipic acid production	l / t	N_2O	1.48 %	0.29 %	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 category for 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 Guidlines 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 this 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.

Production doubled in the period 1990 to 2005.

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.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 category.

During the reunification period, calcium carbide production took place primarily in the new German Länder. A short time later, production there was discontinued, while only one producer remained in the old German Länder. In the period under consideration, this producer cut his production by about half.

According to the responsible specialised association within the VCI, no silicon carbide has been produced in Germany since 1993. Emissions from this sector thus no longer occur.

4.2.4.2 Methodological issues (2.B.4)

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.

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; this data was published, until 1989, by that country's central statistical authority. That data, together with existing estimates for 1991 and 1992, has been used to interpolate the production in the new German Länder for 1990.

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.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Other	l / t	CO_2	0.53 %	0.97 %	rising

Gas	**CO_2**	**CH_4**	**HFC**	**PFC**	**SF_6**	**N_2O**	**NO_X**	**CO**	**NMVOC**	**SO_2**
Emission factor (EF) Industrial soot	CS	CS	NO	NO	NO	NO	NO	CS	NO	CS
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 category for 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 industrial soot (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.

The NIR 2007 reported on N_2O emissions from hydroxylamine production (Chapter 4.2.6). Additional enquiries directed to the leading producers have found that thermal exhaust-gas treatment, in place since the early 1990s, has eliminated N_2O emissions.

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 industrial soot production, methanol production, transformation processes and catalyst consumption in refineries.

The EF for CO_2 from industrial soot production was taken from a research project for estimation of CO_2 emissions from non-energy-related use of fossil raw materials in Germany (WEISS et al., 2006). In the process, only the specific input of oil soot (primary raw materials used for non-energy-related purposes), minus the relevant industrial soot's carbon content, was taken into account. The input quantity of natural gas, and the resulting CO_2 emissions, are reported as energy-related emissions, in keeping with the pertinent allocation in the Energy Balance. 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 emissions sources – without any claim to completeness – production of industrial soot, 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; these IPCC default EF are listed in Table 59 below.

Table 59: IPCC default emission factors for CH_4 from other chemical industry processes

Industrial soot	Styrene	Ethylene	1,2-Dichloroethane[25]	Methanol
[kg CH_4/t]				
0.06 (with thermal post-combustion) 28.4 (without thermal treatment)	4	1	0.4	2

The IPCC Good Practice Guidance does not discuss this subject further.

Pursuant to Point 5.2.5 of the TA Luft (Technical Instructions on Air Quality Control), German plants subject to the TA Luft must meet a standard of 50 mg/m³ (total carbon) for total mass concentration of organic substances (NMVOC and CH_4, but not including organic substances in dust form). The current state of the art provides for thermal post-combustion of volatile organic substances from plants for production of primary organic chemicals.

In keeping with these technical standards, the three German producers of industrial soot report an emission factor of 0.027 kg methane per tonne of industrial soot. Since relevant

[25] 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".

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 these 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 60: National emission factors for CH_4 from other chemical industry processes

Industrial soot	Styrene	Ethylene	1,2-Dichloroethane[26]	Methanol
[kg CH_4/t]				
0.03	0	0	0	0

NMVOC, CO and SO_2 – emission factors

For pollutants other than the methane considered above, the emission factors listed in Table 61 were used for Germany.

Table 61: Emission factors used in Germany for other pollutants

	Industrial soot [kg CO/t]	Industrial soot [kg SO_2/t][27]	Ethylene [kg NMVOC/t]	1,2-Dichloroethane [kg NMVOC/t]	Polystyrene [kg NMVOC/t]	Styrene [kg NMVOC/t]
1990	4.8 / 5	19.5 / [(28)]	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

The EF figures for NMVOC – polystyrene – were taken from the European Commission (2005, BREF polymers, 2nd draft), while for other products figures of German producers were used (these figures are available as confidential data). The default factors were used until 1994. The EF figures for CO and SO_2 in industrial soot production are based on assumptions of the responsible expert within the Federal Environment Agency.

[26] 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".

[27] Where two EF are listed, the second figure refers to the new German Länder.

[28] No EF is listed for the new German Länder, since these SO_2 emissions can be taken account of only as a lump sum.

Activity rates

The production statistics of the Federal Statistical Office (DESTATIS) include the following products (Table 62).

Table 62: Reporting numbers (Meldenummern) from production statistics

Line	Polystyrene	Methanol	1,2 - Dichloroethane	Industrial soot	Ethylene	Styrene
Until 1994	4414 42	4232 11	4228 22	4113 70	4221 11	4224 60
As of 1995	2416 20 350 and ...390	2414 22 100	2414 13 530	2413 11 300	2414 11 300	2414 12 500

Most of the following activity rates were taken from production statistics.

Table 63: Activity rates of methanol, 1,2-dichloroethane, soot, ethylene and styrene [t]

Production		Methanol	1,2-Dichloroethane (ethylene dichloride)	Industrial soot	Ethylene	Styrene
Year	Region					
1990	D	1266239	1504577	401365	3071829	1289781
	ABL	751083	1504577	394365	3071829	1289781
	NBL	515156		7000		
1991	D	1231541	1306091	381561	3059474	1208046
	ABL	716385	1306091	379561	3059474	1208046
	NBL	515156		2000		
1992	D	1290994	1512774	377384	3335942	1130836
	ABL	768831	1512774	376384	3335942	1130836
	NBL	522163		1000		
1993	D	1202189	1654694	334620	3904814	1041505
1994	D	1438327	1881032	299000	4182722	1150723
1995	D	1425795	1796930	330799	4163377	1080531
1996	D	1546958	1887791	315587	3814680	1151244
1997	D	1409850	2278858	337579	4186421	1099974
1998	D	1596258	2528542	343319	4269586	1182697
1999	D	1533113	2806415	338542	4894764	1096934
2000	D	1886429	2902378	345976	5119316	1089573
2001	D	1921680	2597093	348371	5005029	957750
2002	D	1843285	3188715	338592	4944099	960561
2003	D	2008075	3184280	348318	5258006	1226236
2004	D	1822267	3276355	339765	5290938	1668951
2005	D	1960901	3323226	332505	5417942	1048420
2006	D	2089216	3045886	630843	5133129	921664

D: Germany; ABL: Old German Länder; NBL: New German Länder (ABL/NBL only 1990-1992)

The figure for industrial soot 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 industrial soot production, and for production of ethene, styrene, methanol and 1,2 dichloroethane as of 1990, were provided by the Federal Statistical Office (DESTATIS, Fachserie 4, Reihe 3.1, 1991-2006 Produzierendes Gewerbe, Produktion im Produzierenden Gewerbe)

The reasons for the production fluctuations during the period under consideration are unknown. According to the Federal Statistical Office, the nearly 100 % increase in industrial soot production 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 is 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.

The following figures, from inventory reports of other countries, could provide information relative to the EF that should be used for Germany:

- Japan:
  From representative waste-gas measurements, EF were formed that, in some cases, are more than 30 to 80 times smaller than the IPCC defaults. This is due to reduction measures (methane recovery, flaring) that, presumably, have not yet been taken into account in the IPCC defaults.
- Portugal:
  This country's EF for soot production, which is 25 % below the IPCC default, was obtained from measurements made in 1990-94 at the country's sole producer.

4.2.5.5 Source-specific recalculations (2.B.5)

The N_2O emissions from caprolactam production were reviewed, and relevant recalculation was carried out. A thermal exhaust-gas-treatment system has been in operation since the early 1990s. No N_2O emissions now occur.

4.2.5.6 Planned improvements (source-specific) (2.B.5)

As to CO_2 emissions from refineries, further review is required to determine whether these emissions include emissions from heavy-oil gasification, calcination and hydrogen production related to refineries' own consumption.

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.C0.4) is not further sub-divided. In the CSE, sub-category Other (2.C.5) includes lead production, thermal galvanisation, copper production and zinc production.

Figure 40: Structural allocation, 2.C Metal 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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Steel (integrated production)	l / t	CO_2	3.79 %	4.29 %	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 category for CO_2 emissions in terms of emissions level and trend.

In 2006, a total of 32.5 million t of raw steel, from ore, was produced in Germany in six integrated steel works. Electric steel production amounted to 14.7 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 these processes are 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. In addition, CO_2 emissions from limestone inputs in pig iron production and in electrode consumption in electric 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 64 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 64: 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 electric 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

In keeping with the difficulties of differentiating between process-related and energy-related emissions in oxygen steel production, the following actions are taken:

1. All of the CO_2 emissions resulting from use of reducing agents and fuels are calculated,
2. Process-related CO_2 emissions are determined from the carbon requirements for the ideal blast-furnace process and from limestone inputs in pig iron production, and CO_2 emissions are determined from electrode consumption in electric steel production.

3. Then, the determined emissions are aggregated and allocated to the total process-related and energy-related CO_2 emissions from iron and steel production (2.C.1 and 1.A.2.a). This approach rules out the possibility of any double-counting, and it simplifies the process of summing up all carbon inputs and outputs.

Determination of total CO_2 emissions from inputs of reducing agents and fuel in pig-iron and oxygen-steel production

For determination of total CO_2 emissions from inputs of reducing agents and fuel, pig-iron and oxygen-steel production are considered in one step. In terms of methods, this procedure for determining total emissions corresponds to that used until the NIR 2004 for determining iron and steel industry emissions as reported under 1.A.2.

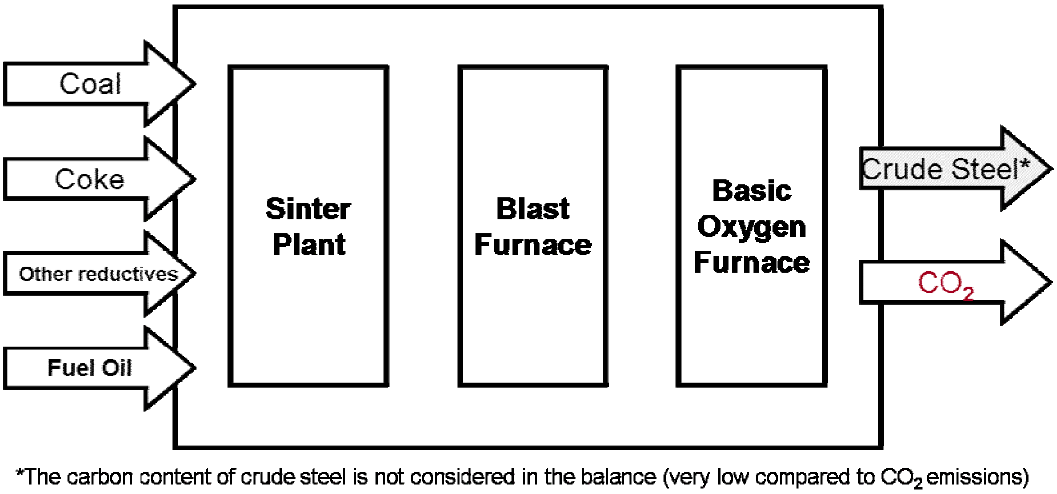


Figure 41: Carbon balance in pig-iron and oxygen-steel production

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 41). 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 65). 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 65: Inputs of secondary fuels in blast furnaces, their biogenic fractions and the relevant emission factors for CO_2

Secondary fuel	Units	Year	Animal fat	Recycled plastics
CO_2 emission factor	kg/ TJ		71,380	74,630
	kg/t			2850
Biogenic mass fraction	%		100	0
Input quantities in blast furnaces	t	1996	-	48,467
	t	1997	-	112,055
	t	1998	-	118,132
	t	1999	-	104,139
	t	2000	-	135,855
	t	2001	-	146,753
	t	2002	14,589	148,483
	t	2003	28,877	105,924
	t	2004	13,476	93,958
	t	2005	-	39,142
	t	2006	-	34,232

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) steel-works 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 66.

Table 66: 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**	**Year**	**Sinter**	**Pig iron**
1990	4,681	705	2,060	310	2,370
1991	4,566	726	2,009	319	2,328
1992	4,152	669	1,827	294	2,121
1993	3,988	632	1,755	278	2,033
1994	4,281	701	1,884	308	2,192
1995	4,426	703	1,947	309	2,257
1996	4,273	649	1,880	286	2,166
1997	4,507	725	1,983	319	2,302
1998	4,526	707	1,991	311	2,303
1999	4,190	654	1,844	288	2,131
2000	4,381	723	1,928	318	2,246
2001	4,240	684	1,866	301	2,167
2002	4,091	689	1,800	303	2,103
2003	4,202	691	1,849	304	2,153
2004	4,371	703	1,923	309	2,233
2005	4,144	808	1,823	355	2,179
2006	4,255	850	1,872	374	2,246

Source: until 2004: Calculations from the "limestone balance" project ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02); as of 2005: calculations via the product-specific factors determined in the aforementioned project

Determination of CO_2 emissions from electrode consumption in electric steel production

In electric steel production, CO_2 emissions occur directly via consumption of graphite electrodes. These emissions must also be allocated to process-related CO_2 emissions for steel production. They are calculated from quantities of produced electric steel, via a standard factor for electrode consumption (1.3 kg C per tonne of electric 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 electric iron production.

The relevant so-determined emissions quantities are shown in Table 68. The contribution of electric steel production (electrode consumption), at 0.16% of total process-related CO_2 emissions, and 0.12% of total emissions, from iron and steel production, is insignificant.

Table 67: Total process-related emissions to be reported under 2.C.1

Year	Process-related CO_2 emissions pursuant to Scholz factor [t/a]	CO_2 emissions from limestone input [t/a]	CO_2 emissions from electrode consumption [t/a]	2.C.1 total [t/a]
1990	43,198,964	2,369,840	75,242	45,644,046
1991	42,924,494	2,328,480	68,464	45,321,438
1992	40,009,884	2,121,240	64,358	42,195,482
1993	37,832,422	2,032,800	56,805	39,922,027
1994	41,712,905	2,192,080	62,447	43,967,432
1995	41,703,756	2,256,760	65,930	44,026,446
1996	38,487,229	2,165,680	67,249	40,720,158
1997	43,306,138	2,302,080	71,238	45,679,456
1998	41,758,650	2,302,520	66,528	44,127,698
1999	38,942,065	2,131,360	61,335	41,134,760
2000	43,198,964	2,245,760	66,620	45,511,344
2001	41,371,778	2,166,560	62,721	43,601,059
2002	41,574,363	2,103,200	62,993	43,740,556
2003	40,957,459	2,152,920	64,071	43,174,450
2004	42,003,059	2,232,560	67,910	44,303,529
2005	40,330,099	2,178,835	65,192	42,574,125
2006	42,542,850	2,246,327	69,995	44,859,172

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.

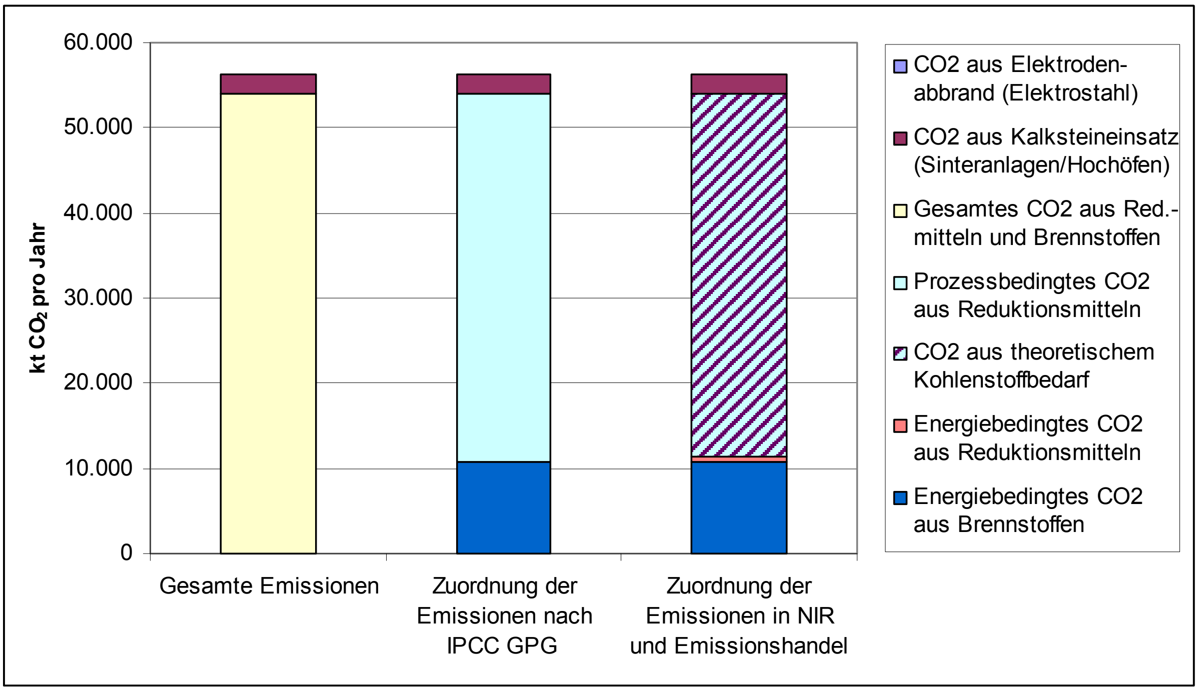
Secondly, via a corrective time series in the CSE, non-process-related emissions from the blast furnace (the difference between the sum of the CO emissions resulting from the aforementioned reducing agents and the calculated process-related emissions from the ideal blast-furnace process (see above)) 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 a procedure in contrast to that used in the 2005 National Inventory Report, CO_2 emissions from top gas in the iron and steel industry are not reported in sector 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 42. The difference, i.e. the different allocation to energy-related emissions, amounting to no more than 800 kt/a CO via the approach described here (and referred to in Figure 42 as "energy-related CO_2 from reducing agents"), accounts for less than 1.8% of process-related emissions pursuant to IPCC GPG.



[kt CO_2 per year; Total emissions, Emissions allocation pursuant to IPCC GPG; Emissions allocation in NIR and emissions trading; CO_2 from electrode consumption (electric steel); CO_2 from limestone inputs (sinter plants / blast furnaces); Total CO_2 from reducing agents and fuels; Process-related CO_2 from reducing agents; CO_2 from theoretical carbon requirements; Energy-related CO_2 from reducing agents; Energy-related CO_2 from fuels]

Remark: 2.C.1 and 1.A.2a; CO_2 emissions from electrode consumption in electric steel production, amounting to 0.1% of total emissions, are not visible in the above figure

Figure 42: 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 according to 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. The determined emissions quantities have been successfully checked with 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)

Plans call for determination of the precise amounts of electrode consumption involved.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2005 - 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 category. 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).

A constant activity rate figure of 25,000 t has been used 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 (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has not been carried out completely.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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 Primary aluminium production source category is a key category for 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. In this area, PFCs are produced in the production process as secondary products of electrolytic reduction of aluminium oxide (from alum earth) to aluminium. 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. The reason why a marked reduction of CF_4 emissions occurred with respect to 2005 is that certain plants were decommissioned in 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 2006 were taken from the monitoring report by the aluminium industry for the year 2006. The average anode consumption is 430 kg of petrol coke per tonne of aluminium. Table 68 shows the process-related emission factors.

The total quantity of waste gas incurred per tonne of aluminium during the production of primary aluminium was multiplied by an average concentration value formed from several individual figures, from various different plants, with appropriate weighting. The emission factors also make allowance for fugitive emission sources, such as emissions via hall roofs. The emission figures used for CO are the results of emission measurements within the context of investment projects.

The emission factors for SO_2 and CO_2 were calculated from the specific anode consumption. The anodes consist of petrol coke; this material has specific sulphur concentrations of about 1.2 %, from which an SO_2 emission factor of 10.4 kg/t Al can be calculated. The CO_2-emission factor is calculated on the basis of the specific carbon content of petrol coke, 857 kg per t. (cf. Chapter 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 68 were compared with the emission data in Best Available Technology Reference Documents (BREFs)[29] and other sources (such as VDI Guideline 2286 sheet 1).

Table 68: Activity rates and process-related emission factors for primary aluminium production in 2006

		AR	Emission factors						
	Number of foundries	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	516,425	1367	0.05	0.005	k.A.	10.4	k.A.	180

Emission data is available for PFC emissions from primary aluminium foundries, 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 foundries 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[30] were calculated, in keeping with the technology used. The number of anode effects is recorded and documented in the foundries. The total CF_4 emissions in 2006 were calculated by multiplying the total anode effects by the specific CF_4 emissions per anode effect determined in 2006. The total emission factor for CF_4 is obtained by adding the CF_4 emissions of the foundries and then dividing the sum by the total aluminium production of the foundries. 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 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, no surveys of the plant-specific number of anode effects were conducted in 1991, 1992, 1993 and 1995, under applicable voluntary commitments, and no calculation was carried out for these years (cf. 4.3.3.6).

[29] cf. http://www.bvt.umweltbundesamt.de/kurzue.htm

30 "...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 25 tonnes of CF_4 in 2006, while they emitted 45 tonnes in 2005. The reason for this decrease was that production decreased by about 130,000 tonnes of aluminium. The reasons for the production decrease, in turn, were that the HAW plant was temporarily shut down and that the Stade/Hydro plant's furnaces were partly shut down.

4.3.3.4 Source-specific quality assurance / control and verification (2.C.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.

The industry conducts annual surveys of activity data and reports this 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 is subject to quality assurance measures.

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 2005, the German emission factor for CF_4, resulting from anode effects, was 0.070 kg/t aluminium. This factor is slightly below 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)

Uncertainties continue to be determined, 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 category by level (l) / trend (t)		**Gas (key category)**	**1995 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
SF_6 used in aluminium and magnesium foundries	- / t	SF_6	0.01 %	0.25 %	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 used in aluminium and magnesium production is a key category for SF_6 emissions in terms of trend. Aluminium and magnesium production accounted for about 43 % of SF_6 emissions in 2005.

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. In Germany, protective gas is only used for processing of magnesium that has been imported in ingot form.

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.

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.

For the report year 2002, a first survey of gas providers' SF_6 sales figures was carried out, and these figures were compared with data obtained from a survey of amounts consumed by industry. This made it possible to identify SF_6 users, in the area of aluminium casting, who use pure SF_6. Since report year 2006, annual surveys have been taken of gas suppliers' sales figures relative to the application "aluminium casting".

Activity data for magnesium production

To date, SF_6-input quantities have been determined via direct surveys of foundries' annual consumption levels. This year, thusly determined input data were cross-checked for the first time against sales quantities as determined via surveys of gas sellers in this sector. The described procedure has been applied to all report years other than 1996 and 1999, for which lacking yearly data was obtained via interpolation. Good agreement was found, and thus in future only gas sellers will be surveyed.

4.3.4.3 Uncertainties and time-series consistency (2.C.4)

As studies have shown, part of the SF_6 used in 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. The uncertainties for the emission factors cannot be quantified without more precise measurements that could be used to determine an average degree of decomposition in the process, however.

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.

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.

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 the new source, "aluminium casting". Sales figures and industrial usage quantities were compared for the report year 2004 and showed excellent agreement.

The data for the report year, like the data for most of the previous years, were collected by an external expert working under commission to the Federal Environment Agency and also responsible for pertinent quality assurance. In addition, where possible, data are checked by the relevant Federal Environment Agency expert upon receipt.

4.3.4.5 Source-specific recalculations (2.C.4)

No recalculations are required.

4.3.4.6 Planned improvements (source-specific) (2.C.4)

As of report year 2007, surveys to determine sold quantities of SF_6 are to take place solely pursuant to the Environmental Statistics Act (UStatG) (surveys of gas sellers).

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 Metallproduktion: HFKW-134a in der Magnesiumproduktion

4.3.5.1.1 Source-category description (2.C.5)

Since 2003, in isolated cases HFC-134a has been used, instead of SF_6, as a protective gas over molten metal. The quantities used are still very small, however.

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.

4.4 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.

Figure 43: Structural allocation, 2.D Other production

4.4.1 Other production: Pulp and paper production (2.D.1)

4.4.1.1 Source-category description (2.D.1)

CRF 2.D.1					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 - contribution to total emissions**	**2006 - 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	D	D	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.

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 lime ovens.

A total of nine plants produce wood pulp.

A detailed description of the relevant processes – in the present example, fibre production (including wood-pulp production) and paper and carton production – as well as supplementary information about auxiliary boilers, is 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 69 were used.

Table 69: IPCC default emission factors for SO_2, NO_x CO and NMVOC from wood 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

In 2006 the following quantities were produced, in a total of 113 plants:

Table 70: Pulp and paper production, produced quantities

Product	**Quantities produced in 2006**	
Production of paper, cardboard and carton (PCC):	22.6	million tonnes
Raw-material production:		
Paper pulp	1,469,973	t
of this, sulphite pulp	632,784	t
of this, sulphate pulp	836,189	t
Wood pulp	1,467,813	t
Recycled paper	12,747,000	t
Quantity of recycled paper used for this purpose	(15,243,994)	(t)

Source: Verband Deutscher Papierfabriken, Leistungsbericht 2007

These figures can be traced to the base year, 1990.

4.4.1.3 Uncertainties and time-series consistency (2.D.1)

The IPCC default values (IPCC, 1996b) were used for emissions calculation. These values were confirmed via consultation with German plant operators.

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 not been carried out.

4.4.1.5 Source-specific recalculations (2.D.1)

No recalculations are required.

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 "limestone balance sheet" ("Kalksteinbilanz") R&D project (FKZ 205 41 217) is not covering caustification in sulphate pulp production, because such production is not relevant with regard to the limestone balance sheet and since pertinent limestone use does not produce CO_2 emissions.

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 category by level (l) / trend (t)		Gas (key category)	1990 - contribution to total emissions	2006 - 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 %									10 - 20	
Distribution of uncertainties									N	
Method of EF determination									CS	

The source category "Other production: food and drink" (2.D.2) is not a key category.

The food and beverage industry's emissions of directly acting 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). 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 138.2 billion, the food and beverage industry was one of the most important industries in Germany in 2006. Nation-wide, some 5,900 industry companies employed about 519,300 people (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: S. 2.41f):

4.4.2.2 Methodological issues (2.D.2)

Emissions were calculated with the emission factors recommended by IPCC and CORINAIR.

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 71 shows the activity rates determined, emission factors used and the relevant NMVOC emissions calculated for the year 2006.

Table 71: NMVOC emissions from the food industry (2 D 2)

Product	Activity rates		Emission factors		Emissions [t]
Bread	4,318,605	t	3	kg/t	12,955.8
Cake, cookies and breakfast cereals	1,664,552	t	1	kg/t	1,664.6
Sugar	3,563,556	t	1	kg/t	3,563.6
Meat, poultry, fish	4,150,928	t	0.3	kg/t	1,245.3
- Fish, smoked	20,977	t	1.1	kg/t	23.1
Margarine and hard and hardened fats	650,379	t	1*(10)	kg/t	650.4
Sugar	3,563,556	t	1*(10)	kg/t	3,563.6
Coffee roasting	537,062	t	0.55	kg/t	295.4
Animal feedstuffs	288,000	t	1	kg/t	288.0
Beer	9,693,700	t	0.2	kg/t	1,938.7
Wine					
- Red wine	360.742	t	0.8	kg/t	288.6
- White wine	530.858	t	0.35	kg/t	185.8
- Other wines	471.735	t	0.35	kg/t	165.1
Spirits					
- Whisky	49,623	hl	15	kg/hl	744.7
- Brandy	1,115.3	hl	3.5	kg/hl	3,518.5
- Other spirits	3,165.8	hl	0.4	kg/hl	1,266.3

* The default emission factor has been multiplied by 0.1 to take account of reduction measures

For source category 2.D.2, this yields a total of 28.8 Gg NMVOC emissions (up from 29.9 Gg NMVOC in 2005).

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%. Emission factors from the IPCC Workbook (1996a, 2.41f) and the Emission Inventory Guidebook (EMEP, 2006c, B 465, B 466) were used. Those factors do not always properly reflect the circumstances in Germany, however. A research project is currently being carried out, in the UFOPLAN framework, with the aim of improving the database and facilitating maximally realistic estimation of emissions from the food industry.

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 completely.

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)

No recalculations are required.

4.4.2.6 Planned improvements (source-specific) (2.D.2)

In the UFOPLAN 2006 framework, a research project entitled "Emissions from the food and drink industry" ("Emissionen aus der Nahrungsmittelindustrie") is being carried out with the aim of improving determination of process-related emissions from the food and drink industry.

4.5 Production of halocarbons and SF_6 (2.E)

CRF 2.E					
Key category by level (l) / trend (t)		**Gas (key category)**	**1995 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Production of halocarbons and SF_6: fugitive emissions	- / t	HFC	0.34 %	0.03 %	falling

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 HFCs) and SF_6 is a key category for HFC emissions in terms of trend. It is subdivided into 2.E.1 By-product emissions and 2.E.2 Fugitive emissions.

Figure 44: Structural allocation 2.E: Production of halocarbons and SF_6

4.5.1 By-product emissions (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. These 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. This 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 sharply reduced 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.

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) und SF_6 production takes place at two locations. Emissions trends are tied to trends in amounts produced. While SF_6 and HFC-134a are produced in Germany, 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 and from the AWACS maintenance application 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.

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 category by level (l) / trend (t)		**Gas (key category)**	**1995 - contribution to total emissions**	**2006 - contribution to total emissions**	**Trend**
Consumption of halocarbons and SF_6	l / t	SF_6	0.35 %	0.24 %	falling
Consumption of halocarbons and SF_6	l / t	HFC	0.00 %	0.91 %	rising

Gas	**CO_2**	**CH_4**	**HFC**	**PFC**	**SF_6**	**N_2O**	**NO_X**	**CO**	**NMVOC**	**SO_2**
Emission factor (EF)			s. Text	s. Text	s. Text					
EF uncertainties in %			-	-	-					
Distribution of uncertainties			-	-	-					
Method of EF determination			s. Text	s. Text	s. Text					

The source category Consumption of halocarbons and SF_6 is a key category for HFC und SF_6 emissions, in terms of emissions level and trend. The role of SF_6, in terms of share of total emissions, has been decreasing, while that of HFC has been increasing.

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 further sub-divided; cf. Table 72. The Table also shows the CRF divisions as they are shown in the CSE national database (cf. Figure 45).

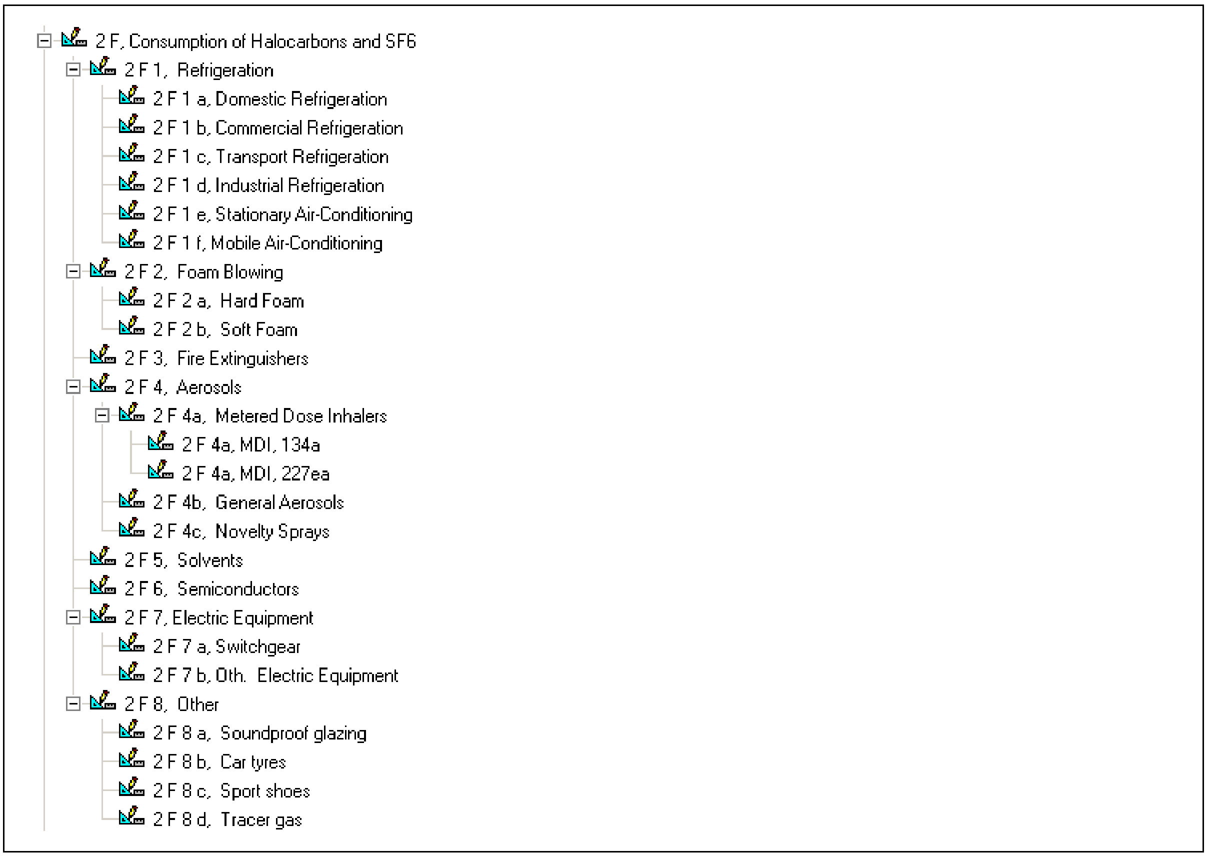


Figure 45: Structural allocation 2.F Consumption of halocarbons and SF_6

Figure 46 shows, for 2005, and by way of example, the various sub - source categories' percentage shares of total pertinent emissions of HFCs, PFCs and SF_6.

Use of refrigerants in stationary and mobile cooling/refrigeration systems accounted for over 80 % of HFC emissions in 2005 and thus was the primary source of such emissions. In 2005, mobile air-conditioning systems accounted for about 32 % of total HFC emissions. Use of HFCs as blowing agents for foam production was another main source of HFC emissions, accounting for about 8 % of such emissions.

The sub-category "Fire extinguishers" accounted for 0.1 % of HFC emissions. Nearly 7% of HFC emissions were produced by "Metered dose inhalers" and by a diverse range of other aerosols, including cooling sprays and party-streamer sprays. The latter belong to the group of novelty aerosols. In the report year, semiconductor manufacturing (including circuit boards, an area not considered, due to its low significance) accounted for about 5 % of all PFC emissions, 0.01 % of all HFC emissions and about 4 % of all SF_6 emissions. The sub- source category "Electrical operating equipment" accounted for about 20 % of all SF_6 emissions of 2005. Utilisation in automobile tyres, as a trace gas, in sport shoes and in AWACS maintenance accounted for about 2 % of SF_6 emissions.

Use in insulating windows contributed strongly – over 30 % – to SF_6 emissions in 2005.

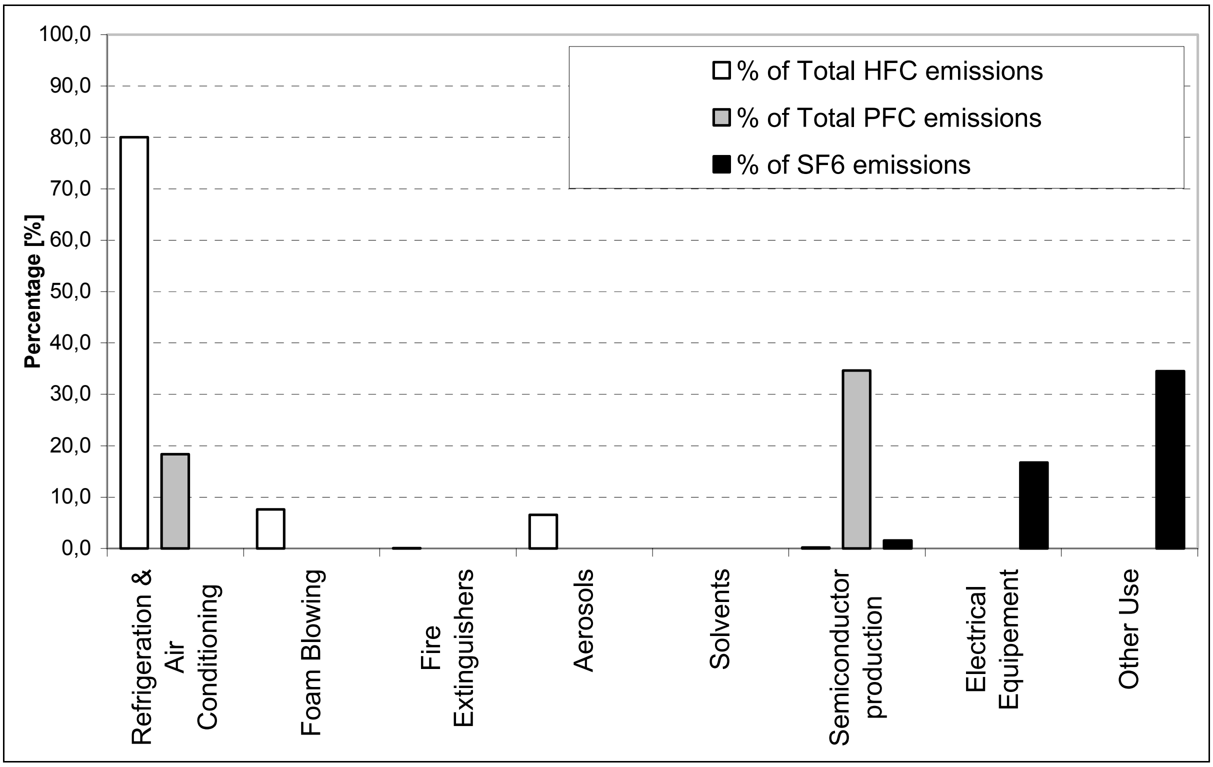


Figure 46: CRF 2.F sub - source categories' shares of emissions of HFCs, PFCs and SF_6 in 2005

Table 72: 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**			**Emission factor** (dimensionless)		
			HFC	**PFC**	**SF_6**	**Production (CS)**	**Use**	**Disposal**
1. Air-conditioning 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	NO
Stationary air-conditioning systems	2.F.1e					20 g/system	0.06	NE
Room air conditioners						NE	0.025	
Mobile air-conditioning systems	2.F.1f							
- Trucks						2 g/system	0.10 – 0.15	0.3
- Automobiles						2 g/system	0.1	
- Busses						5 g/system	0.15	
- Ships						0.01	0.05	
- Railway vehicles						0.002	0.15 – 0.25	
- Agricultural machines						5 g/system	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						0.15	0.01	
Integral foam						1	NO	
PUR foam (134a)						1.5 g/can	1	
PUR foam (152a)						1.5 g/can	1	
XPS foam (134a)						0.27	0.0066	
XPS foam (152a)						1	NO	
Soft foam	2.F.2b							
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 (10mL)	1	NO
Other aerosols / novelties	2.F.4b/c	Equ. 3.35				0.015	1	
5. Solvents	**2.F.5**	**Equ. 3.36**				**NE**	**1**	
6. Semiconductor 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**							
Insulating windows	2.F.8a	Equ. 3.23			SF_6	0.33	0.01	1
Trace gas	2.F.8b					1	NO	NO
Car tyres	2.F.8c	Equ. 3.24ff				NE	NE	1
Sports shoes	2.F.8d	CS						

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. Emissions from use are based on the average annual stock of relevant pollutants (the activity rate), and they are calculated via the following formula:
   $EM_{use} = EF_{use}$ * 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 use 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)

4.6.1.1.1 Source-category description (2.F.1)

This category is divided into the sub-categories of household refrigeration, commercial refrigeration, transport refrigeration, industrial refrigeration, stationary air-conditioning systems and room air-conditioners, and mobile air-conditioning systems (cf. Table 72).

In Germany, the leading pure-HFC refrigerants 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.

Disposal emissions will be included in the emissions database as of the next report year.

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 sales 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. Such systems are less common 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 commonly 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 refrigeration model described below also holds for industrial refrigeration systems. The same section also discusses pertinent differences between the two areas.

1. Foreign trade plays a negligible role with regard to refrigeration systems that are installed on site, 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).
2. 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".
3. 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.
4. 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.
5. 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 liquification rates (low emissions).
6. In the category of other commercial refrigeration, the data are combined into the categories of plug-in-ready single appliances and installed stationary systems.
7. 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.

8. 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.
9. 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.
10. The production emissions and emissions from stocks are calculated with Equation 1 and Equation 2. Production normally takes place at the relevant sites.
11. 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 sales) to 15 % for old devices. These values are in the lower range of pertinent values given by IPCC-GPG (2000).

Activity data

The number of system operators is substantiated by official statistics. The types of refrigeration equipment (i.e. as sets) commonly involved have been described 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.

Refrigerated containers are used primarily for transports of perishable goods by ocean-going ships. Since their emissions take place primarily in international waters, their refrigerant emissions are divided, in each case, in keeping with the relevant country's share of world trade. Germany is assigned 10% of global emissions from refrigerated containers. Since 1993, the most commonly used refrigerant has been HFC-134a. R404A is also used to some extent, however.

The following refrigeration model is applied:

1. 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.
2. Solid refrigerants (types), and fixed refrigerant fill amounts, are assigned to the various size classes. Each refrigerant is also assigned a fixed share of each size class. It may become necessary to modify the refrigerant breakdown used.
3. 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.
4. When one knows the final stocks from the previous year, one can calculate the average yearly stocks and the year-end stocks.
5. 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.
6. Production emissions are calculated with Equation 1, since they must be seen in connection with new consumption. No use is made of the possibility of calculating emissions on the basis of numbers of newly filled vehicle refrigeration systems, and of the filling loss per system. Emissions from stocks are calculated with Equation 2.
7. 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 is based are listed in Table 72. Except for EF disposal, the emission factors used are the result of surveys of experts.

The ongoing HFC emissions from refrigeration systems of refrigerated vehicles are estimated to be 15 % for new systems and 25 % for old systems. "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), although 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)

Stationary air-conditioning systems are used for cooling entire buildings or large rooms. 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:

1. Stationary air-conditioning systems are divided into three categories. The number of new systems in each category 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 calling for lower-performance systems, room air conditioners are normally used. Foreign trade with HFC-based systems does not have to be taken into account, since that refrigerant is almost always filled on location in connection with system installation.
2. For each category, a certain fill amount and refrigerant composition is assumed.
3. 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.

4. When one knows the existing stocks, one can calculate the average yearly stocks and the year-end stocks.
5. Production emissions are calculated by multiplying "number of new systems" by $EF_{production}$.
6. Emissions from stocks are calculated with Equation 2.
7. No disposal emissions have occurred to date.

IPCC-GPG (2000) gives a service lifetime of 10 to 30 years for refrigeration systems for liquids. 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.

4.6.1.2.6 Room air conditioners (2.F.1.e)

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 stationary air-conditioning systems.

There is no domestic production of room air-conditioners. All room air conditioners are imported as filled units. 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:

1. Room air-conditioners are divided into three categories. Annual sales in each category are determined via surveys of sellers: mobile devices, split devices, multi-split devices.
2. The pertinent fill amounts and refrigerant mixtures are determined for each category.
3. 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.
4. 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.

5. Emissions from stocks are calculated with Equation 2.
6. 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 types of units (mobile, split, multi-split), sizes and refrigerant types.

4.6.1.2.7 Mobile air-conditioning systems (2.F.1.f)

"Mobile air-conditioning systems" comprises vehicle air-conditioning systems in passenger cars, trucks and commercial vehicles, busses, 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:

1. Determination of annual numbers of newly licensed vehicles, for the classes automobiles, trucks, busses and agricultural machines.
2. Determination of the average rates of installation of air-conditioners in automobiles, trucks, busses and agricultural machines. For automobiles, the average rate is based on figures for each vehicle type; these are supplemented as appropriate with figures of industry experts.
3. Determination of the average fill amounts (refrigerant), from figures for each vehicle type (automobiles) and from figures provided by industry experts.
4. 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.
5. 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.
6. 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.
7. Production emissions are computed with Equation 1.
8. 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), 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 following 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 the various 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 was compared with the sales data (substance-oriented) of the manufacturers.

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 is 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.

Systematic quantification of the uncertainties for the entire sub - source category of refrigeration and air-conditioning systems has begun for report year 2005. That work will be completed for report year 2007.

4.6.1.4 Source-specific recalculations (2.F.1 all)

In the industrial refrigeration systems category, a review of calculations relative to disposal has been carried out for the years 2003 and 2004. This was necessary, because relevant calculations relative to disposal were lacking in the national database. These problems primarily affect emissions from stocks. And they apply to nearly all HFCs.

In report year 2005, in the category of industrial refrigeration systems, recalculations were required as a result of calculation errors in determination of emissions from R-134a stocks, and of emissions from disposal of R-134a, and because an erroneous value for low-temperature refrigeration had been used for 1998.

The implied emission factors were recalculated, since the pertinent calculated factors used in the previous submission were too low, due to a software error.

4.6.1.5 Planned improvements (2.F.1 all)

In future, efforts will be made to improve data for the area of stationary refrigeration systems by means of prompt enquiries, carried out by the Federal Statistical Office, regarding consumption levels (repairs, refill quantities, etc.). Such information can then be compared with model data. In view of the large number of systems involved (several million), however, emissions data are likely to remain subject to major uncertainties. Additional possibilities for collecting and improving data are currently being evaluated. Such possibilities could include evaluation of IT-aided programmes for conducting surveys of refrigeration systems. Programming of disposal information in the national database is to be completed in the next report year. This will apply especially to stationary refrigeration systems and refrigerated vehicles. In that area, comprehensive recalculations are planned for the NIR 2009.

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 soft-foam, 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 1995 to 1997, HFCs were used only in integral foams. Since 1998, they have also been used as blowing agents in PU hard foams. HFC use has been decreasing, as HFCs are being supplanted by 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).

The pre-1995 data for foam sealants were obtained via discussion, in 2006, with leading foreign OCF sellers and from older publications.

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 inclusion 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 rates

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 hard-foam industrial 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 on H-CFCs, include mixtures of HFCs and propane, butane or dimethyl ether (DME). At the same time, the HFC quantities in spray cans have been continually reduced since 1996. Use of HFC-152a, as a substitute for HFC-134a, has increased.

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 propellant. The bulk of this propellant eventually 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):

1. Number of cans filled per year in Germany
2. HFC content per can, in grams
3. Applicable percentage shares for the various HFC types
4. Specific filling loss

These data are obtained via surveys of experts.

The following information is required for determination of use emissions per year:

1. Domestic sales of cans (standardised to 750 ml; since can sizes range from 300-750 ml)
2. HFC content per can, in grams
3. Applicable percentage shares for the two blowing agents 134a and 152a

These data are provided by the manufacturers themselves.

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. Domestic new HFC consumption is calculated from the total volume of XPS insulation material (in m^3) produced per year, with the two HFCs (134a and 152a), and from the amount of HFC required to produce one cubic metre of XPS foam. In the case of HFC-134a, 3.2 kg are required, while with 152a 3.0 kg are required.

Collection and recovery trials have been conducted, but to date no relevant systems have been implemented, for both technical and economic reasons.

Use emissions are calculated from the average amount of HFCs in XPS insulating foams in domestic service. This amount increases annually solely through new addition of insulation boards containing 134a. Given a product lifetime of 50 years, removals from products in service do not yet play any significant role. The new HFC additions are not equivalent to annual new consumption, minus production emissions. The reason for this is that, as a result of foreign trade, especially exports of 134a-based XPS, only 25 % (the complementary value to the export rate) of the HFC-134a contained in products amount to new additions to domestic HFC stocks.

Disposal emissions 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. Its $EF_{production}$ is determined empirically; in 2001 and 2004, it amounted to 27 % (= 0.27).

The two $EF_{production}$ were reported by the Fachverband Polystyrol-Extruderschaumstoff e.V. (FPX; extruded polystyrene-foam association) and the European Extruded Polystyrene Insulation Board Association (EXIBA). A representative of the FPX 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 data required for emissions calculation, such as total produced volumes of XPS insulation materials (in m^3), loss rates in production and the foreign-trade balance for HFC-134a-based insulation boards, have been provided by the German and European industry associations (FPX and EXIBA).

4.6.2.4 Uncertainties and time-series consistency (2.F.2)

Systematic quantification of the uncertainties for 2.F.2 was begun for report year 2005 and will be completed for report year 2007.

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 light of the product diversity expected, it will become more difficult to obtain a good market overview in future, however.

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 industry association has carried out research to determine production of XPS (AR) and consumption of the two HFCs 152a and 134a (AR). Since only three manufacturers use HFC for XPS blowing, there is little reason to doubt the reliability of the activity data. This also applies to the export rate and the HFC production emissions determined for use of HFC-134a.

The production emissions in use of HFC-152a, 100 %, do not agree with the existing IPCC estimates. Nonetheless, the industry association considers them to be realistic.

The value for the emissions rate from current stocks, as determined by a laboratory study, will be used as long as no reliable measurements with insulation boards in actual service have been carried out; such measurements could be considered more conclusive than laboratory values.

4.6.2.5 Source-specific recalculations (2.F.2)

The implied emission factors were recalculated, since the pertinent calculated factors used in the previous submission were too low, due to a software error.

4.6.2.6 Planned improvements (source-specific) (2.F.2)

New possibilities for data collection are currently being evaluated. A first assessment of these possibilities has shown that it may be possible to obtain the AR for "new domestic consumption" via the Environmental Statistics Act (UStatG). At present, it is unclear whether data obtained in this manner will be available on time for reporting and whether it will be possible to take account of all HFC users relative to PU-foam production. Furthermore, it has emerged that existing statistics cannot be used to survey imports and exports of foams – and, thus, to survey domestic sales – since these statistics do not differentiate between the various relevant blowing agents. An effort is being made to find other solutions in this area.

In connection with PUR foams, additional verification is needed with regard to the average HFC quantity. Co-operation with manufacturers has not been possible to date.

The option of a monitoring system for XPS hard-foam products, with formalised data transmission, is currently being discussed with the manufacturers and industry associations. This process is just getting underway. And existing statistics cannot be used to survey imports and exports of foams – and, thus, to survey domestic sales – since these statistics do not differentiate between the various relevant blowing agents.

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 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 case of a fire, and trial floodings in Germany (by analogy to Tier 2). As a result, not all of the market is covered, since there is another seller. That seller has only a very small market share, however. That seller is taken into account by adding a small quantity to the market leader's reported emissions figures.

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)

Systematic quantification of the uncertainties for sub- source category fire extinguishing agents was begun for report year 2005 and will be completed for report year 2007.

4.6.3.4 Source-specific recalculations (2.F.3)

The implied emission factors were recalculated, since the pertinent calculated factors used in the previous submission were too low, due to a software error.

4.6.3.5 Planned improvements (source-specific) (2.F.3)

No improvements are planned at present.

4.6.4 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 producer determination of filling emissions. These amount to about 1 %, with respect to new consumption for filling. This translates to about 0.15 g per 10 ml inhaler.

In agreement with IPCC specifications (IPCC, 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 comparable, 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.

4.6.4.2.3 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%.

Systematic quantification of the uncertainties was begun for report year 2005 and will be completed for report year 2007.

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.

4.6.4.2.4 Source-specific recalculations (2.F.4 all)

The implied emission factors were recalculated, since the pertinent calculated factors used in the previous submission were too low, due to a software error.

4.6.4.2.5 Planned improvements (source-specific) (2.F.4 all)

Improvements have been initiated in collaboration with the industry association. In addition, the possibility of using additional data sources is being reviewed. A first assessment of such data sources has shown that it may be possible to obtain the AR for "new consumption" via the Environmental Statistics Act (UStatG). And existing statistics cannot be used to survey imports and exports – and, thus, to survey domestic sales – since these statistics do not differentiate between the various relevant propellant gases.

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 IPCC-GPG (2000, Equation 3.36).

Emission factors

No emission factor for production can be defined. In each case, use emissions are assumed to be completed within 2 years.

Activity data

The emissions data are based on sales data of the authorised vendor, and they apply solely to HFC-4310mee. Since the data are confidential, they are summed with other-aerosol data for HFC-134a.

4.6.5.3 Uncertainties and time-series consistency (2.F.5)

Systematic quantification of the uncertainties for the sub- source category Solvents was begun for report year 2005 and will be completed for report year 2007.

4.6.5.4 Source-specific recalculations (2.F.5)

The implied emission factors were recalculated, since the pertinent calculated factors used in the previous submission were too low, due to a software error.

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

Relable emissions data are available for 1990 and 1995. Lineare interpolation was carried out for the years 1991 to 1994.

Until the 2000 report year, emissions data was 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, good 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)

The implied emission factors were recalculated, since the pertinent calculated factors used in the previous submission were too low, due to a software error.

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, obligated itself to reduce 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.

The pertinent emissions-reduction measures and reporting are described in Schwarz, W. et al (2006) "The German Monitoring System for SF_6 Emissions from Equipment for Electricity Transmission and Distribution".

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.

Use emissions:

Ongoing emissions from stocks are tied to 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 before 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.

1. 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).
2. In the area of high-voltage systems, stocks and emissions are determined via direct surveys of the some 100 operators. These operators are surveyed directly with regard to their current stocks of SF_6 in operating equipment (GIS, power switches, outdoor converters) and to their annual refilling (for operating equipment) to compensate for emissions.
3. 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, and deducting decommissioned units, to/from the previous year's stock level. To date, for reasons of practicality, the resulting calculatory, marginal emissions reductions from 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 middle 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 obligation, 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 obligation jointly determine quantities of decommissioned units.

The following Table shows the 2006 inventory data, broken down by sub- source categories, along with pertinent explanations. The total figure 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.

Table 73: Source category 2.F.8 – electrical operating equipment for energy transmission and distribution, with sub- source categories – 2006 inventory

Source category 2.F8 – electrical operating equipment for energy transmission and distribution, with sub-source categories – 2006 inventory	Activity data			Emissions			
	Annual cons-umption, production	Stocks	Decom-missioned	Production	Operation	Subse-quent use	Total
	(Tonnes of SF_6)						
Electrical operating equipment for energy transmission and distribution 2.F.8 (Total), including:	599.4	1679.0	1.462	18.198	8.449	0.026	26.67
MV switching systems and equipment (in hermetically sealed pressurised systems)*	146.4	631.8	0.295	1.305	0.632	0.004	1.94
HV switching systems and equipment (in hermetically sealed pressurised systems)**	394.6	920.8	1.167	4.547	7.435	0.021	12.00
Subtotal: HV and MV switching systems and equipment	541.0	1552.6	1.462	5.852	8.067	0.026	13.94
Other electrical operating equipment ***	58.4	126.4	IE	12.346	0.382	IE	12.73

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 measuring converters (all emissions categories) + gas-insulated lines (GIL) (all emissions categories) + high-voltage fairleads (only production emissions) + medium-voltage cast-resin measuring converters (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, less well-sealed older-model systems.

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 middle-voltage sector may be considered reliable for stocks in recent years. Since the Association of German Network Operators (VDN) has always, in its surveys, included queries concerning refills of middle-voltage systems, samples for checking can now be taken: VDN documents show SF_6 losses of only 0.06 % for medium-voltage switching systems (circuit breakers) in the years 1998/1999.

4.6.7.4 Source-specific recalculations (2.F.7)

Last year, doubly high activity rates and emissions were reported for the area of "Electrical operating equipment" for the period from 1990 to 2005. This was the result of a software error that was then corrected for report year 2006. The emissions from production and use were recalculated for 2005 by the German Electrical and Electronic Manufacturers' Association (ZVEI). All other data are also subject to ongoing recalculation; frequently, additional companies report, and additional small areas of application are taken into account.

Figures from the relevant associations were reviewed by an external expert and then entered into the CSE database.

The implied emission factors were recalculated, since the pertinent calculated factors used in the previous submission were too low, due to a software error.

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 comprises applications in insulating glass windows (2.F.8a Insulating glass windows), automobile tyres (2.F.8.b Automobile tyres), sport shoes (2.F.8.c Sport shoes), as trace gases (2.F.8.d Trace gases) and in radar systems (2.F.8 Radar systems).

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. Emphasis on thermal insulation – e.g. via 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 over 150 companies. The windows are filled with gas as is necessary. Exports of assembled windows play no significant role.

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 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, 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 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 rates

The new annual consumption is determined via top-down survey (domestic sales by the gas industry). Practical considerations – the large number of manufacturers (nearly 400) – preclude any double-checking via bottom-up survey (manufacturers' purchase data).

4.6.8.2 Automobile tyres (2.F.8.b)

4.6.8.2.1 Source-category description (2.F.8.b)

In the past, 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. 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 rates

Annual sales are determined via surveys of gas suppliers, regarding their domestic sales to tyre dealers and automobile service centres.

4.6.8.3 Sport shoes (2.F.8.c)

4.6.8.3.1 Source-category description (2.F.8.c)

SF_6 has been 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. Since then, PFC-218 has been used, in decreasing amounts. Today, nitrogen is usually used for this purpose. In Germany, no sport shoes are now manufactured that have SF_6 in their soles.

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 and data for 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 have been 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 gases (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 rates

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. The pertinent estimates indicate that the quantities used vary only slightly.

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.

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 were based on estimates that were 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.

New domestic consumption, stocks and emissions are reported under CRF 2.G, together with data for use on sport-shoe soles and for production of SF_6, since these data are confidential.

4.6.8.6 Uncertainties and time-series consistency (2.F.8 alle)

For insulating glass windows, the data for annual new consumption, which is based on commercial sales data, may be considered sufficiently reliable and complete. 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.

4.6.8.7 Source-specific recalculations (2.F.8)

The implied emission factors were recalculated, since the pertinent calculated factors used in the previous submission were too low, due to a software error.

4.6.8.8 Planned improvements (source-specific) (2.F.8)

No improvements are planned at present.

4.6.8.9 Source-specific quality assurance / control and verification (2.F all)

In the 2005 report year, several procedures for calculating HFCs were reviewed. As a result of correction of doubly counted disposal emissions, the total emissions for the years 1995-2004 are lower than the corresponding values reported in the previous year.

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 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[31], production and sales figures[32], 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.

Plausibility checking of emissions from use in insulating glass windows was carried out in 2001, with the help of a calculation model. That check showed excellent agreement between SF_6 consumption as surveyed and consumption as calculated.

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) and from use in AWACS maintenance (2.F.8 Other – AWACS maintenance) are reported under 2.G.

No other sources of greenhouse-gas emissions are known.

[31] Surveys pursuant to Art. 11 of the Environmental Statistics Act (UStatG).

[32] 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. The inventories do not take account of chemical processes in the atmosphere by which released carbon (for example, in NMVOC) is transformed into CO_2.

Source category 3 Solvents and other product use is subdivided into the categories listed in Figure 47. In the CSE, "Other" (3.D) includes emissions of laughing gas (cf. Chapter 5.2), emissions from SCR systems and the above-detailed other solvent uses that cannot be allocated to source categories 3A through 3C.

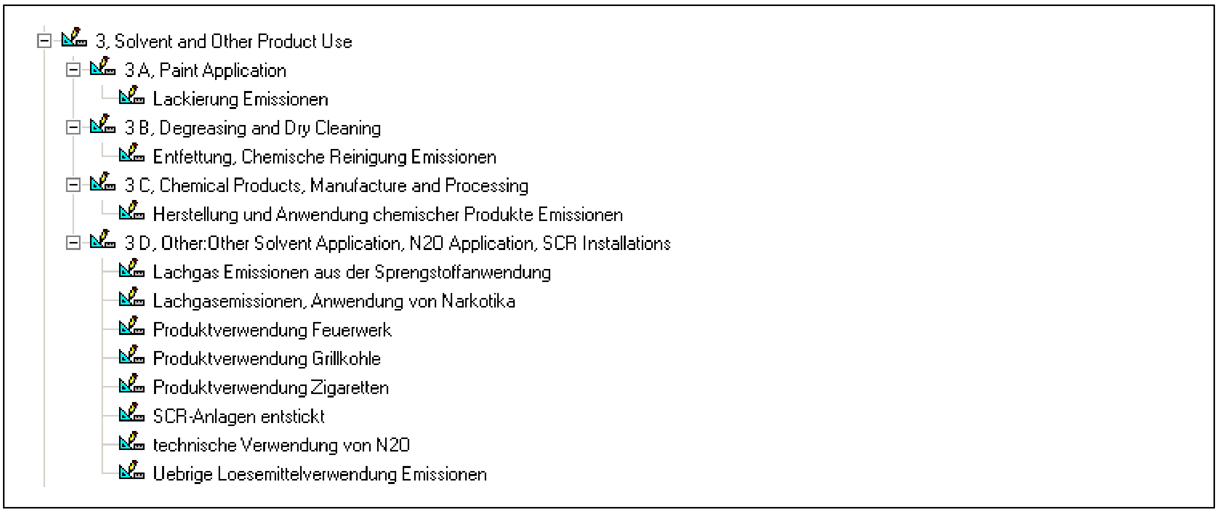


Figure 47: Structural allocation, source category 3 Solvents and other product use

N_2O emissions from source category 3.D Other are reported separately from the other parts of Chapter 5.2, since 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. This research project considered the various pertinent potential emissions sources (including explosives production), as listed in the IPCC Good Practice Guidance (2000), and it will specify methods, prepare documentation, carry out relevant recalculations and make 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 category by level (l) / trend (t)		**Gas (key category)**	**1990 – contribution to total emissions**	**2006 – 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)	NE	NO	NO	NO	NO	CS	NO	NO	CS	NO
EF uncertainties in %										
Distribution of uncertainties										
Method for 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 category.

The NMVOC emissions released through use of solvents and solvent-containing products all belong to sub-categories of this source category.

The four reporting categories 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[33] .

Category 3D "other" includes the following applications and activities:

- Treatment of glass and stone wool
- Printing industry (printing applications)
- Extraction of oils and fats
- Use of glues and adhesives
- Use of wood preservatives
- Undersealing and wax treatments for automobiles
- Household use of solvents (not including paints and lacquers)
- Automobile-wax stripping
- Manufacturing of pharmaceutical products
- Household use of pharmaceutical products
- Other

"NMVOC" is defined in keeping with the VOC definition found in the EC solvents directive[34]. For purposes of the definition of solvents, the term "solvent use" is also defined in keeping with the EC solvents directive[35].It is important to note that some volatile organic compounds are used both as solvents and as chemical reactants – for example, toluene, which is used as a solvent in lacquers and glues and as a reactant for production of toluenediisocyanate

33 In the present area, this involves "SNAP Level 3" detailing.

34 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.

35 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.

(TDI), and methyl ethyl ketone (butanone), which is used as a solvent in printing inks and as a base material for synthesis of methyl ethyl ketone peroxide. Consequently, VOC (either substances or fractions of substances or products) used as chemical reaction components are not included in this source category.

Delimitation of this source category as outlined above takes a highly diverse range of emissions-causing processes into account. The factors considered with regard to such processes include:

- Concentrations and volatility of VOC used.
  The relevant spectrum includes use of volatile individual substances as solvents – for example, in cleansing; use of products with solvent mixtures – for example, in paints and lacquers; and applications in which only small parts of mixtures used (also) have solvent properties (as is the case, for example, in polystyrene-foam production).
- The great differences in emissions conditions.
- Solvent uses can be open to the environment – as is the case in use of cosmetics – or largely closed to the environment – as in extraction of essential oils or cleaning in chemical dry-cleaning systems.

5.1.2 Methodological aspects (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.

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. These efforts lead to the NMVOC emissions from solvent use shown in Table 74.

Table 74: Current NMVOC emissions from solvent use

Greenhouse-gas source categories	NMVOC [Gg]
Sum for solvent and other product use	**723.806**
A. Paint application	304.857
B. Degreasing and dry cleaning	44.963
C. Production and use of chemical products	49.368
D. Other	324.618

Not all of the necessary basic statistical data required for calculation of NMVOC emissions for the most current relevant year in 2003 and 2004 are available; as a result, the data determined for the previous year are used as a basis for a forecast for the current report. The forecast for NMVOC emissions from solvent use for the relevant most current year is calculated on the basis of specific activity trends. As soon as the relevant basic statistical data are available for the relevant most current year, in their final form, the inventory data for NMVOC emissions from solvent use 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.

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). Table 75 shows the thus-determined error ranges for the report categories.

Table 75: Experts' assessment of uncertainties (Tier 1)

Greenhouse-gas source categories	Uncertainties	
Sum for solvent and other product use	**+ 23.61 %**	**- 15.50 %**
A. Paint application	+ 6.29 %	- 4.83 %
B. Degreasing and dry cleaning	+ 72.74 %	- 51.29 %
C. Production and use of chemical products	+ 10.96 %	- 11.93 %
D. Other	+ 42.40 %	- 22.63 %

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 been carried out.

The NMVOC-emissions data for 2001 and 2002, as used in the emissions inventory, was obtained via a research project and was 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)

No recalculations are required.

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 category by level (l) / trend (t)		**Gas (key category)**	**1990 – contribution to total emissions**	**2006 – 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 as anaesthetics						CS				
EF uncertainties in %										
Distribution of uncertainties						N				
Method for 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 medical 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 anaesthetic 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.

N_2O-emissions trends are summarised in Table 76. 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 substance was used for domestic consumption. Via the per-capita emissions calculated from this for the former GDR, and assuming identical conditions, N_2O emissions of 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. Due to a lack of other data, a linear reduction of N_2O use in this sector is assumed between 1990 and 2001 (cf. Table 76).

Table 76: Time-series trend for N_2O emissions in medical uses in the Federal Republic of Germany

Application	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Medicine	N_2O [t/a]	6200	*5932*	*5664*	*5395*	*5127*	*4859*	*4591*	*4323*	*4055*	*3786*
Application	**Units**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Medicine	N_2O [t/a]	*3518*	*3250*	*3250*	*3250*	*3250*	*3250*	*3250*			

The numbers in italics are interpolated and extrapolated values

The reduction in N_2O use in this period results from acceptance of the "low-flow method"[36] 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 have remained at a constant level 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. The so-estimated values for the period as of 2002, and the values calculated via linear interpolation for the period between 1990 and 2001, are shown in Table 76 in *italics*.

The "worst case" is shown in Figure 48 as a solid line, while the linearised trend appears as a dotted line for the years 1990 to 2005.

[36] 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).

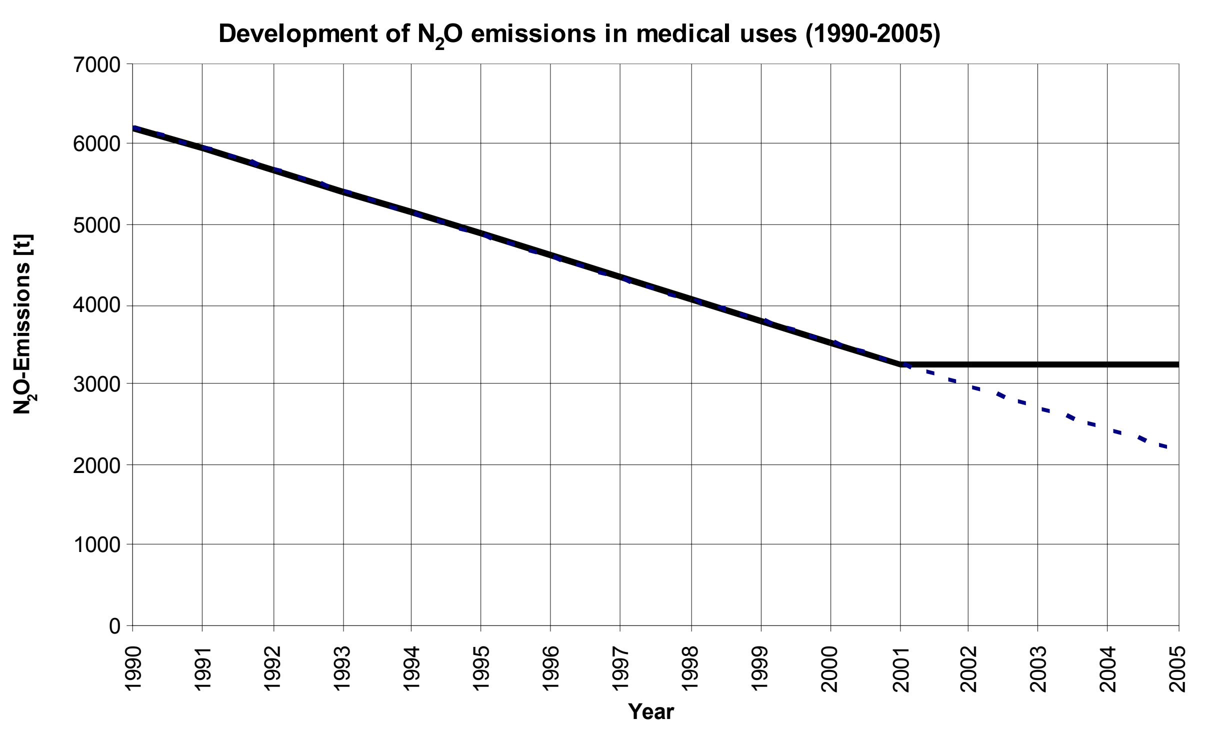


Figure 48: Development of N_2O emissions in medical uses (1990-2005)

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[37] was informed, however, that the N_2O amounts involved are small (less than 5 %) and thus are insignificant.

N_2O in technical applications

A wide range of different chemicals and gases is used in semiconductor production. Argon, ultra-pure oxygen, hydrogen, ultra-pure helium and nitrogen account for the lion's share of the gases used. Special process gases, such as 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).

[37] Personal communication from the Industriegaseverband e.V. (IGV) industrial-gas association

In automotive technology, nitrous oxide is used to improve combustion in gasoline / petrol engines, via so-called "laughing-gas injection". This "tuning" tactic can quickly increase engine performance. In Germany, relevant systems are not certified by the TÜV technical certification agency. They are thus illegal and are not considered in the present context.

For the technical-applications sector, there is also a lack of any statistics that could be used to estimate N_2O emissions. At the same time, the amount of N_2O in question is considerably smaller than the relevant N_2O-emissions amounts from medical applications. As a result, this sector plays a minor role in the area of "product use"[38].

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 %[39]) and food-technology applications (less than 5 %[40]) . 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.

Table 77 shows the time series trend for N_2O emissions for medical and "other" applications, and their sums, for the period 1990 through 2005. Here, "other" applications is a combination of food-technology applications and technical applications. The N_2O-applications distribution in 2001 is 90 % for medical applications and 10 % for other 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.

Table 77 Time-series development for N_2O emissions, with assumed constant N_2O emissions in the "other" sector

Area	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Medicine	N_2O [t/a]	6200	*5932*	*5664*	*5395*	*5127*	*4859*	*4591*	*4323*	*4055*	*3786*
Other	N_2O [t/a]	361	361	361	361	361	361	361	361	361	361
Total	N_2O [t/a]	6561	6293	6025	5757	5488	5220	4952	4684	4416	4147
Area	**Units**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Medicine	N_2O [t/a]	*3518*	3250	*3250*	*3250*	*3250*	*3250*	*3250*			
Other	N_2O [t/a]	361	361	*361*	*361*	*361*	*361*	*361*			
Total	N_2O [t/a]	3879	3611	*3611*	*3611*	*3611*	*3611*	*3611*			

Numbers in italics: Interpolated and extrapolated values

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.

5.2.1.2 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

[38] Written communication from the Industriegaseverband e.V. (IGV) industrial-gas association

[39] Personal communication from the Industriegaseverband e.V. (IGV) industrial-gas association

[40] Personal communication from the Industriegaseverband e.V. (IGV) industrial-gas association

- Constant level, or linear reduction of N_2O emissions from 2002 to 2004

From these figures, values for maximum and minimum N_2O emissions can be estimated. The reference figure for the uncertainty calculation is defined as 3250 t/a. In the process, the aforementioned distribution is retained (medical applications in 2001 at 90 %; constant N_2O level for the "other" sector between 1990 and 2005). These figures lead to the following theoretically possible combinations:

1. N_2O emissions in 2001 3,500 t/a;
   constant level for N_2O emissions from 2002 through 2004
2. N_2O emissions in 2001 3,500 t/a;
   linear reduction of N_2O emissions from 2002 through 2004
3. N_2O emissions in 2001 3,000 t/a;
   constant level for N_2O emissions from 2002 through 2004
4. N_2O emissions in 2001 3,000 t/a;
   linear reduction of N_2O emissions from 2002 through 2004

Consequently, 1) shows the maximum possible N_2O amount, while 4) shows the minimum possible N_2O amount. Table 78 shows the maximum emission level (case 1) for the period 1990 through 2005, while Table 79 shows the minimum emissions level (case 4) for the same period. Here as well, the values for 1991 through 2000 are calculated via linear interpolation, while the values for the period 2002 through 2004 are obtained via extrapolation.

Table 78 Time-series development for N_2O emissions in the "product use" sector, with the assumption that 3500 t/a was used in medical applications in 2001 (maximum emissions levels)

Area	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Medicine	N_2O [t/a]	6200	5955	5709	5464	5218	4973	4727	4482	4236	3991	3745	3500	3500	3500	3500
Other	N_2O [t/a]	389	389	389	389	389	389	389	389	389	389	389	389	389	389	389
Total	N_2O [t/a]	6589	6343	6098	5853	5607	5362	5116	4871	4625	4380	4134	3889	3889	3889	3889

Table 79 Time-series development for N_2O emissions in the "product use" sector, with the assumption that 3,000 t/a was used in medical applications in 2001 (maximum emissions levels)

Area	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Medicine	N_2O [t/a]	6200	5909	5618	5327	5036	4745	4455	4164	3873	3582	3291	3000	2709	2418	2127
Other	N_2O [t/a]	333	333	333	333	333	333	333	333	333	333	333	333	333	333	333
Total	N_2O [t/a]	6533	6242	5952	5661	5370	5079	4788	4497	4206	3915	3624	3333	3042	2752	2461

From these figures, the uncertainties can be summarised as follows: Between 1990 and 2001, a symmetric uncertainty can be seen in both directions (U_{min} and U_{max}). From 1990 to 2001, U_{max} shows a linear increase in the uncertainty that reaches a level of 8 %. As of 2001, this value remains constant. U_{min} also shows a linear progression between 1990 and 2001. Its increase as of 2001 is much larger, however, reaching an uncertainty level of –40 % in 2005.

With these results, the time series can be considered to show a normal distribution (distribution type).

Table 80 Uncertainties for development of N_2O time series in the "product use" sector

Uncertainty	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
U max [%]	0 %	1 %	1%	2%	2%	3%	3%	4%	5%	6%	7%	8%	8%	8%	8%	8%
U min [%]	0 %	-1 %	-1%	-2%	-2%	-3%	-3%	-4%	-5%	-6%	-7%	-8%	-16%	-24%	-32%	-40%

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.

5.2.1.3 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.

5.2.1.4 Source-specific recalculations (3.D.1)

No recalculations are required.

5.2.1.5 Source-specific planned improvements (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 Explosives (3.D)

5.2.2.1 Source category description (3.D)

CRF 3.D					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 – contribution to total emissions**	**2006 – 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 for 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[41], 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[42]. 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[43], for which analyses have been carried out that support relevant estimates. The following result has been obtained: upon detonation, amatoles and ammonites form about 0.1 mole N_2O per mole of ammonium nitrate (AN).

[41] Amatol x/y : military explosives. pourable mixtures, i.a. of x % TNT and y % ammonium nitrate

[42] Personal communication: Federal Office for Material Research and Testing (BAM).

[43] Ammonite: Composition: 70-88 % ammonium nitrate, with 5-20 % nitroaromates, 1-6 % vegetable flour and, in some cases, 4 %

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[44] , 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).

Table 81 Time-series trend for N_2O emissions from explosives use

Area	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Explosives	[t/a]	51800	51800	51800	51800	51800	51800	51800	51800	51800	51800
N_2O 5%	[t/a]	176	176	176	176	176	176	176	176	176	176
Area		**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Explosives	[t/a]	51800	51800	51800	51800	51800	51800	51800			
N_2O 5%	[t/a]	176	176	176	176	176	176	176			

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:

Table 82 Time-series trend for N_2O emission factors from explosives use

Area	Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Explosives	[Kg/t]	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4
Area	**Units**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Explosives	[Kg/t]	3,4	3,4	3,4	3,4	3,4	3,4	3,4			

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 % (cf. Table 83). A normal distribution is assumed. This basis yields the following uncertainties for the above-determined time-series trend (Table 84).

[44] 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.

Table 83 Time-series trend for N_2O emissions from explosives use, 1990 to 2005 (3 %, 5 %, 7 %)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
N_2O 7% [t/a]	247	247	247	247	247	247	247	247	247	247	247	247	247	247	247	247
N_2O 5% [t/a]	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176	176
N_2O 3% [t/a]	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106	106

Table 84 Uncertainty for time-series trend for N_2O emissions from explosives use, 1990 to 2005

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Umax [%]	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
Umin [%]	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%	-40%

5.2.2.4 Source-specific QA/QC 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 has 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.

5.2.2.6 Source-specific planned improvements (3.D)

No improvements are planned at present.

6 AGRICULTURE (CRF SECTOR 4)

For the 2008 agricultural emissions inventory, 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 has acted on SBSTA's suggestion to gather experience with the IPCC Guidelines 2006 (cf. FCCC/SBSTA/2007/4, paragraph 56). Germany's approach in this matter was expressly approved by Expert Review Teams on the occasion of Initial Reviews in June 2007. The results obtained via this approach diverge considerably from those obtained with earlier methods. Because their pertinent procedures and results thus lack comparability, as a temporary measure the data for 2006 will be carried forward, in the 2008 agricultural emissions inventory, on the basis of last year's report. Calculatory implementation of the changes proposed by ERT is being carried out, for the time being, in the "Work report for the NIR 2008" ("Arbeitsbericht für den NIR 2008"). Following further review, the changes will be described in detail in the NIR 2009; plans call for the NIR 2009 to be produced solely 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; IPCC Guidelines: IPCC, 1996b; 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.D.

Origins of the activity data

Activity data are taken from official German agricultural statistics, in keeping with availability. Every other year, results of the complete animal census for German districts are available. For the years in between, only animal head counts for the various Länder are available. The animal censuses cover all cattle, pigs, 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 2005 animal census (the most recent) were used.

German agricultural statistics do not include herd-size figures for goats, mules and asses, fur animals and buffalo. Some indications as to the sizes of the relevant herds are available, however:

The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) estimates numbers of goats kept. These figures are used for 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, for the year 2000 (as one instance); in some cases, the figures are 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 herd-size figures used for calves and weaners diverge from the relevant aggregated figures in the official statistics.

Complete area-use data is gathered in Germany every four years. In the inventories, the area figures are used in the 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 (2005) 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 were 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. (2007).

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 (see Table 85).

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 no method for such calculation is known (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. (2007).

Figure 49: Structural allocation, 4.A Enteric fermentation

6.1.1 Source category description (4.A)

CRF 4.A					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 – contribution to total emissions**	**2006 – contribution to total emissions**	**Trend**
Enteric fermentation, dairy cattle (CRF 4.A.1.a)	l / -	CH_4	0,99 %	0,96 %	falling
Enteric fermentation, non-dairy cattle (CRF 4.A.1.b)	l / t	CH_4	0.78 %	0.66 %	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 for 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 category for CH_4 emissions in terms of level; the sub- source category "other cattle" (4.A.1.b) is a key category 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, bulls, heifers, 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 85.

In Germany, almost all CH_4 emissions from enteric fermentation come from keeping of cattle (2005: 93 %). The pertinent shares from keeping of swine are small (2005: 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 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 rural districts. Aggregated data on CH_4 emissions (national and at the Länder level) is provided by LÜTTICH et al, 2007.

Table 85: 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}	1.15	1.01	0.99	0.99	0.99	0.99	0.98	0.95	0.94	0.95
[Tg a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
E_{CH4}	0.93	0.94	0.91	0.90	0.88	0.87	0.87			

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

IPCC-GPG (IPCC, 2000) 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-independent 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

$$EF_{\mathrm{i}} = \frac{GE_{\mathrm{i}} \cdot x_{\mathrm{m}} \cdot \alpha}{\eta_{\mathrm{CH4}}}$$

where
- EF_i Emission factor for each sub-category i [kg $space^{-1}$ a^{-1} CH_4]
- GE_i Gross energy intake of the sub-category i [MJ $space^{-1}$ 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 using the *Detailed characterisation of livestock herds* and the methane-conversion rate from the IPCC-GPG (2000: Table 4-8) and from national data. The unit "space" refers to per-animal spaces actually occupied for production. With it, emission factors and annual emissions can be calculated independently of the duration for which animals are kept, time periods which can be either shorter or longer than one year.

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. The relevant values are given in IPCC (1996b). National values were used for calves.

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 $space^{-1}$ a^{-1}]
	n_i	Population size for each sub-category i [number of spaces]
	β	Conversion factor for weight units [10^{-6} Gg kg^{-1}]

In analysis of key categories in agriculture, CH_4 emissions from dairy cows and other cattle in category 4 A, "Enteric fermentation", were identified as key categories. 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[45], 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 stocks

The total animal population is divided into main and sub-categories for which activity data and emission factors are available. Disaggregation is carried out only where emission factors differ significantly. The following table compares the German sub-categories and the IPCC proposals.

[45] VS (volatile solids): the easily convertible carbon fractions in excrement

Table 86 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 additions	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	Sows	Pregnant sows Farrowing sows	Sows (including suckling pigs)
	Boars	---	Boars
	Young animals	Suckling pigs Growing young animals Slaughter-ready animals	Weaners, Fattening pigs
Sheep	Ewes	Pregnant ewes Dairy sheep	Sheep, ewes, lambs
	Sheep >1 year	---	
	Young animals	Male animals, castrated animals, female animals	
Other	Horses, poultry, goats, asses, mules, camels, fur animals, etc.	---	Horses (heavy horses and light horses), poultry (laying hens, broilers and hens), pullets, geese, ducks, turkeys), goats, fur animals, buffalo

Columns 1 and 2 pursuant to IPCC (2000)

6.1.2.1.1 Numbers of animals

The primary basis for the activity data consists of the animal censuses for the years 1990, 1992, 1994, 1996, 1999, 2001, 2003 and 2005. The figures obtained represent populations, i.e. animal spaces actually used for production. The animal population figures were not interpolated for description of the years without animal population figures; in each case, the figures were carried forward (LÜTTICH et al., 2007). 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 (with 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 supplementation and rejuvenation or for slaughter, depending on the market situation. Cattle used to supplement and rejuvenate herds and animals 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., 2007).

6.1.2.1.6 Sheep

The applicable numbers of sheep had to be corrected (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 the Tier -1 approach. 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 is not available. Detailed data on animal herds (national and at the Länder level), as well as additional information, is provided by LÜTTICH et al (2007).

6.1.2.2 Calculation of CH_4 emissions from keeping of dairy cows

The emission factor is determined by means of the approach proposed in IPCC (1996b). 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. The energy for feed intake can be derived from time spent grazing (resolution: Länder and years). Milk-yield data is available for (nearly) every district and every year. Data on milk-fat concentrations is taken from reports of the relevant associations (resolution: Länder and years). For dairy cows, it is assumed that weight gains during this period of the cows' lives can be neglected. Digestibility has been formulated as a function of yield, under a typical feeding framework (national data; resolution: districts and years).

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 2005, the corresponding value is 18.5 kg $space^{-1}$ d^{-1}. The pertinent difference is significant. A compilation of all relevant information is provided by LÜTTICH et al. (2007).

On a national average, the CH_4 emission factors increased from 94.8 kg $space^{-1}$ a^{-1} CH_4 (1990) to 113.3 kg $space^{-1}$ a^{-1} CH_4 (2005). A detailed overview of the emission factors used is found in LÜTTICH et al. (2007). The manner in which the factors were obtained is described in DÄMMGEN et al., 2007).

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 (1996b) 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, see LÜTTICH et al. (2007); for details on derivation of the emission factors, see DÄMMGEN et al. (2007).

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 2005 resulted:

Table 87 CH_4 emission factors IEF_{CH4} from keeping of cattle, with the exception of dairy cows (enteric fermentation) (2005)

Sub-category	EF_{CH4} [kg $place^{-1}$ a^{-1} CH_4]
Calves	3.8
Heifers	33.5
Bulls	52.2
Suckling cows	56.7
Stud bulls (mature males)	71.6
Average	37.2
IPCC default	48

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 is determined by the 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. That data was obtained from discussions with experts. At the end of the process, then, complete national data was available. These data are provided in the overview in LÜTTICH et al. (2007), while the calculations of numbers of animals, and the manner in which pertinent methods were derived or adjusted, are presented in DÄMMGEN et al. (2007).

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 2005 are shown in the following table.

Table 88 CH_4 emission factors IEF_{CH4} from keeping of swine (enteric fermentation) (2005)

Sub-category	IEF_{CH4} [kg place^{-1} a^{-1} CH_4]
Sows	1.8
Weaners	0.39
Fattening pigs	1.45
Breeding boars	1.48
Average	1.28
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 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 space^{-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 (1996b: Chapter 4) were used. For light horses, an $EF_{CH4,\,po}$ = 12 kg space^{-1} a^{-1} CH_4 was determined:

Table 89 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 (1996b, Chapter 4) [kg space^{-1} a^{-1} CH_4]		*IEF* after application of national data records [kg space^{-1} a^{-1} CH_4]
Sheep	8	(Table 4-3)	
Goats	5	(Table 4-3)	
Heavy horses	18	(Table 4-3)	16.4
Buffalo	55	(Table 4-3)	

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 herd sizes – considerably, in some cases. Impacts were seen especially in numbers of horses and sheep. Therefore, correction factors were derived, to permit standardised description of the time series. 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, 1996b) and the actual feed-ration composition, especially that for cattle.

6.1.4 Source-specific quality assurance / control and verification (4.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 not been carried out completely.

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 lies within the middle section of the range.

Table 90 Methane emissions from enteric fermentation in dairy cows, in various countries – a comparison of Implied Emission Factors (IEF) [46]

	IEF_{CH_4}	Milk yield	Weight	Pregnant-cow percentage
	[kg space^{-1} a^{-1} CH_4]	kg space^{-1} d^{-1}	[kg animal^{-1}]	[%]
Austria	115.0	15.9	700	90
Belgium	103.3		580	
Czech Republic	110.4	19.3		90
Denmark	126.2	22.2	575	
Germany	*113.3*	*18.0*	*590*	*78*
France	103.6			
Netherlands	Other source categories for cattle			
Poland	90.0			
Switzerland	109.3			
United Kingdom	101.8	18.1	579	

Source: UNFCCC 2006, Table 4.A

For the first time, 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.

6.1.5 Source-specific recalculations (4.A)

In most cases, the preliminary animal figures (animal head counts) for 2004 have been replaced with final figures.

Census-taking at the district level, along with the availability of land-use data for 2003, made it possible to recalculate emission factors for 2003 and subsequent years. The relevant changes with regard to the last inventory are slight (cf. Table 91 to Table 93).

The description of ration composition for bulls (mature males) was improved. N-reduced feeding of fattening pigs in the Weser-Ems region was taken into account. Incorporation of that factor also changed the figures for feed energy content.

[46] IEF: Emission factor calculated from emissions and numbers of dairy cows. Figures for Germany for 2004; data of other countries for 2003.

Table 91 Comparison of the mean CH_4 emission factors used in the NIR 2006 and NIR 2008 for animal husbandry (enteric fermentation); here, dairy cows.

[kg space^{-1} a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2006	94.8	95.7	99.1	101.6	101.3	102.3	103.3	103.3	104.9	106.6
NIR 2008	94.8	95.7	99.1	101.6	101.3	102.3	103.3	103.3	104.9	106.6
[kg space^{-1} a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006			
NIR 2006	108.1	110.1	109.9	111.6	111.7					
NIR 2008	108.1	110.1	109.9	111.5	111.8	113.3	113.3			

Table 92 Comparison of the mean CH_4 emission factors used in the NIR 2006 and NIR 2008 for animal husbandry (enteric fermentation); here, other cattle.

[kg space^{-1} a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2006	37.5	37.7	38.1	38.4	38.5	38.3	38.1	38.0	38.2	38.4
NIR 2008	36.2	36.0	36.7	36.9	37.1	36.9	36.7	36.5	36.9	37.0
[kg space^{-1} a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006			
NIR 2006	38.8	39.2	38.9	38.8	38.5					
NIR 2008	37.2	37.5	37.2	37.4	37.2	37.2	37.2			

Table 93 Comparison of the mean CH_4 emission factors used in the NIR 2006 and NIR 2008 for animal husbandry (enteric fermentation); here, swine.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2006	1.19	1.17	1.19	1.20	1.22	1.23	1.24	1.25	1.26	1.26
NIR 2008	1.19	1.18	1.19	1.21	1.23	1.24	1.25	1.26	1.27	1.27
	2000	2001	2002	2003	2004	2005	2006			
NIR 2006	1.26	1.26	1.27	1.27	1.27					
NIR 2008	1.27	1.27	1.27	1.28	1.28	1.28	1.28			

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.

Overall, the resulting CH_4 emissions from enteric fermentation, for the past few years, are now considerably different. The relevant changes are shown in Table 94.

Table 94 Comparison of the total CH_4 emissions for animal husbandry (enteric fermentation) as calculated for the NIR 2006 and NIR 2008. Figures are for Germany.

[Tg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2006	1.16	1.03	1.00	1.00	1.00	1.00	0.99	0.96	0.95	0.95
NIR 2008	1.15	1.01	0.99	0.99	0.99	0.99	0.98	0.95	0.94	0.95
[Tg a^{-1} CH_4]	2000	2001	2002	2003	2004	2005	2006			
NIR 2008	0.94	0.95	0.92	0.91	0.88					
NIR 2008	0.93	0.94	0.91	0.90	0.88	0.87	0.87			

6.1.6 Source-specific planned improvements (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 category by level (l) / trend (t)		**Gas (key category)**	**1990 – contribution to total emissions**	**2006 – 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 for EF determination		D/T1/T2				CS/T1				

The source category "Manure management" (4.B) is not a key category.

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 animals (only NH_3) and poultry, but not on emissions from management of mule and ass manure (NE).

In the CSE, source category 4.B manure management is divided into the sub-categories shown in Figure 50.

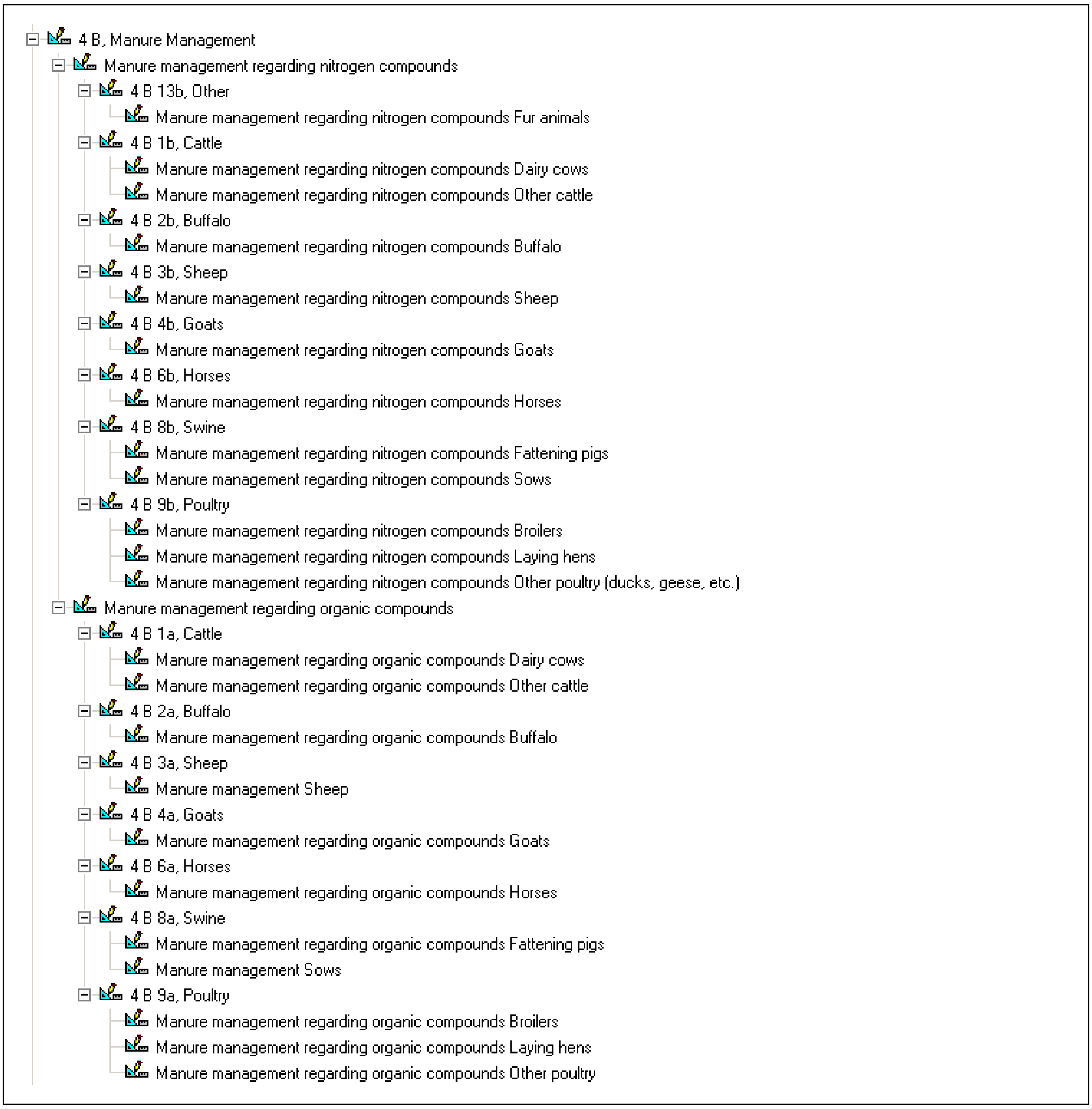


Figure 50: Structural allocation, 4.B Manure management

6.2.1.1 Methane emissions from manure management (4.B)

6.2.1.1.1 Calculated emissions

Table 95 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. Of total emissions, cattle contribute about two-thirds (69 % for 1990; 64 % for 2005) and swine contribute nearly one-third (28 % for 1990; 31 % for 2005). As these figures indicate, emissions from keeping of poultry, and from keeping of horses, sheep, goats and buffalo, are negligible.

Table 95: 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}	0.28	0.25	0.24	0.24	0.26	0.26	0.26	0.26	0.26	0.26
[Tg a^{-1} CH_4.]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
E_{CH4}	0.25	0.26	0.25	0.24	0.23	0.24	0.24			

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., 2007). The time series for NMVOC emissions is shown in Table 96. 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 96 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**			
E_{NMVOC}	0.26	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	0.12	0.12			

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 0.03 to 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 97. Since N_2O and NO emissions are proportional, NO emissions were not considered separately. 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 (65 % in 1990, and a decrease to 56 % in 2005). With respect to 1990, a total of 64 % of NH_3 emissions were emitted by cattle farms, 29 % were emitted by swine farms and 6 % were emitted by poultry operations. A total of 65 % of (direct) N_2O and NO emissions originate in keeping of cattle, while 17 % originate in keeping of swine and 13 % originate in keeping of poultry. In 2005, the respective shares for NH_3 were 60 %, 29 % and 8 %. The respective shares for N_2O and NO in 2005 were 56 %, 16 % and 18 %.

Table 97 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 or NH_3]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
EN2O	0.013	0.012	0.011	0.011	0.009	0.009	0.010	0.009	0.009	0.010
ENO	0.0018	0.0016	0.0015	0.0015	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
ENH3	0.62	0.54	0.53	0.53	0.52	0.52	0.52	0.51	0.51	0.51
[Tg a^{-1} N_2O, NO or NH_3]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
EN2O	0.009	0.010	0.009	0.010	0.010	0.010	0.010			
ENO	0.0013	0.0013	0.0013	0.0014	0.0013	0.0013	0.0013			
ENH3	0.50	0.51	0.50	0.50	0.49	0.49	0.49			

6.2.2 Methodological issues (4.B)

6.2.2.1 Methodological issues and requirements, CRF 4.B (CH_4)

IPCC (1996b) 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[47] 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

$$EF_i = VS_i \cdot \alpha \cdot B_{oi} \cdot \rho_{CH4} \cdot \sum_{jk} MCF_{jk} \cdot MS_{ijk}$$

where
- EF_i Emission factor for sub-category i [kg space^{-1} a^{-1} CH_4]
- VS Volatile solids (excretion of readily decomposable material, dry mass - DM) for the sub-category i [kg space^{-1} d^{-1} DM]
- α Conversion factor for time units (α = 365 d a^{-1})
- B_{oi} 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 have been classified as a key source (for details, see Chapter 6.2.1). For this inventory, VS excretions of laying hens and pullets were also calculated, taking mean outputs / weight gains and feeding into account (HAENEL & DÄMMGEN, 2007a, 2007b).

The calculations are carried out for rural districts (DÄMMGEN et al., 2007)

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

[47] 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 and poultry (except for laying hens and pullets).

6.2.2.2 Methodological issues and requirements, CRF 4 B (N_2O, NO and 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., 2007). It considers *all* flows of N species, both in succession and in parallel, in keeping with the scheme shown in Figure 51.

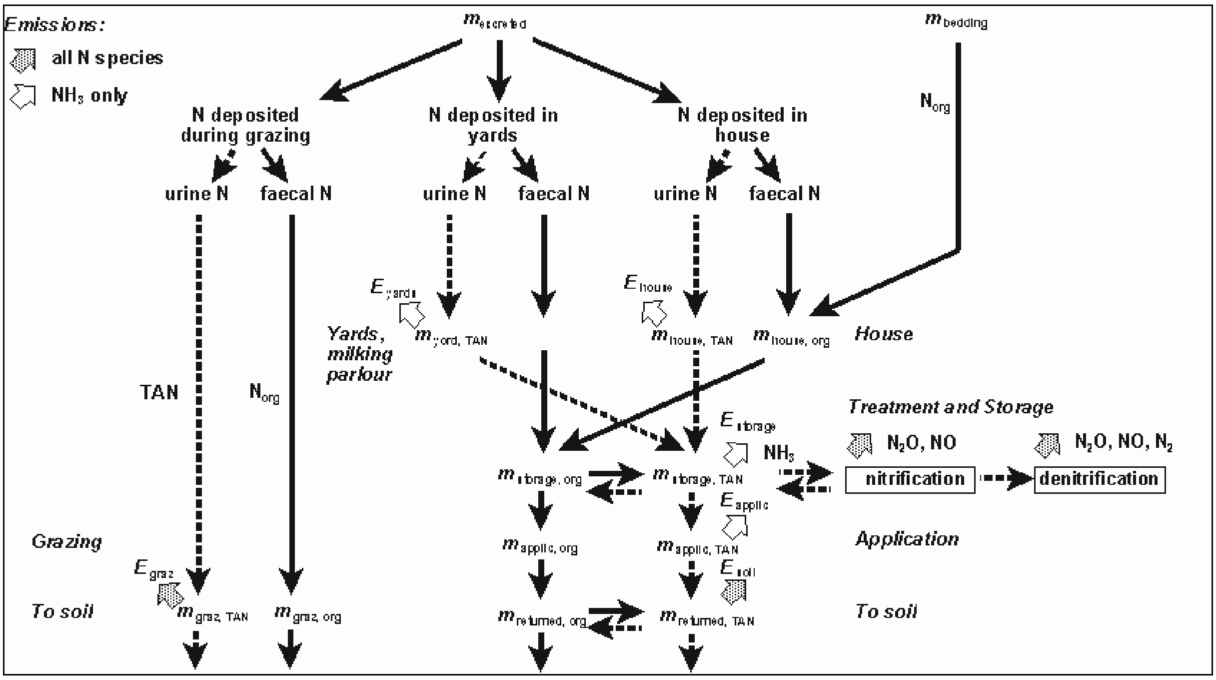


Figure 51: Nitrogen flows in manure management for a given category.[48]

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 (1996b) 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 (2000), 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 spaces in category i [number of spaces]

[48] 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)

$m_{ex,i}$	mean annual N excretion of category i [kg space^{-1} a^{-1} N]
$x_{i,j}$	Percentage of the annual excretions of category i that is subject to a certain manure-management system j [kg kg^{-1}].
$EF_{N2O-N, J}$	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 (1996b) 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 (total N $\rightarrow$ TAN) is mineralised.

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), 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 (2000) also contains default values for emission factors, however (Tables 4-12 and 4–13).

The emission factors (liquid-manure-based systems: EF_{N2O-N} = EF_{NO-N} = 0.001 kg kg^{-1} N, EF_{N2} = 0.007 kg kg^{-1} N; straw-based systems: EF_{N2O-N} = 0,02 kg kg^{-1} N, EF_{NO-N} = 0,002 kg kg^{-1} N, EF_{N2} = 0,06 kg kg^{-1} N) have either been taken from IPCC or derived from that source (IPCC 1996b: Table 4-22; Data for NO and N_2 are in conformance with experiments in the UK and are also applied in the UK, Switzerland and Denmark. All of the stall categories commonly found in Germany are considered. Information on frequency distribution is provided by LÜTTICH et al. (2007).

The figures are determined for each rural 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., 2007).

Pursuant to key-source analysis, category 4.B N_2O emissions are not a key source. For this reason, a simple method (Tier -1 approach) may be used for calculation. In such calculation, national data for N excretion is 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 is 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.

6.2.2.4 Excrement

C species:

In the categories cattle, swine, laying hens and pullets, 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 (1996b: Tables B-1 and B-7) are used:

Sheep	0.40	kg space^{-1} d^{-1} C
Goats	0.40	kg space^{-1} d^{-1} C
Horses	1.72	kg space^{-1} d^{-1} C
Poultry	0.10	kg space^{-1} d^{-1} C
Buffalo	2.7	kg space^{-1} d^{-1} C

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 raw-fodder composition. A detailed description of this procedure is provided by DÄMMGEN et al. (2007), while an assessment of the procedure is provided by DÄMMGEN & LÜTTICH (2005). This calculation procedure also yields the pertinent TAN excretions.

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.

The factors determining excretions for laying hens include egg production, weight and weight gain and feeding. For laying hens, excretions are calculated as a function of weight gain, final weight, number of eggs and feed characteristics (HAENEL & DÄMMGEN, 2007a, 2007b).

For all other animals, N-excretion figures were taken from the German literature (DÄMMGEN et al., 2007). Specifically, the following figures were used:

Male beef cattle	44 kg	Space^{-1} a^{-1} N
Young female cattle (heifers)	40 kg	Space^{-1} a^{-1} N

Calves	16 kg	$Space^{-1}\ a^{-1}$ N
Suckling cows	96 kg	$Space^{-1}\ a^{-1}$ N
Boars	27.7 kg	$Space^{-1}\ a^{-1}$ N
Sheep, not including lambs	10 kg	$Space^{-1}\ a^{-1}$ N
Lambs	3 kg	$Space^{-1}\ a^{-1}$ N
Heavy horses	53.6 kg	$Space^{-1}\ a^{-1}$ N
Light horses	33.4 kg	$Space^{-1}\ a^{-1}$ N
Broilers	0.41 kg	$Space^{-1}\ a^{-1}$ N
Geese	0.55 kg	$Space^{-1}\ a^{-1}$ N
Ducks	1.48 kg	$Space^{-1}\ a^{-1}$ N
Turkeys	0.81kg	$Space^{-1}\ a^{-1}$ N
Buffalo	70 kg	$Space^{-1}\ a^{-1}$ 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	variable
Cattle, except for dairy cows	0.60 kg kg^{-1} N
Sows and boars	0.70 kg kg^{-1} N
Weaners and fattening pigs	variable
Sheep	0.40 kg kg^{-1} N
Horses	0.40 kg kg^{-1} N
Poultry	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 stable categories commonly found in Germany are taken into account (LÜTTICH et al., 2007). The relevant data is compiled 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 forms commonly used in Germany are taken into account. Daily application is not commonly practiced in Germany;

open lagoons are not used. CRF Table 4.B(b) lists the frequency distributions for the various forms of 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. For N_2O, NO and N_2, the order of magnitude is probably accurate.

The time series from official statistics is inconsistent with regard to herd populations, due to amendment of the Agricultural Statistics Act (Agrarstatistikgesetz); i.e. a break occurs 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 agricultural operations do not keep "recreational horses". 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). As to uncertainties, only approximate (order-of-magnitude) information is available.

6.2.4 Source-specific quality assurance / control and verification (4.B)

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

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 is 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 (with pasturing, type of stabling), type of storage, spreading methods, etc.. Such data must be obtained via surveys.

For the first time, 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 in the present inventory. The mass-flow procedure has been reviewed by the EAGER experts' group, and the results obtained in Europe have been compared. A summarising description with regard to cattle is provided by REIDY et al. (2007).

6.2.5 Source-specific recalculations (4.B)

6.2.5.1 Source-specific recalculations (CH_4)

Provisional animal heat counts for 2004 were replaced with final counts. The availability of data from the 2003 animal census and land-use survey led to a change in frequency distributions of storage procedures after 2002.

Feeding data were updated for fattening bulls. This led to changes in the excretion figures.

Excretions of laying hens and pullets are calculated pursuant to a Tier-2 procedure (HAENEL & DÄMMGEN, 2007a, 2007b).

The pertinent differences are shown in the following table.

Table 98 Comparison of figures given in NIR 2006 for 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
NIR 2006	0.29	0.26	0.25	0.25	0.27	0.26	0.27	0.26	0.26	0.27
NIR 2008	0.28	0.25	0.24	0.24	0.26	0.26	0.26	0.26	0.26	0.26
[Tg a^{-1} CH_4]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
NIR 2006	0.26	0.26	0.26	0.26	0.25					
NIR 2008	0.25	0.26	0.25	0.24	0.23	0.24	0.24			

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.

Transfer errors were corrected in the calculations with respect to sheep.

Table 99 Comparison of figures for NMVOC emissions E_{NMVOC} from animal husbandry (manure management) as listed in the NIR 2006 and NIR 2008.

[Tg a^{-1} NMVOC]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2006	0.33	0.29	0.28	0.28	0.26	0.26	0.26	0.26	0.26	0.26
NIR 2008	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			
NIR 2006	0.25	0.26	0.25	0.25	0.25					
NIR 2008	0.26	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 application procedures were recalculated in RAUMIS for the years 2003 through 2005, on the basis of the pertinent 2003 statistics. New figures resulted for emissions in 2003 and 2004, which had previously been calculated with 1999 data.

For the categories of dairy cows, fattening bulls and swine, a new basis was used for calculation of N excretions. This made it necessary to recalculate emissions of all N species from animal husbandry.

Specifically, the following changes were made:

Nitrogen 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 had 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.

Nitrogen excretions of pullets and laying hens were calculated as a function of weight / egg production.

Nitrogen excretions of turkeys, ducks and geese were differentiated by fattening procedures and breeds and updated. A number of transcription errors were eliminated.

- 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.
- Nitrogen excretions from broilers, and from geese, ducks and turkeys, were brought into conformance with the most recent findings.

Last year, the emission factors for NO and N_2 emissions from manure were based on findings regarding the relevant emissions from soils. These have been replaced with experimentally determined values from the UK. All European countries in which inventories of N species are calculated in accordance with the mass-flow procedure use these factors.

The resulting changes in emissions, which are significant for NO, are shown in the following Tables:

Table 100 Comparison of figures for N_2O emissions E_{N2O} from animal husbandry (manure management) as listed in the NIR 2006 and NIR 2008. Figures are for Germany.

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2006	13.3	11.8	11.4	11.3	9.5	9.5	9.6	9.5	9.5	9.6
2007	13.2	11.7	11.3	11.2	9.4	9.7	9.5	9.4	9.4	9.6
[Gg a^{-1} N_2O]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
2006	9.5	9.6	9.4	9.4	9.2					
2007	9.4	9.6	9.3	10.0	9.9	9.8	9.8			

Table 101 Comparison of figures for NO emissions E_{NO} from animal husbandry (manure management) as listed in the NIR 2006 and NIR 2008. Figures are for Germany.

[Gg a^{-1} NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2005	18.2	16.0	15.5	15.4	13.0	13.0	13.2	13.0	12.9	13.1
2006	1.8	1.6	1.5	1.5	1.3	1.3	1.3	1.3	1.3	1.3
[Gg a^{-1} NO]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
2006	12.9	13.1	12.8	12.8	12.5					
2007	1.3	1.3	1.3	1.4	1.3	1.3	1.3			

Table 102 Comparison of figures for NH_3 emissions E_{NH3} from animal husbandry (manure management) as listed in the NIR 2006 and NIR 2008. Figures are for Germany.

[Tg a^{-1} NH_3]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2006	0.61	0.54	0.53	0.52	0.51	0.51	0.51	0.50	0.50	0.50
2007	0.62	0.54	0.53	0.53	0.52	0.52	0.52	0.51	0.51	0.51
[Tg a^{-1} NH_3]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
2006	0.49	0.50	0.49	0.49	0.48					
2007	0.50	0.51	0.50	0.50	0.49	0.49	0.49			

6.2.6 Source-specific planned improvements (4.B)

The mass-flow-model method and its parameters are being reviewed, expanded and harmonised via international cooperation.

Improving the database for derivation of emission factors will be the focus of a project that is to run from 2007 through 2009.

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.

In the CSE, source category 4.D Agricultural soils includes crop cultivation with and without fertiliser use.

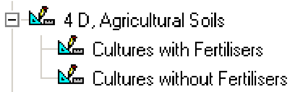


Figure 52: Structural allocation, 4.D Agricultural soils

6.4.1 Source category description (4.D)

CRF 4.D					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 – contribution to total emissions**	**2006 – contribution to total emissions**	**Trend**
Agricultural soil, direct soil emissions (CRF 4.D.1)	l / t	N_2O	2.17 %	2.29 %	Rising
Agricultural soil, indirect emissions (CRF 4.D.3)	l / -	N_2O	1.17 %	1.19 %	Stagnating

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 for EF determination		C				C/D/T1/T2				

With regard to N_2O emissions, source category Agricultural soils (4.D) is a key category for direct and indirect emissions, in terms of levels, and it is a key category for 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 assumed 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 depend 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 103. 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 103: N_2O, NO and NH_3 emissions E_{N2O}, E_{NO} and E_{NH3} from agricultural soils (not including NH_3 emissions from grazing)

[Gg a^{-1} N_2O], [Gg a^{-1} NO] or [Gg a^{-1} NH_3]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{N2O}	142.9	131.2	127.1	123.6	117.5	123.0	123.0	122.1	123.2	126.8
E_{NO}	65.2	59.3	57.1	55.6	52.0	55.0	55.2	54.8	55.4	57.3
E_{NH3}	74.8	67.5	62.8	66.8	61.9	69.7	70.0	71.9	73.6	80.0
[Gg a^{-1} N_2O], [Gg a^{-1} NO] or [Gg a^{-1} NH_3]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
E_{N2O}	129.0	126.0	122.7	122.1	123.2	122.1	122.1			
E_{NO}	58.3	56.5	54.6	54.1	55.1	54.4	54.4			
E_{NH3}	84.1	87.3	86.7	86.1	90.0	82.7	82.7			

For 2005, a share of 30 % of N_2O emissions from soils can be allocated to use of mineral fertilisers in the soil; 29 % can be allocated to indirect emissions resulting from leaching; 18 % can be allocated to application of farm manure; and 15 % can be allocated to cultivated organic soils. The remaining emissions consist of emissions from grazing, legumes, harvest residues and indirect emissions from deposition of reactive N species.

Use of mineral fertilisers also accounts for the largest share of NH_3 emissions: a share of 81 % in 1990 and of 85 % in 2004.

In principle, plant stocks are always sources of volatile organic compounds. A first estimate of such emissions was carried out for important crops. For procedural reasons, NMVOC emissions can be given only as NMVOC-C emissions (Table 104).

Agricultural soils are sinks for atmospheric methane that is oxidised by methanotrophic bacteria (Table 105).

Fertilisation with urea releases CO_2. This area is being reported on for the first time (Table 106).

Table 104: NMVOC-C emissions E_{NMVOC} from agricultural plants.

[Mg a^{-1} NMVOC-C]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{NMVOC}	0.138	0.130	0.125	0.125	0.120	0.127	0.132	0.130	0.128	0.122
[Mg a^{-1} NMVOC-C]	2000	2001	2002	2003	2004	2005	2006			
E_{NMVOC}	0.122	0.120	0.118	0.120	0.128	0.128	0.128			

Table 105: CH_4 consumption E_{CH4} by agricultural soils.

[Tg a^{-1} CH_4]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
E_{CH4}	0.032	0.031	0.030	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			
E_{CH4}	0.030	0.030	0.030	0.030	0.030	0.030	0.030			

Table 106: CO_2 emissions E_{CO2} from urea application.

[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			
E_{CO2}	0.58	0.64	0.65	0.63	0.67	0.60	0.60			

6.4.2 Methodological issues and requirements (4.D)

The IPCC (2000) describes Tier-1a and Tier-1b procedures for determining **direct nitrous-oxide emissions** from agricultural soils. The Tier-1a procedure is the procedure that conforms to IPCC (1996b). The Tier-1b procedure is more precise with regard to development of individual terms. Where sufficiently precise activity data is not available, calculation may be carried out in accordance with the Tier-1a method, however. 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 input
3. Calculation of total emissions

The Tier-1a procedure differentiates between two different emission factors – one for emissions from N inputs and one for emissions from cultivation of organic soils (IPCC, 2000: S. 4-54):

Equation 9: Tier-1a procedure for determination of direct N_2O emissions from agricultural soils

$$E_{N_2O,\,direkt} = \left[\left(m_{SN} + m_{AM} + m_{BN} + m_{CR} + m_{SS} \right) \cdot EF_1 + \left(A_{OS} \cdot EF_2 \right) \right]$$

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 = 0.0125 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]

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 (2000).

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-1a procedure for determination of indirect N_2O emissions from agricultural soils

$$E_{\mathrm{N2O,indirekt}} = E_{\mathrm{N2O,ge}} + E_{\mathrm{N2O,l}} + E_{\mathrm{N2O,s}}$$

where
$E_{\mathrm{N2O\ (indirect)}}$ indirect N_2O emissions [kg a^{-1} N_2O]
$E_{\mathrm{N2O,ge}}$ 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]
$E_{\mathrm{N2O,l}}$ N_2O emissions from surface run-off and leaching of applied fertilisers [kg a^{-1} N_2O]
$E_{\mathrm{N2O,s}}$ 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. $Frac_{\mathrm{GASF}}$ and $Frac_{\mathrm{GASM}}$ are not constants.

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. The data on land under cultivation is taken from the official statistics for each reporting year. The emissions calculations for the years after 1999 are based on preliminary assumptions regarding land use.

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 farmland (EF_{CH4} = - 1.5 kg ha^{-1} a^{-1} CH_4). (in this regard, see the more detailed description in DÄMMGEN et al, 2007).

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, 2003). This source provides area-dependent emission factors for some of the main crops in question (for details, cf. DÄMMGEN et al., 2007).

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., 2007).

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 (arable land, grassland). Under the assumption that no type of fertilisation was preferred over others, fertiliser inputs were calculated for each rural district for 1999 and 2003, and for each German state (Land) for all other years. Separate calculations were carried out for arable land and grassland. The emissions were then obtained via the following equation:

Equation 11: Procedure for plausible disaggregation of fertiliser inputs. Calculation of relevant quantities per rural district

$$m_{\mathrm{fert,\,i,\,d}} = x_{\mathrm{fert,\,d}} \cdot m_{\mathrm{fert,\,i,\,sold}}$$

where
$m_{\mathrm{fert,\,i,\,d}}$ Quantity of a type of fertiliser i used in a district / Land d [Gg a^{-1} N]
$x_{\mathrm{fert,\,I,\,d}}$ Share of fertiliser type i applied in a district d, with respect to the quantity sold in the relevant state (Land) [kg kg^{-1}]
$m_{\mathrm{fert,\,i,\,sold}}$ 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

$$x_{\mathrm{fert,\,d}} = \frac{\sum_j A_{\mathrm{j,\,d}} \cdot m_{\mathrm{rec,\,j}}}{\sum_j A_{\mathrm{j,\,FS}} \cdot m_{\mathrm{rec,\,j}}}$$

where
$A_{\mathrm{j,\,d}}$ Area under cultivation with crop j in district d [ha]
$m_{\mathrm{rec,\,j}}$ recommended quantity of fertiliser for crop I j [kg ha^{-1} N] (cf. Table 107)
$A_{\mathrm{j,\,FS}}$ Area under cultivation with crop j in Land FS [ha]

Table 107 Recommended fertiliser quantities

Crop	Recommended quantity of fertiliser kg ha^{-1} N	Source
Winter wheat	220	LWK-WE (2003)
Spring wheat	200	LWK-WE (2003)
Rye	150	LWK-WE (2003)
Winter barley	190	LWK-WE (2003)
Spring barley	130	LWK-WE (2003)
Oats	100	LWK-WE (2003)
Triticale	190	LWK-WE (2003)
Grain maize	180	LWK-WE (2003)
Maize for silage	180	LWK-WE (2003)
Rape	200	LWK-WE (2003)
Sugar beets	160	LWK-WE (2003)
Fodder beets	160	
Clover, clover-grass mixtures, clover-alfalfa mixtures (fodder production on arable land)	0	
Alfalfa	0	
Grass (fodder production on arable land)	270	KTBL (2004), p. 301
Potatoes	160	LWK-WE (2003)
Broad beans	0	
Fodder peas	0	
Other pulses	0	
Meadows and pastures	130	KTBL (2004), p. 301

The relevant fertiliser quantities were taken from official statistics, while the emission factors were taken from EMEP (2003) and IPCC (1996b).

6.4.2.5 Carbon dioxide emissions from urea application (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 44/14, with respect to the N in urea.

6.4.2.6 Nitrous oxide and nitrogen monoxide emissions from agricultural soils (legumes) (4.D)

The N quantities fixed via legumes are calculated from the areas under cultivation (DÄMMGEN et al., 2007) and from national averages for area-specific N fixing.

Equation 13: Determination of emissions of N species from legume cultivation

$$E_N = b \cdot EF_1 \cdot \sum_i A_i \cdot m_{NF,i}$$

Where E_N Emission of N species [Gg a^{-1} N]
β Conversion factor for weight units [10^{-6} Gg kg^{-1}]
EF_1 Emission factor for emissions from N inputs [kg kg^{-1} N] (see below)
A_i Cultivation area for a crop i [ha]
$m_{NF,i}$ N amounts fixed by crop i [kg ha^{-1} a^{-1} N] (see below)

Different fixed amounts $m_{NF,i}$ are differentiated, for:

Legumes	250 kg ha^{-1} N
Clover, clover/grass, clover/alfalfa	200 kg ha^{-1} N
Alfalfa	300 kg ha^{-1} N

The following emission factors are used:

$EF_{1, N2O}$	0.0125 kg kg^{-1} N
$EF_{1, NO}$	0.007 kg kg^{-1} N

Equation 13 is derived directly from Equation 4.21 in IPCC (2000). While that source proposes estimating $m_{NF,i}$, for different crop types, via yields or above-ground biomass, the above-described German procedure draws amounts of fixed N from tables. The activity is $\Sigma(A_i\ m_{NF,i})$.

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 used is described in IPCC(2006)-11.12 as a Tier-2 procedure.):

Equation 14: Determination of emissions of N species from harvest residues

$$E_{N2O,CR} = \left(\sum_i A_i \cdot x_{renew,i} \cdot y_i \cdot x_{DM,i} \cdot \left(a_{above,i} \cdot x_{N,above,i} + a_{below,i} \cdot x_{N,below,i} \right) - m_{N,harvest} \right) \cdot EF_{N2O,CR} \cdot \beta \cdot \gamma_{N2O}$$

$$E_{NO,CR} = \left(\sum_i A_i \cdot x_{renew,i} \cdot y_i \cdot x_{DM,i} \cdot \left(a_{above,i} \cdot x_{N,above,i} + a_{below,i} \cdot x_{N,below,i} \right) - m_{N,harvest} \right) \cdot EF_{NO,CR} \cdot \beta \cdot \gamma_{NO}$$

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}]
	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 below-ground biomass for crop i [kg kg^{-1}]
	$x_{N,\ above,\ i}$	N content of above-ground biomass of crop i [kg kg^{-1} N]
	$a_{below,\ i}$	Ratio of below-ground biomass to yield of crop i [kg kg^{-1}]
	$x_{N,\ above,\ i}$	N content of below-ground biomass of crop i [kg kg^{-1} N]
	$m_{N,\ harvest}$	N quantity removed with above-ground biomass [kg N]
	$EF_{N2O,\ CR}$	N_2O emission factor for harvest residues ($EF_{N2O,\ CR}$ = 0.0125 kg kg^{-1} N_2O-N)
	β	Conversion factor for weight units ($\beta = 10^{-6}$ 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 by Table 108. The cultivation-area and yield figures are taken from statistics. The calculations were carried out for rural districts for the years 1999 and 2003.

Table 108: 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	0.005	0.59	0.008
Spring wheat		0.89	0.9	0.005	0.59	0.008
Rye		0.88	1.4	0.005	0.55	0.008
Winter barley		0.89	1.0	0.005	0.50	0.008
Spring barley		0.89	1.1	0.005	0.50	0.008
Oats		0.89	1.2	0.005	0.53	0.008
Triticale		0.88	1.4	0.005	0.55	0.008
Grain maize		0.65	1.3	0.007	0.48	0.008
Maize for silage		0.30	1.2	0.0035		
Rape			1.7	0.007		
Sugar beets		0.22	0.8	0.029	0.1	0.016
Beets		0.22	0.3	0.024	0.1	0.016
Clover, clover-grass mixtures, clover-alfalfa mixtures (fodder production on arable land)	50,000	0.15	0.5	0.02	0.8	0.015
Alfalfa	50,000	0.99	0.3	0.06	0.4	0.023
Grass (fodder production on arable land)	34,000	0.15	0.5	0.02		0.015
Potato	0	0.22		0.004	0.1	0.016
Broad beans	0	0.90	2.1	0.015	0.55	0.022
Fodder peas	0	0.90	2.1	0.015	0.55	0.022
Other pulses	0	0.90	2.1	0.016	0.55	0.022
Meadows and pastures	45,000	0.15	0.5	0.02	0.59	0.022

Sources: detailed description in DÄMMGEN et al. (2007)

The calculations use default emission factors for determination of emissions from use of mineral and farm fertilisers (IPCC et al., 1996b: Table 4-19 and EMEP, 2003: B1010-15): $EF_{N2O\text{-}N}$ = 0.0125 kg kg^{-1} N; $EF_{NO\text{-}N}$ = 0.007 kg kg^{-1} N; EF_{N2} = 0.1 kg kg^{-1} N. The same factors are also applied to the N amounts bound in harvest residues.

The areas under cultivation are listed in LÜTTICH et al. (2007).

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 this 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., 2005). The emission factor used is the "new" default factor EF_2 (old: IPCC, 1996b: Table 4.18: 5 kg ha^{-1} a^{-1} N_2O-N; new: IPCC, 2000: Table 4.17: 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., 2007). N_2-emissions levels influence the amount of N that is input into the soil.

The following emission factors are used (EMEP, 2003: B10 90-13; EMEP: draft for chapter 10 09; IPCC, 1996b: Table 4-22):

NH_3	0.075 kg kg^{-1} N
N_2O	0.02 kg kg^{-1} N
NO	0.02 kg kg^{-1} N
N_2	0.14 kg kg^{-1} N

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 15: Determination of indirect N_2O emissions from soils resulting from deposition of reactive N species from agriculture

$$E_{\mathrm{N2O,ge}} = \left[\left(m_{\mathrm{N,fert}} \cdot x_{\mathrm{fert}}\right) + \left(m_{\mathrm{N,ex}} \cdot x_{\mathrm{ex}}\right)\right] \cdot EF_4 \cdot \gamma \cdot \mathrm{N2O}$$

where:

$E_{\mathrm{N2O,ge}}$	N_2O emissions from emissions of NO_x and NH_3 from fertiliser, and their subsequent atmospheric deposition [Gg a^{-1} N_2O]
$m_{\mathrm{N, fert}}$	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): $Frac_{\mathrm{GASF}}$)
$m_{\mathrm{N,ex}}$	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: $Frac_{\mathrm{GASM}}$)
EF_4	Emission factor for N_2O emissions from atmospheric deposition [EF_4 = 0.010 kg kg^{-1} N]
γ_{N2O}	Umrechungsfaktor für Massen (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 is based on spreading of mineral fertilisers and on manure management. The data on use of mineral fertilisers and on legume cultivation comes 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, 1996b: Table 4-23).

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 calls for fugitive nitrogen releases from mineral fertilisers and farm manure to be listed as a source. IPCC default values are used for the leachable fraction and for the emission factor (IPCC, 1996b: Tab. 4-24 and Tab. 4-23).

The N_2O emissions are calculated pursuant to the following formula:

Equation 16: Determination of indirect N_2O emissions from soils resulting from leaching of nitrogen from agricultural 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:

$E_{\mathrm{N2O,l}}$	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]
x_{leach}	Leachable N fraction [kg kg^{-1} N]

EF_5 Emission factor for N_2O emissions from leaching
[EF_5 = 0.025 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 QA/QC and verification (4.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 not been carried out completely.

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)

In the area of emissions from application of mineral fertilisers, disaggregation at the rural-district level was carried out for the first time for 1999 and 2003. A distinction was made between application on grassland and application on arable land. A smaller emission factor then resulted. This led to increased inputs into the soil.

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 methods or improved methods (sows, laying hens, pullets), and updating of N excretions (for example, for ducks and turkey), resulting in changes in the pertinent direct emissions of NH_3 and NO. The indirect emissions also have changed as a result.

Table 109: Comparison of figures used in the NIR 2006 and NIR 2008 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 2006	97.1	89.7	87.2	84.9	80.5	84.2	84.1	83.6	84.4	86.7
NIR 2008	94.8	87.6	84.9	82.8	78.6	82.3	82.4	81.9	82.6	84.9
[Gg a^{-1} N_2O]	2000	2001	2002	2003	2004	2005	2006			
NIR 2006	88.3	86.0	84.2	84.2	84.5					
NIR 2008	86.3	84.3	82.1	81.5	82.6	81.9	81.9			

Table 110: Comparison of figures used in the NIR 2006 and NIR 2008 for indirect N_2O emissions from agricultural soils.

[Gg a^{-1} N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2006	45.9	41.6	40.3	38.9	36.7	38.6	38.4	38.0	38.4	39.7
NIR 2008	48.1	43.6	42.2	40.8	38.8	40.7	40.6	40.2	40.6	41.8
[Gg a^{-1} N_2O]	2000	2001	2002	2003	2004	2005	2006			
NIR 2006	40.6	39.1	38.2	38.1	38.1					
NIR 2008	42.7	41.6	40.6	40.6	40.7	40.2	40.2			

Table 111: Comparison of figures used in the NIR 2006 and NIR 2008 for NO emissions from agricultural soils.

[Gg a^{-1} NO]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NIR 2006	63.9	57.9	56.1	54.4	50.7	53.5	53.5	53.1	53.7	55.5
NIR 2008	65.2	59.3	57.1	55.6	52.0	55.0	55.2	54.8	55.4	57.3
[Gg a^{-1} NO]	2000	2001	2002	2003	2004	2005	2006			
NIR 2006	56.7	54.6	53.2	53.1	53.2					
NIR 2008	58.3	56.5	54.6	54.1	55.1	54.4	54.4			

Table 112 Comparison of figures given by the NIR 2006 and NIR 2008 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 2006	0.115	0.105	0.099	0.103	0.093	0.104	0.104	0.106	0.109	0.117
NIR 2008	0.091	0.082	0.077	0.082	0.075	0.083	0.084	0.086	0.087	0.094
[Tg a^{-1} NH_3]	2000	2001	2002	2003	2004	2005	2006			
NIR 2006	0.121	0.125	0.124	0.123	0.128					
NIR 2008	0.098	0.101	0.100	0.099	0.103	0.096	0.096			

6.4.5.4 Carbon dioxide emissions from agricultural soils (4.D)

CO_2 emissions from urea application are being reported for the first time.

6.4.6 Source-specific planned improvements (4.D)

6.4.6.1 Ammonia emissions from agricultural soils (4.D)

These emissions are to be further disaggregated, both spatially and chronologically; to this end, applied amounts of fertiliser are to be differentiated by grassland and arable land. This is now possible when suitably resolved activity data are available. Chronological resolution of 1 month is planned.

Emissions during grazing are also to be determined within a chronological resolution of 1 month.

The improvement depends on the availability of suitable resources.

6.4.6.2 Nitrous oxide and nitrogen monoxide emissions from agricultural soils (4.D)

Medium-term plans call for use of a Tier-3 method for calculation of emissions of these gases. In the short term, an attempt will be made to evaluate the literature with regard to NO emissions from agricultural lands, in order to obtain better emission factors.

The improvement depends on the availability of suitable resources.

6.4.6.3 Uncertainty for emissions from agricultural soils (4.D)

In future, the statistics on which emissions calculation is based will have to be expanded to include error and scattering, to make it possible to calculate the required uncertainties. The current inventory of agricultural emissions already responds to this need. 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. Here, this should be carried out especially for NH_3 emissions leading to indirect emissions, as well as for the N amounts added to the soil following application of farm manure.

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 exemptions are considered to be irrelevant (NO).

7 LAND USE, LAND USE CHANGES AND FORESTRY (CRF SECTOR 5)

In this report, the inventories and the NIR cannot be completely updated. The data were updated only for source category 5.A Forests. Inventory preparation for this source category, and the pertinent data sources and methods used, were described in detail in the NIR 2006. For the other source categories, the data from that report of two years ago have been retained without any changes. For this reason, information on those source categories should also be taken from the NIR 2006.

8 WASTE AND WASTE WATER (CRF SECTOR 6)

8.1 Solid waste disposal on land (6.A)

CRF 6.A					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 – contribution to total emissions**	**2006 – contribution to total emissions**	**Trend**
6.A.1 Solid waste disposal on land	l / t	CH_4	2,82 %	0,92 %	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 for EF determination		T2								

The source category "Solid waste disposal on land" is a key category for 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", i.e. uncontrolled, 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 (MBA) 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.

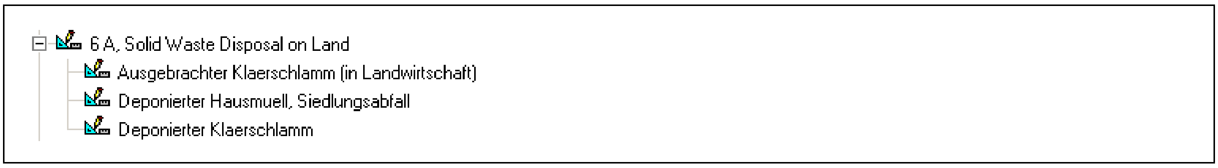
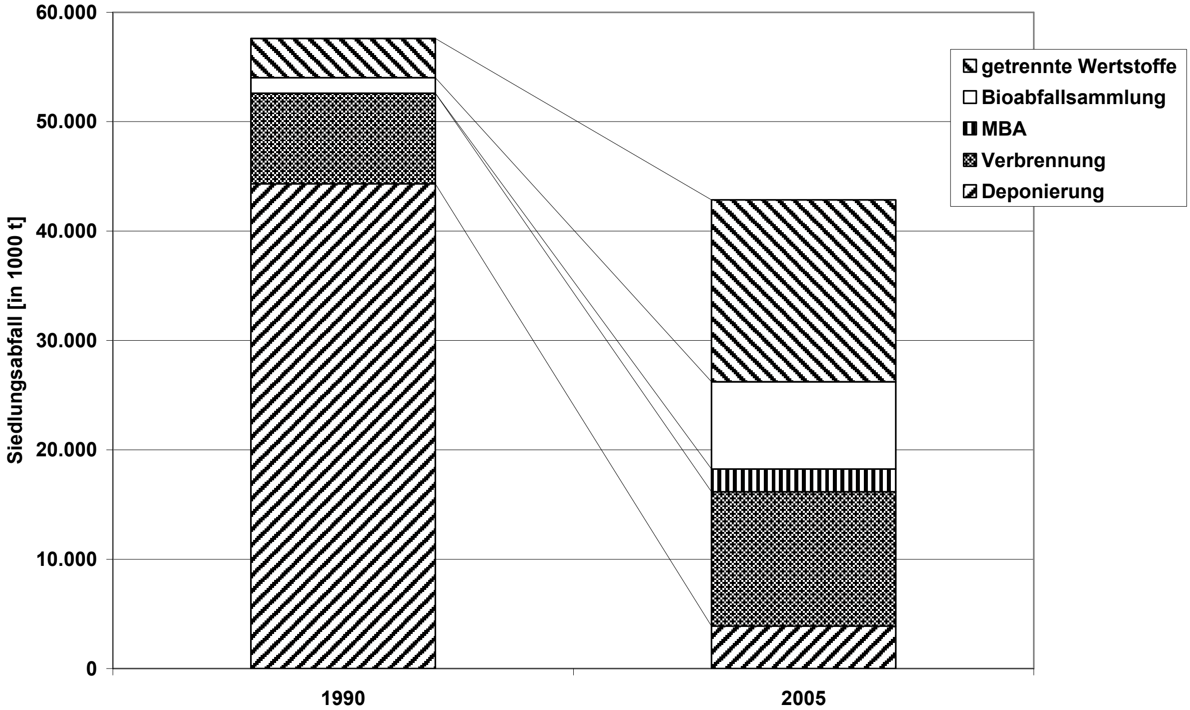


Figure 53: Structural allocation, 6.A Sold waste disposal on land

8.1.1 Managed disposal in landfills – landfilling of municipal waste (6.A.1)

8.1.1.1 Source category description (6.A.1)

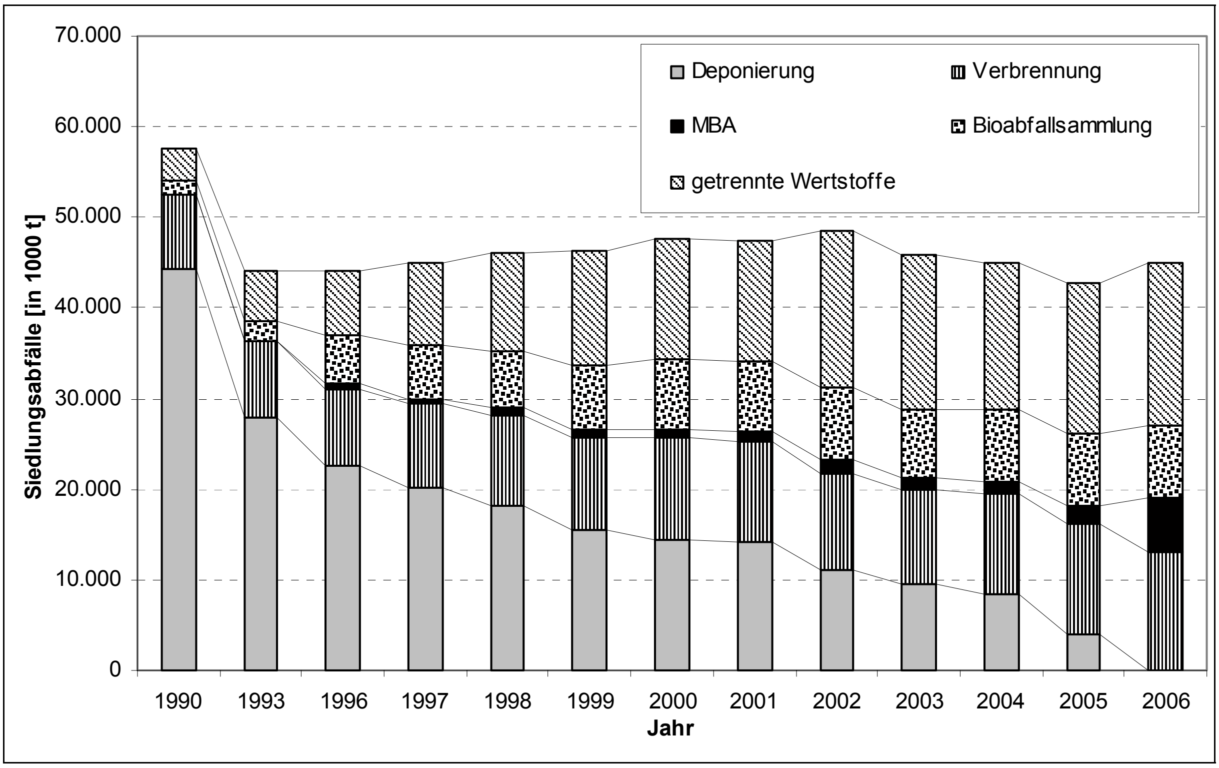
In the period since 1990 (and previously, to some extent), a number of legal provisions have been issued pertaining to Germany's waste-management sector, and a number of relevant organisational measures have been initiated. These moves have had a strong impact on trends in emissions from waste-landfilling. 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 by nearly 90% from 1990 to 2005 (see Figure 54). 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).



[Municipal waste [in thousands of tonnes]; Separated recyclable materials; Collection of biological waste; Mechanical-biological treatment (MBA); Incineration; Landfilling]

Figure 54: Changes in pathways for management of household waste, 1990 to 2004

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. These 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 are now still in operation. As of June 2005, landfilling of biodegradable waste is not longer permitted – in other words, as of June 2005, landfilling of waste that can produce significant quantities of methane is no longer permitted. For conformance with pertinent requirements, municipal waste must be pre-treated via thermal or mechanical-biological processes. Pre-treatment will reduce stored waste amounts, in comparison to their 2003 levels, by an additional 60 - 70 % in future. 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.



[Composition of household waste; Food and organic waste; Paper, cardboard; Composites; Textiles; Diapers; Wood]

Figure 55: Changes in pathways for management of household waste, 1990 to 2006, with intermediate years

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 several 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 German 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 this reason, in the following section, CH4 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 17[49]**:**

Equation 17

$$CH_4 \ produced \ in \ year \ t \ (Gg / year) = \sum_x [(A * k * MSW_T(x) * MSW_F(x) * L_0(x) * e^{-k(t-x)}]$$
$$where: L_0(GgCH_4 / kg \ waste) = MCF * DOC * DOC_F * F * 16/12$$
$$for \ x = first \ year \ to \ t$$

where:

t	= *Inventory year*
x	= *Year as of which the consideration begins and quantities data is 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.

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 18:

Equation 18

CH_4 emitted in year t (Gg/year) = (CH_4 produced in year t – R(t)) • (1- OX)

Where

R(t) = CH_4 collection in year t

OX = Oxidation factor (fraction)

For both Tier 1 and Tier 2, the relevant quantities of municipal waste (MSW_T), and the proportion of municipal waste that is landfilled (MSW_F), must be determined; for Tier 2, production of municipal waste over the previous decades must also be determined. Pursuant to IPCC Good Practice Guidance (2000), landfilled settlement waste should be broken down – via estimation – into waste types, since the further procedure takes account of the fact that different waste types have different DOCs.

8.1.1.2.1 Quantities of landfilled waste

The FOD model calculates emissions from municipal waste, industrial waste and landfilled sewage sludge.

49 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).

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 be completely free of 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 yields information about the per-capita landfilled quantities of waste, waste composition, landfill types and types of waste storage involved. The per-capita quantities of landfilled waste in 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 the following industrial sectors:

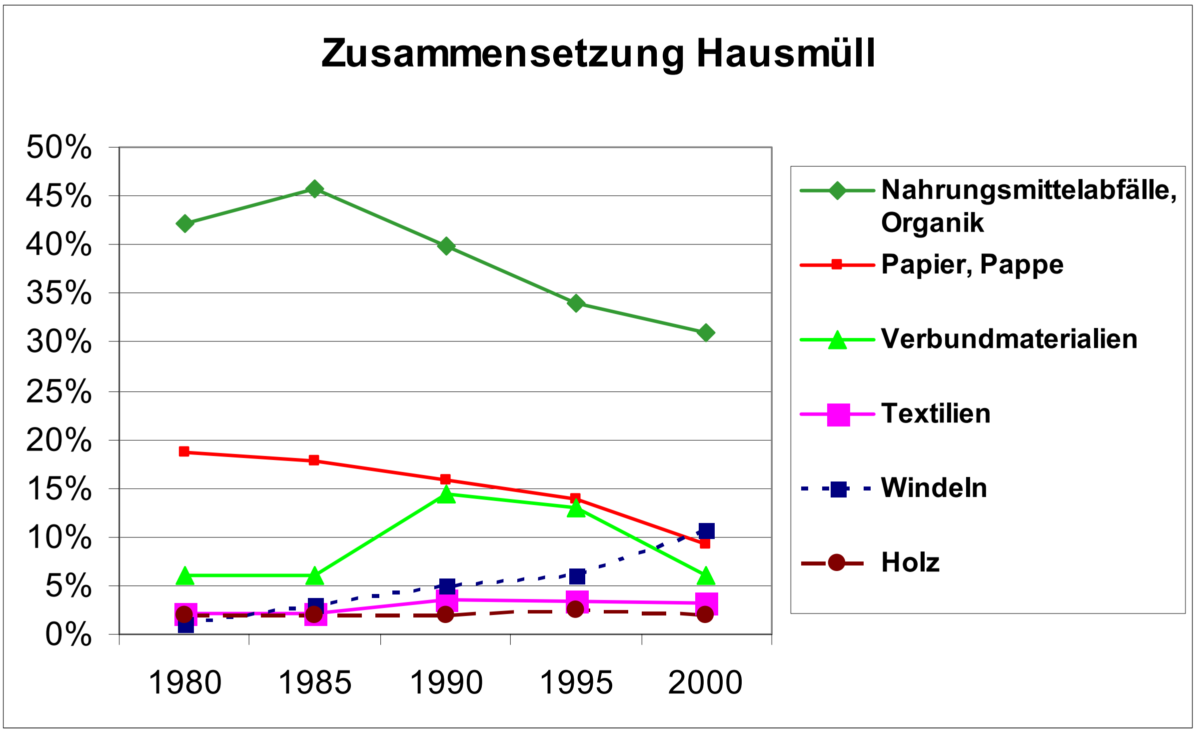
- Waste from agriculture, horticulture, forestry, fisheries and food processing
- Waste from wood processing
- Waste from production of pulp, paper and carton
- Waste from the textile industry
- Packaging waste
- Wood fractions in construction and demolition waste (data since 1975)

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 data 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 to 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. This data has 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.

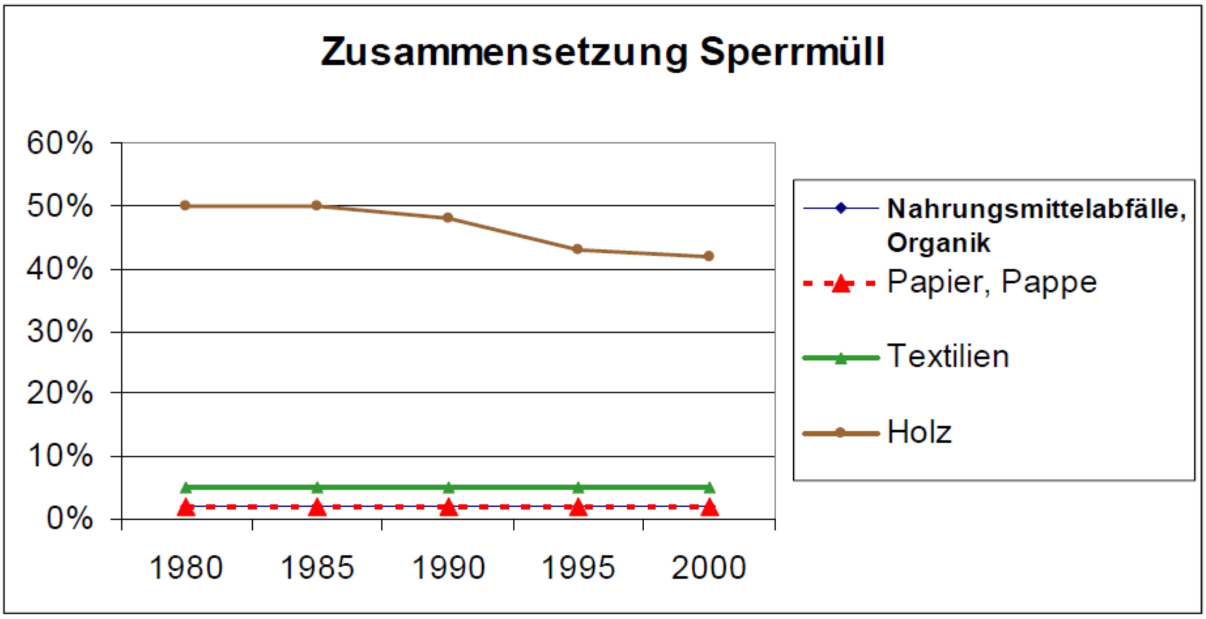
8.1.1.2.2 Waste composition

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, rural 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 (see Figure 56 and Figure 57). 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. Landfilled household waste consisted largely of ash from household combustion systems.



[Composition of household waste; Food and organic waste; Paper, cardboard; Composites; Textiles; Diapers; Wood]

Figure 56: Trends in waste composition (old German Länder) between 1980 and 2000



[Composition of bulky waste; Food and organic waste; Paper, cardboard; Textiles; Wood]

Figure 57: 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 is 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.

8.1.1.2.3 DOC

Both national data and IPCC default factors were used for DOC, the degradable organic carbon in waste. Table 113 provides an overview of the DOC values used.

Table 113: 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

8.1.1.2.4 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). This value lies within the IPCC default range of 0.5-0.6.

8.1.1.2.5 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).

8.1.1.2.6 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 114 shows the half-lives used for the pertinent waste fractions.

Table 114: 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

8.1.1.2.7 Landfill-gas use

The "TA Siedlungsabfall" of 1993[50] 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 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 basic 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 is not based on data from all facility operators.

8.1.1.2.8 Oxidation factor

As to the factor determining the proportion of CH_4 that is oxidised in landfill covering layers, the IPCC default value of 0.1 was accepted for the entire time series. On the one hand, a larger proportion of uncontrolled landfills can be expected in the former GDR in the early 1990s; on the other hand, a research project found only a low CH_4-formation potential for landfills of the former GDR, and thus the factor 0.1 was also used for this period (BMBF, 1997).

8.1.1.3 Uncertainties and time-series consistency (6.A.1)

The method's uncertainties have been estimated for the first time. The results of this experts' assessment are presented in the Annex, Chapter 14.6.1.1.

[50] Technical instructions on recycling, treatment and other management of municipal waste (Third general administrative provision on the Waste Act (Abfallgesetz)) of 14 May 1993

Over the long, 30-year period covered by the activity data, inconsistencies in the time series are unavoidable, since the pertinent waste categories and survey methods changed several times as a result of improvements in legislation and waste statistics. In Germany, special problems arise especially via German reunification and the resulting merging of two different economic and statistical systems. For this reason, considerable effort has to be invested in reviewing data consistency and allocations to the reported categories, in the interest of making time series as consistent as possible.

8.1.1.4 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.

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)

The entire time series for CH_4 emissions from landfilling of municipal waste, for the period 1990 to 2004, was recalculated using a revised Tier 2 method. The improvements over the previous year include the following aspects:

- For the first time, industrial waste was included in the calculations.
- The picture for waste composition, which had previously been assumed to be constant throughout the period covered by the report, was improved via a waste-fraction time series, for the 1980 through 2004 period, that reflects intensified separate collection and waste recycling.
- Among waste fractions, diapers and composite materials were taken into account for the first time with national DOC values.
- The Federal Statistical Office provide additional data sources for the period 1975 through 1990; these sources have supplanted the previously used assumptions for this period. Study of the relevant literature yielded new sources of data on waste composition and landfilling in the former GDR.
- The calculation model was converted into a multi-phase model that takes account of the different half-lives of different waste fractions. In this connection, the model's time frame was expanded; it now begins at 1950, rather than at the previously used 1970; the IPCC Guidelines consider this to be "good practice".

8.1.1.6 Planned improvements (6.A.1)

No improvements are planned at present.

8.2 Wastewater handling (6.B)

CRF 6.B					
Key category by level (l) / trend (t)		**Gas (key category)**	**1990 – contribution to total emissions**	**2006 – contribution to total emissions**	**Trend**
6.B.2 - Domestic and commercial wastewater	- / t	CH_4	0.17 %	0.01	falling

The source category Wastewater handling is a key category, in terms of trend, for CH_4 emissions from municipal wastewater treatment.

Under source category 6.B Wastewater handling (treatment), the CSE lists 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	NE	NO	NO	NO	NE	NO	NO	NO	NO
EF uncertainties in %										
Distribution of uncertainties										
Method for EF determination										

The source category "Methane emissions from industrial wastewater and sludge treatment" (6.B.1) is a key category only via the aggregated source category Wastewater handling (6.B). No calculations for this source category are carried out at present. In 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 category.

The composition of industrial wastewater, in contrast to that of household wastewater, varies greatly – 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. This 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. Like 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 a) aerobically or b) 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)	NE	D/CS	NO	NO	NO	D/CS	NO	NO	NO	NO
EF uncertainties in %		+/- 50				+/- 50				
Distribution of uncertainties		N				N				
Method for EF determination		D/CS				D				

The source category Municipal wastewater treatment is a key category 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 percentage of inhabitants connected to small wastewater-treatment facilities has continually increased, especially in eastern Germany.

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 115. The average organic load is assumed to be 60 g BOB_5 per inhabitant. This value, which is the IPCC default value, is used in Germany as a statistical mean value.

Table 115: Organic wastewater load in cesspools and septic tanks

Organic load [BOB_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 [BOB_5 in kt/a]	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**			
Cesspools and septic tanks	27.74	24.42	23.20	21.98	20.76	19.54	18.32			

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 BOB_5), and an MCF of 0.5 for cesspools and septic tanks, are used, by assumption. 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:

Equation 19

$$CH_4(cesspools\ and\ septic\ t.) = kg\ BOB_5\ /\ year\ x\ 0.6\ kg\ CH_4\ /\ kg\ BOB_5\ x\ 0.5$$

Table 116: 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**			
Cesspools and septic tanks	8.32	7.33	6.96	6.59	6.23	5.86	5.50			

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). 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 2006 were extrapolated from the 2001-2004 time series.

Until 1995, data for the old and new Federal Länder were collected 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 (Tier 1) in conformance with the requirements of the QSE manual and its associated applicable documents has been carried out.

The MCF for cesspools and septic tanks in Germany was derived on the basis of an evaluation of national inventory reports of other countries (cf. Chapter 14.6.2).

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)

Extensive recalculations were reported in the NIR 2004 (UBA, 2004a). Recalculations, for the period 2002 to 2005, were recently carried out in order to take account of new activity data for 2004 (cf. the following Table).

Table 117: Source-specific recalculations in 6.B.2

Methane emissions: [kt CH_4]	2002	2003	2004	2005	2006
Cesspools and septic tanks (NEW)	6.96	6.59	6.23	5.86	5.50
Cesspools and septic tanks (OLD)	6.33	5.33	4.34	4.34	
Difference	+0.63	+1.26	+1.89	+1.52	

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 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, and liming helps to stabilise such waste.

Sludge stabilisation is carried out in order to prevent uncontrolled putrefaction. In facilities < 10,000 inhabitants, such stabilisation is usually carried out aerobically, with energy consumption, while for facilities > 30,000 inhabitants it is normally 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 eastern Germany in the early 1990s, 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 biological wastewater treatment is managed in the following three ways (where applicable, after dehydration and stabilisation):

- Landfill storage: 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 118 lists the emission factors for open sludge digestion and the methane emissions determined for that process.

Table 118: 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)[51]. 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 uncertainties for calculation of emissions from open sludge digestion in eastern Germany have not been estimated to date.

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

8.2.2.2.5 Source-specific recalculations (6.B.2)

Extensive recalculations were reported in the NIR 2004 (UBA, 2004a). No recalculations were carried out for the present report.

51 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.

8.2.2.2.6 Planned improvements (6.B.2)

At present, improvements seem neither necessary nor possible, since no further activity data can be obtained.

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 an auxiliary product of municipal wastewater treatment, especially in connection with denitrification, in which gaseous end products – but, mainly, molecular nitrogen – 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 Länder-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)[52] 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[53] 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 119).[54]

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 Länder-specific values in the food table and in the 2000 nutrition report are more precise or enjoy greater national acceptance.

Table 119: 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**			
	99	100	100	100	*100*	*100*	*100*			

Numbers in italics: Extrapolated or automatically extended values

(FAO, 2004)

52 The nutrition report is published every four years.

53 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).

54 FAO Statistical Yearbook 2004 Vol.1/1 http://www.fao.org/statistics/yearbook/vol_1_1/index.asp; September 2007

Table 120: 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**			
	82,260	82,440	82,537	82,532	82,501	82,438	82,315			

(DESTATIS, 1991-2006)

The nitrous oxide emissions can be determined with the aid of Table 119 and Table 120 and the IPCC method; cf. Table 121.

$$N_2O_{(s)} = Protein \ x \ Frac_{NPR} x \ NR_{PEOPLE} x \ EF_6$$

where:

$$N_2O_{(s)} = N_2O \ emissions \ in \ human \ wastewater \ (kg \ N_2O - N / a)$$
$$Protein = annual \ protein \ intake \ (kg / person / a)$$
$$NR_{PEOPLE} = number \ of \ inhabitants \ in \ the \ country$$
$$EF_6 = emission factor \ (default \ 0.01 \ (0.002 - 0.12) \ kg \ N_2O - N / kg \ produced \ wastewater - N)$$
$$Frac_{NPR} = oxygen \ fraction \ in \ protein \ (default = 0.16 \ kg \ N / kg \ protein)$$

Table 121: 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 have been obtained by carrying over the FAO's published data for 2003.

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)

Since the quality of some data, and of the pertinent data-collection methods, has improved by comparison to the 2006 report, the reporting quality has improved by comparison to the previous year. At the same time, data as of 2004 are carryover values, because relevant current data are lacking, and thus a certain uncertainty prevails. 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 be any larger than a figure of about the same magnitude.

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 (cf. Annex, Table 167).

8.2.2.3.5 Source-specific recalculations (6.B.2)

Recalculations until 1990 have been carried out, and the data as of 2004 carried over, with the help of data, published by the FAO in 2007, on average protein intake per person and day for the periods 1989-1991 and 2001-2003 (FAO Yearbook 2004, published in 2007) .

The resulting N_2O emissions for the aforementioned period were recalculated on the basis of these updates and the latest population figures for Germany for the period 1990 to 2006. The relevant data is presented in Table 8a of the CRF reporting tables.

The following comparison of the two tables shows the relevant changes.

N_2O emissions [t N_2O]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
NEW	7,173	7,220	7,357	7,390	7,408	7,433	7,451	7,455	7,453	7,465
OLD	7,173	7,146	7,134	6,867	7,109	7,058	7,225	6,853	7,228	7,239
Difference	0	+74	+223	+523	+299	+375	+226	+602	+225	+226
	2000	2001	2002	2003	2004	2005	2006			
NEW	7,474	7,566	7,575	7,574	7,571	7,566	7,554			
OLD	7,247	7,414	7,423	7,347	7,344	7,338				
Difference	+227	+152	+152	+227	+227	+228				

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 inputs; 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.

Figure 58: Structural allocation for 6.D: Other areas

8.4.1 Other areas – composting systems (6.D)

8.4.1.1 Source category description (6.D.1)

In Germany, annually increasing fractions of biodegradable waste are being managed in composting systems. For this reason, the 2006 inventory included a first report on CH_4 and N_2O emissions from composting of municipal waste in composting systems, 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 systems. Since 2000, data on pertinent inputs of kitchen waste and plant waste (garden and park waste), and on waste inputs in composting and fermentation plants, 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.

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. In this project, research is being conducted to obtain pertinent literature data, and measurements of composting systems are being carried out. The project aim is to produce emission factors based on measured emissions from real systems. New emission factors for both gases are thus expected to come out of the project.

8.4.2 Other areas – mechanical-biological waste treatment (MBT) (6.D.2)

8.4.2.1 Source category description (6.D.2)

Since 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 fulfill 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. No data from the Federal Statistical Office are yet available for the year 2006, however. The Federal Environment Agency estimates that some 5 million tonnes of waste were treated in MBT systems in 2006.

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, 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 lie considerably below those standards. The only uncertainties are found in the question of the extent to which emissions during actual plant operations lie below the standards. At present, the uncertainties for the year 2005 cannot be quantified, for the reasons described above. Such quantification is planned for the coming year, however, and will be carried out on the basis of experience then gained with conformance with the 30th BImSchV in practice.

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.

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 other specified source categories.

10 RECALCULATIONS AND IMPROVEMENTS

In the following section, recalculations based on quantitatively effective inventory improvements are documented that occurred between the inventory calculations for the 2007 report year and those for the 2008 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. This 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 also become necessary when more precise data are included, when manual transfer errors are corrected and when key-category analysis reveals a need to change methods for individual source categories. In addition, a range of 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.
- The source category has become a key category, thus making a change of methods necessary.
- New country-specific calculation procedures need to be used.
- Indications and results of 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 2007 report year, by source categories

This year, as in the previous year, recalculations are based primarily on improvements in details. The inventories contain improvements in the following areas:

Energy:

- All activity data for electricity production from heating oil have been updated in keeping with Energy Balance updates (1.A.1, 1.A.2).
- The activity data for electricity production from heating oil have been corrected for 1995 (1.A.1).
- The activity data for inputs of household and municipal waste, as fuel inputs, have been updated for 2005 (1.A.1).
- The CO_2 emission factors for raw lignite from Helmstedt have been updated (1.A.1).
- The activity data for lignite drying have been updated for 2005 (1.A.1.c).
- The activity data for the entire time series in the areas Iron and steel industry (1.A.2.a), Non-ferrous metals (1.A.2.b) and Sugar production (1.A.2.e) have been updated.
- The activity data for the entire time series in the areas of cement, glass, ceramics and others have been updated (1.A.2.f, all).
- The CO_2 emission factor for jet kerosene in national air transports has been updated for the years 1990 to 1999 (1.A.3a).
- The CH_4 emission factors for construction-sector transports have been updated for the period as of 1995 (1.A.3e).
- The activity data in the area of Other combustion systems have been updated for 2004 and 2005 (1.A.4).
- The activity data in the military sector have been updated for 2005 (1.A.5).
- The activity data for the source category Coal mining and handling have been updated (1.B.1.a).
- The CH_4 emissions from decommissioned hard-coal mines as of 1998 have been recalculated (1.B.1.c).

Industrial processes:

- The N_2O emissions from caprolactam production for the period 1991-2005 have been recalculated for the area of emissions from other production processes (2.B.5).
- The HFC emissions from industrial refrigeration systems have been recalculated for 2003 and 2004 (2.F.1).
- The figures for emissions of individual gases from commercial refrigeration systems have been corrected for 1998 and 2005 (2.F.1).
- The implied emission factors (IEF) for the entire area of Consumption of halocarbons and SF_6 have been recalculated (2.F.1 – 2.F.7).
- The activity data – and, thus, the emissions data – for the period 1990 to 2005 have been recalculated (2.F.7).

- The emissions data in the area of electrical equipment have been recalculated for 2005 (2.F.7).

Solvent and other product use:

- No recalculations

Agriculture:

- No recalculations

Land use, land-use changes and forestry:

- No recalculations

Waste and wastewater:

- The entire CH_4 time series has been recalculated, via a revised Tier-2 method.
- The activity data in the area of Managed disposal in landfills – landfilling of municipal waste (6.A.1) have been updated, and supplemented with new data.
- Certain individual waste fractions in the area Managed disposal in landfills – landfilling of municipal waste have been included for the first time, with such inclusion extending retroactively to 1980 (6.A.1).
- New data sources for the years 1975 to 1990 have been included (6.A.1).
- The calculation model for the area Managed disposal in landfills – landfilling of municipal waste (6.A.1) has been improved, and the time period considered has been extended back to 1950.
- The activity data for the area of Methane emissions from municipal wastewater treatment (6.B.2) have been updated for the period as of 2002.
- The activity data for the area of Nitrous oxide emissions from municipal wastewater treatment (6.B.2) have been updated for the period as of 1990.

The activity data for the areas of Composting systems (6.D.1) and Mechanical-biological waste treatment (6.D.2) have been updated for 2004 and 2005.

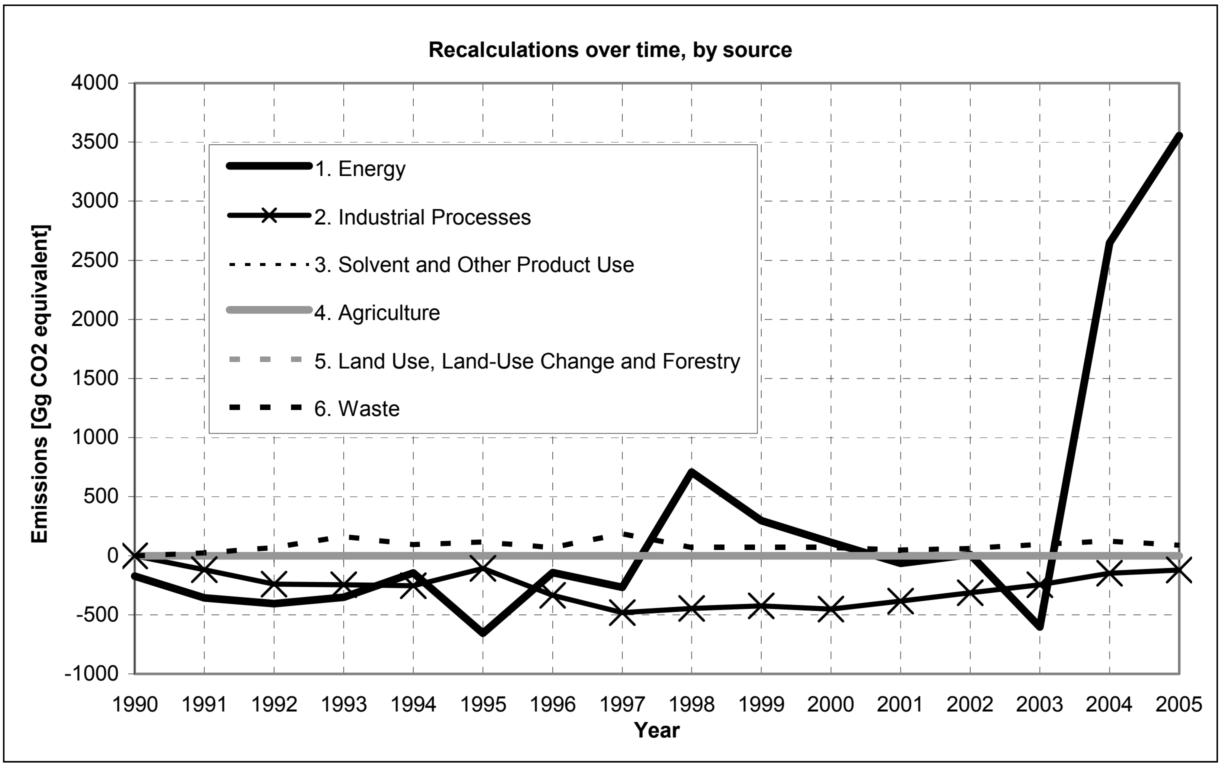


Figure 59: Change in total emissions, for all categories, and for the entire time series, in comparison to the relevant figures in the 2007 report

10.1.3 Recalculations in the 2007 report year, by gases

Most of the recalculations made this year have to do with carbon dioxide emissions.

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

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 "waste" 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 122: Inventory recalculations with respect to last year's report

	Base year (1990/ 1995)	2004
	[Gg CO_2 equivalent]	
Total	-0.01%	0.46%
CO_2	-0.02%	0.44%
CH_4	0.00%	0.10%
N_2O	0.00%	-0.57%
HFC, PFC, SF_6	-0.14%	-0.02%

Source: own calculations; emissions do not include LULUCF

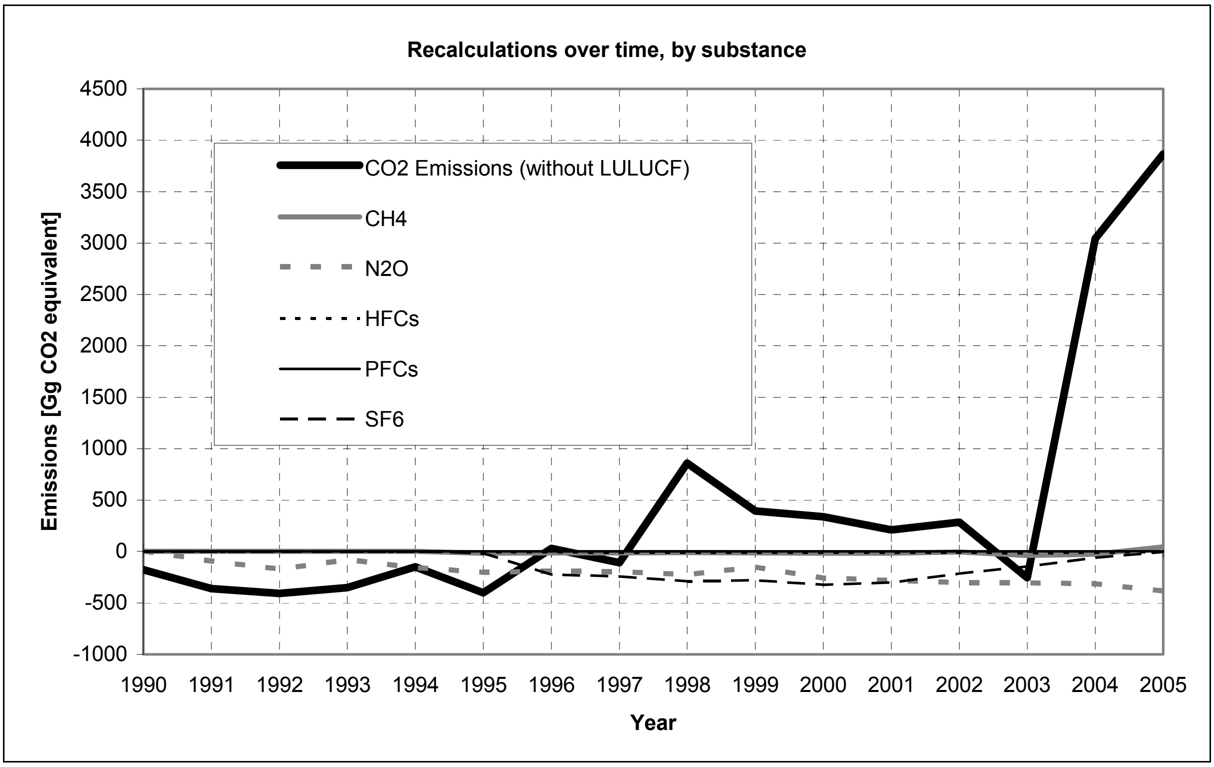


Figure 60: Change in pollutant-specific total emissions, for all source categories, and for the entire time series, in comparison to the relevant figures in the 2007 report

10.1.4 Recalculations to implement results of the review process

Some recalculations have been made in direct response to requirements identified in past reviews:

- The CO_2 emission factor for jet kerosene has been adjusted. Such correction was carried out in textual form in the NIR 2007. In the present inventory report, the recalculations are carried out in the CRF Tables.

10.2 Impact at the emissions level

The inventory has been considerably improved with regard to completeness and accuracy. Emissions increases have resulted from updating of Energy Balances and of the calculations based on those balances.

Table 123: Inventory recalculations, in time series, with respect to last year's report

	Total national emissions of greenhouse gases, not including carbon dioxide from LULUCF		
	2007 submission	2008 submission	Recalculation / difference
	[Gg CO_2 equivalent]	[Gg CO_2 equivalent]	[%]
1990	1,228,235.33	1,228,063.02	-0.01
1991	1,180,420.74	1,179,969.14	-0.04
1992	1,129,912.79	1,129,336.49	-0.05
1993	1,116,782.17	1,116,347.71	-0.04
1994	1,098,429.74	1,098,124.32	-0.03
1995	1,096,029.35	1,095,385.40	-0.06
1996	1,115,461.73	1,115,055.27	-0.04
1997	1,078,309.94	1,077,745.91	-0.05
1998	1,052,352.20	1,052,680.36	0.03
1999	1,021,044.44	1,020,986.54	-0.01
2000	1,020,185.99	1,019,915.63	-0.03
2001	1,037,157.18	1,036,756.03	-0.04
2002	1,017,935.85	1,017,691.90	-0.02
2003	1,031,274.05	1,030,520.65	-0.07
2004	1,025,378.39	1,028,005.47	0.26
2005	1,001,897.31	1,005,422.04	0.35

Source: own calculations; does not include carbon dioxide from LULUCF

No recalculations were carried out in the area of LULUCF.

In the area of informational communications, recalculations were carried out only for carbon dioxide and, in that area, solely with regard to listing of emissions from international air transports and from biomass:

Table 124: Recalculations of additional (for informational purposes) inventory data with respect to last year's report

	1990	2005
	Changes in CO_2 [Gg]	
Emissions from international transports	-0.59%	±0.00%
Air transports	-0.99%	±0.00%
Sea transports	±0.00%	±0.00%
Multilateral missions	NE	NE
CO_2 emissions from biomass	-0.05%	+12.11%

Source: Own calculations

The change in the area of international air transports in 1990 is in keeping with the change for national air transports. In the latter area, the CO_2 emission factor for jet kerosene was adjusted, and relevant recalculations were carried out for the years 1990 to 1999 (cf. Chapter 3.1.5.1.5).

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 -0.014 % – as a result of the methodological corrections.

Most of the changes occurred in the energy sector. The changes in that area included changes in the CO_2 emission factors for jet kerosene and for lignite from Helmstedt.

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 125: Recalculation of source-category-specific total emissions, for all gases in 1990

	Reported 2007 [Gg]	Reported 2008 [Gg]	Change, in CO_2 equivalents [Gg]	Change [%]
Total national emissions (not including LULUCF)	**1,227,860**	**1,227,688**	**-172.1**	**-0.014%**
1. Energy	987,864	987,692	-172.0	-0.017%
2. Industrial processes	119,799	119,799	-0.1	-0.000%
3. Solvent and other product use	2,089	2,089	±0.0	±0.000%
4. Agriculture	77,685	77,685	±0.0	±0.000%
5. Land-use changes and forestry	-28,241	-28,241	±0.0	±0.000%
6. Waste	40,423	40,423	±0.0	±0.000%

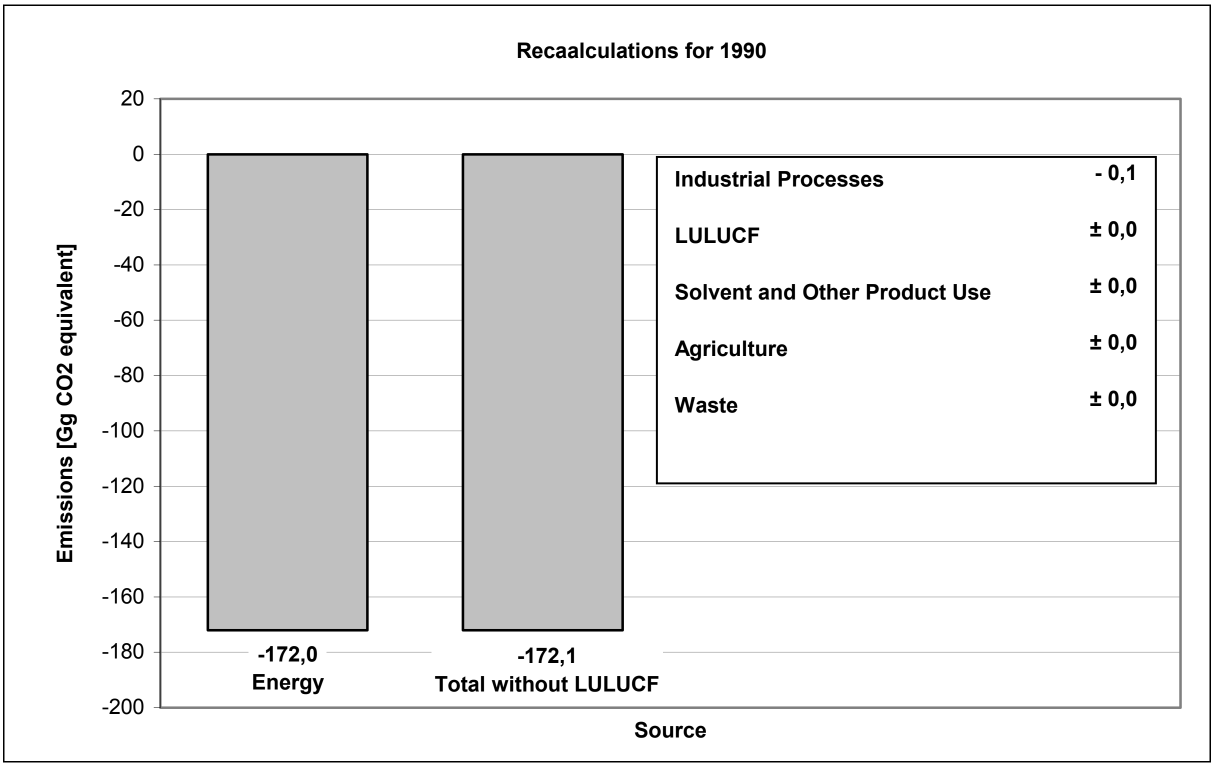


Figure 61: Recalculations of all greenhouse gases for 1990

10.2.2 *Impacts on 2005 emissions levels*

In comparison to the 2007 submission, total emissions for 2005, not including LULUCF, increased by 0.35 %.

Most of the changes occurred in the energy sector. In that sector, the changes included a lowering of the CO_2 emission factor for lignite from Helmstedt.

Additional information about recalculations is provided in CRF tables 8(a)s1, 8(a)s2 and 8(b) and in the following table.

Table 126: Recalculation of source-category-specific total emissions, for all gases in 2005

	Reported 2007 [Gg]	Reported 2008 [Gg]	Change, in CO_2 equivalents [Gg]	Change [%]
Total national emissions (not including LULUCF)	1,001,476	1,005,000	+3,524.7	+0.35%
1. Energy	815,807	819,362	+3,554.7	+0.44%
2. Industrial processes	107,258	107,139	-119.2	-0.11%
3. Solvent and other product use	1,174	1,174	±0.0	±0.00%
4. Agriculture	63,542	63,542	±0.0	±0.00%
5. Land-use changes and forestry	-36,076	-36,076	±0.0	±0.00%
6. Waste	13,694	13,783	+89.2	+0.65%

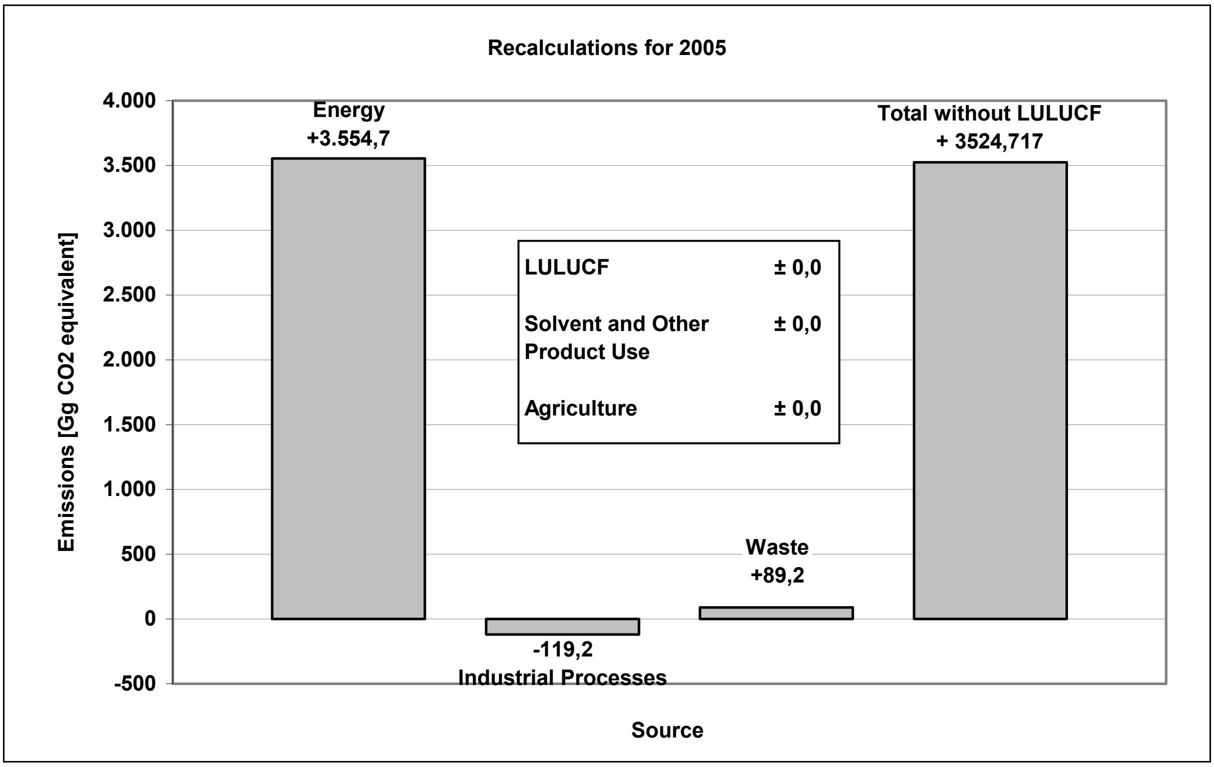


Figure 62: Recalculations of all greenhouse gases for 2005

10.3 Impacts on emissions trends and on time-series consistency

The time-series consistency has improved as a result of the recalculations. In the area of waste / wastewater, methods were adjusted for the entire time series. In the glass-industry sector, methods were adjusted for part of the time series. These changes had the effect of reducing existing time-series discontinuities. At the same time, this led to some changes in source-category-specific trends, although trends at higher aggregation levels were simply weakened somewhat.

In the sum result, the overall trend, with respect to the base year, shows a reduction of 18.4 %. CO_2 emissions have increased slightly with respect to the previous year. On the other hand, emissions of N_2O, CH_4 and – especially – PFCs have decreased. HFC and SF_6 emissions show especially marked increases.

10.4 Planned inventory improvements

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.

Planned specific improvements are described in the chapters for the relevant source categories.

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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*"[55] (*Good Practice Guidance*), the Parties to the Framework Convention on Climate Change, and in future to the Kyoto Protocol as well, are obliged to calculate and publish annual emissions data.

These emissions inventories must be comprehensible to everyone (transparency), calculated in a comparable manner in the time series since 1990 (consistency), be evaluated uniformly at international level via application of the prescribed calculation methods (comparability), contain all the relevant emission sources and sinks in the reporting country (completeness), and be evaluated with error specification and be subject to permanent internal and external quality management (accuracy).

In order to be able to concentrate the many and detailed activities and resources required for this purpose on the principal source categories of the inventory, the IPCC has introduced the definition of a "key category". This refers to those source categories which are highlighted in the national inventory system because their emissions have a significant influence on the total emission of direct greenhouse gases, either in terms of absolute emissions, or as a contribution to the emissions trend over time, or in both ways.

To this end, the Good Practice Guidance specifies, in chapter 7, the methods to be applied for determining key categories. 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 run-through, only emissions from sources are evaluated, and storage in sinks is not considered. In a second run-through, 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 categories.

For identified key categories, the Parties are then required to use highly detailed calculation methods (Tier 2 or higher). 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-category analysis performed overall, must be outlined in the national inventory report to be prepared annually.

[55] 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 has been published on the Internet at: http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm

12.1 Description of the method for determining key categories

The results of the key-category analysis based on the two Tier 1 techniques (Level and Trend) are outlined below. We also refer the reader to the description of the underlying methods in the *Good Practice Guidance*. In a departure from that source's proposal for the structure of the relevant source categories, a greater degree of detail was chosen for the present analysis. Annual emissions inventories were divided, in keeping with their CO2-equivalent emissions, into a total of 114 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 (als CO_2-equivalent emissions), in the Kyoto Protocol's base year and in 2006, are identified as key categories (●). Calculations were performed using formula 7.1 from the Good Practice Guidance.

In the source category summary used in this analysis, a total of 26 key categories were identified in 2006 using this approach (cf. Table 127).

Table 127: Key categories for Germany (2006) based on the Tier 1 Level Approach (without sinks)

IPCC Source Categories	Activity	Emissions Of	2006 [Gg CO_2 Eqiv.]#	Level Assesment	Key Source Decision
1A1a Public electricity and Heat production	all fuels	CO2	329294.5	31.42	●
1A3b. Transport Road Transportation	all fuels	CO2	148881.7	14.21	●
1A4b. Other Sectors Residential	all fuels	CO2	117164.2	11.18	●
1A2f. Manufacturing Industries and Construction Other	all fuels	CO2	88548.5	8.45	●
1A4a. Other Sectors Commercial/Institutional	all fuels	CO2	45976.0	4.39	●
2C1. Metal Production Iron and Steel Production	Steel (integrated production)	CO2	44859.2	4.28	●
5.B Cropland		CO2	25007.1	2.39	●
4D1. Agricultural Soils	Direct Soil Emissions	N2O	23985.0	2.29	●
1A1b. Petroleum Refining	all fuels	CO2	20223.9	1.93	●
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CO2	16620.5	1.59	●
5.C Grassland		CO2	16598.1	1.58	●
2A1. Mineral Products Cement Production		CO2	13208.2	1.26	●
4D3. Agricultural Soils	Indirect Emissions	N2O	12462.9	1.19	●
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CO2	11664.2	1.11	●
2B5 Chemical Industry	Other	CO2	10143.2	0.97	●
4A.1. Enteric Fermentation	Dairy Cattle	CH4	10083.9	0.96	●
6 A1 Managed Waste Disposal on Land		CH4	9618.0	0.92	●
2F. Industrial Processes	Consumption of Halocarbons and SF6	HFC´s	9522.7	0.91	●
2B2 Chemical Industry	Nitric Acid Production	N2O	8478.7	0.81	●
4A.1. Enteric Fermentation	Non-Dairy Cattle	CH4	6867.5	0.66	●
1.B.2.b. (all) Fugitive Emissions from Fuels, Natural Gas	Natural Gas	CH4	6710.6	0.64	●
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CO2	6498.2	0.62	●
2A2. Mineral Products Lime Production		CO2	5502.1	0.52	●
1A3a. Transport Civil Aviation	Aviation Gasoline	CO2	5289.7	0.50	●

IPCC Source Categories	Activity	Emissions Of	2006 [Gg CO_2 Eqiv.][#]	Level Assesment	Key Source Decision
2B1. Chemical Industry	Ammonia production	CO2	5137.7	0.49	•
1B1a. Fugitive Emissions from Fuels Coal Mining and Handling	Solid Fuels	CH4	4835.0	0.46	
1A3e. Transport Other Transportation	all fuels	CO2	4343.5	0.41	
1A1a Public electricity and Heat production	all fuels	N2O	3607.7	0.34	
2B3 Chemical Industry	Adipic Acid Production	N2O	3003.9	0.29	
2C4. SF6 Used in Aluminium and Magnesium Foundries		SF6	2604.2	0.25	
2F. Industrial Processes	Consumption of Halocarbons and SF6	SF6	2520.9	0.24	
6B Wastewater Handling	Domestic and Commercial Wastewater	N2O	2341.8	0.22	
4B1. Manure Management	Dairy Cattle	CH4	1682.8	0.16	
1A5 Other Include Military fuel use under this category	all fuels	CO2	1546.2	0.15	
4B8. Manure Management	Swine	CH4	1545.5	0.15	
4B1. Manure Management	Non-Dairy Cattle	CH4	1476.7	0.14	
4D2. Agricultural Soils	Animal Production	N2O	1396.7	0.13	
4A.2. Enteric Fermentation	other animals	CH4	1390.7	0.13	
1A3c. Transport Railways	all fuels	CO2	1271.6	0.12	
3D.Total Solvent and Other Product Use		N2O	1174.0	0.11	
1A3b. Transport Road Transportation	all fuels	N2O	1096.9	0.10	
4B13. Manure Management Other	Other Cattle	N2O	932.2	0.09	
2A7. Glass Production		CO2	925.5	0.09	
1A3d. Transport Navigation	Diesel Oil	CO2	855.1	0.08	
1A2f. Manufacturing Industries and Construction Other	all fuels	N2O	792.1	0.08	
4B13. Manure Management Other	Dairy Cows	N2O	779.7	0.07	
2C3. Aluminium Production		CO2	706.0	0.07	
1A4b. Other Sectors Residential	all fuels	CH4	678.3	0.06	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	CO2	636.2	0.06	
6 A3 Other - Composting		CH4	556.4	0.05	
4B13. Manure Management Other	Poultry	N2O	543.8	0.05	
5.F Other Land		CO2	530.8	0.05	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CO2	527.9	0.05	
4B13. Manure Management Other	Swine	N2O	470.9	0.04	
1A4b. Other Sectors Residential	all fuels	N2O	438.7	0.04	
5, Land-Use Change and Forestry		N2O	421.6	0.04	
2F. Industrial Processes	Consumption of Halocarbons and SF6	PFC´s	394.0	0.04	
2A7. Bricks and Tiles Production	limesto-input	CO2	392.4	0.04	
6 A3 Other - Composting		N2O	362.9	0.03	
4B13. Manure Management Other	other animals	N2O	309.0	0.03	
2E. Production of Halocarbons and SF6	production of HCFC-22	HFC´s	291.0	0.03	
4B2. Manure Management	other animals	CH4	249.0	0.02	
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	N2O	230.1	0.02	
2E. Production of Halocarbons and SF6	Fugitive emissions	SF6	215.1	0.02	
2C3. Aluminium Production		PFC´s	188.2	0.02	
1A3b. Transport Road Transportation	all fuels	CH4	155.5	0.01	
1.B.2.a. (all) Fugitive Emissions from Fuels, Oil	Oil	CH4	130.2	0.01	

IPCC Source Categories	Activity	Emissions Of	2006 [Gg CO_2 Eqiv.][#]	Level Assesment	Key Source Decision
1A4a. Other Sectors Commercial/Institutional	all fuels	N2O	115.7	0.01	
6B Wastewater Handling	Domestic and Commercial Wastewater	CH4	115.4	0.01	
1A1a Public electricity and Heat production	all fuels	CH4	112.8	0.01	
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	N2O	104.0	0.01	
5.G Other (please specify)		CO2	93.1	0.01	
1B1c. Fugitive Emissions from Fuels Other (Abandoned Mines)	Solid Fuels	CH4	82.8	0.01	
1A3a. Transport Civil Aviation	Aviation Gasoline	N2O	78.1	0.01	
2B5 Chemical Industry	other	N2O	67.8	0.01	
1A1b. Petroleum Refining	all fuels	N2O	64.8	0.01	
1A2f. Manufacturing Industries and Construction Other	all fuels	CH4	60.4	0.01	
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CH4	50.3	0.00	
1A4a. Other Sectors Commercial/Institutional	all fuels	CH4	42.7	0.00	
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	N2O	30.7	0.00	
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CH4	25.7	0.00	
1A3e. Transport Other Transportation	all fuels	N2O	23.0	0.00	
2B4 Chemical Industry	Carbide Production	CO2	17.5	0.00	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CO2	17.1	0.00	
1A5 Other Include Military fuel use under this category	all fuels	N2O	10.5	0.00	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	N2O	9.3	0.00	
1A1b. Petroleum Refining	all fuels	CH4	8.5	0.00	
1B1b. Fugitive Emissions from Fuels Solid Fuel Transformation	Solid Fuels	CH4	8.5	0.00	
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CH4	8.0	0.00	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	N2O	6.2	0.00	
1A3c. Transport Railways	all fuels	N2O	5.3	0.00	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	N2O	5.2	0.00	
1A5 Other Include Military fuel use under this category	all fuels	CH4	5.2	0.00	
1A3e. Transport Other Transportation	all fuels	CH4	4.5	0.00	
1A3d. Transport Navigation	Diesel Oil	N2O	3.6	0.00	
2C2. Ferroalloys Production	Ferroalloys	CO2	2.8	0.00	
2C1. Metal Production Iron and Steel Production	other	CH4	2.1	0.00	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CH4	1.8	0.00	
1A3a. Transport Civil Aviation	Aviation Gasoline	CH4	1.4	0.00	
2C5. Other		HFC 134a	1.1	0.00	
1A3d. Transport Navigation	Diesel Oil	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	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CH4	0.2	0.00	
1.B.2.a. (all) Fugitive Emissions from Fuels, Oil	Oil	CO2	0.0	0.00	
1B2c. Fugitive Emissions from Fuels Venting and Flaring	Venting and Flaring	CH4	0.0	0.00	
1.B.2.d. Other	Stadtgas	CH4	0.0	0.00	
2A4. Soda Ash		CO2	0.0	0.00	
2E. Production of Halocarbons and SF6		PFC´s	0.0	0.00	

IPCC Source Categories	Activity	Emissions Of	2006 [Gg CO_2 Eqiv.]#	Level Assesment	Key Source Decision
4G. Other	Other	N2O	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 2006, in terms of the development of their contribution since the base year, are identified as key categories (●). 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.

In the source category summary used in this analysis, a total of 35 key categories have been identified using this approach (cf. Table 128).

Table 128: Key categories for Germany (base year & 2006) pursuant to the Tier 1 Trend approach (not including sinks)

IPCC Source Categories	Activity	Emissions Of	Base Year [Gg CO_2 Equi.]#	2006 [Gg CO_2 Equi.]#	Prozent Absolute	Key Source Decission
1A1a Public electricity and Heat production	all fuels	CO2	335864.1	329,294.465	19.48735	•
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CO2	59066.1	16,620.478	11.50728	•
1A3b. Transport Road Transportation	all fuels	CO2	150358.3	148,881.713	9.25370	•
1A2f. Manufacturing Industries and Construction Other	all fuels	CO2	138312.0	88,548.457	8.99551	•
6 A1 Managed Waste Disposal on Land		CH4	35910.0	9,618.000	7.17202	•
2B3 Chemical Industry	Adipic Acid Production	N2O	18804.6	3,003.907	4.49089	•
1A4b. Other Sectors Residential	all fuels	CO2	129474.0	117,164.176	3.97592	•
1B1a. Fugitive Emissions from Fuels Coal Mining and Handling	Solid Fuels	CH4	18415.2	4,835.005	3.71309	•
1A5 Other Include Military fuel use under this category	all fuels	CO2	11797.8	1,546.188	2.93993	•
2F. Industrial Processes	Consumption of Halocarbons and SF6	HFC´s	2253.2	9,522.662	2.77600	•
1A4a. Other Sectors Commercial/Institutional	all fuels	CO2	63949.6	45,976.017	2.33804	•
2C1. Metal Production Iron and Steel Production	Steel (integrated production)	CO2	48326.0	44,859.172	1.89191	•
2B2 Chemical Industry	Nitric Acid Production	N2O	4673.4	8,478.672	1.68057	•
2B5 Chemical Industry	Other	CO2	6783.1	10,143.246	1.65689	•
1A1b. Petroleum Refining	all fuels	CO2	20005.9	20,223.927	1.38118	•
5.B Cropland		CO2	26534.2	25,007.138	1.17495	•
2E. Production of Halocarbons and SF6	production of HCFC-22	HFC´s	4218.5	291.000	1.14594	•
2F. Industrial Processes	Consumption of Halocarbons and SF6	SF6	6873.4	2,520.871	1.12683	•
1A3a. Transport Civil Aviation	Aviation Gasoline	CO2	2868.6	5,289.733	1.06244	•
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CO2	10917.1	6,498.242	0.88761	•
2C4. SF6 Used in Aluminium and Magnesium Foundries		SF6	197.1	2,604.216	0.88347	•
6B Wastewater Handling	Domestic and Commercial Wastewater	CH4	2226.2	115.435	0.61854	•
1B1c. Fugitive Emissions from Fuels Other (Abandoned Mines)	Solid Fuels	CH4	1806.8	82.814	0.50595	•
5.C Grassland		CO2	18555.2	16,598.121	0.50003	•
2B1. Chemical Industry	Ammonia production	CO2	4596.4	5,137.710	0.49500	•
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CO2	12577.9	11,664.172	0.48829	•
4A.1. Enteric Fermentation	Non-Dairy Cattle	CH4	9985.6	6,867.474	0.47778	•
4D1. Agricultural Soils	Direct Soil Emissions	N2O	27711.2	23,984.980	0.45615	•
1.B.2.b. (all) Fugitive Emissions from Fuels, Natural Gas	Natural Gas	CH4	6781.5	6,710.598	0.41580	•
1A3c. Transport Railways	all fuels	CO2	2879.3	1,271.616	0.39405	•

IPCC Source Categories	Activity	Emissions Of	Base Year [Gg CO_2 Equi.][#]	2006 [Gg CO_2 Equi.][#]	Prozent Absolute	Key Source Decission
2C3. Aluminium Production		PFC´s	1551.7	188.235	0.39215	•
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	CO2	1989.2	636.150	0.35991	•
1A4a. Other Sectors Commercial/Institutional	all fuels	CH4	1216.1	42.654	0.34526	•
1A3b. Transport Road Transportation	all fuels	CH4	1271.1	155.465	0.32077	•
1A3d. Transport Navigation	Diesel Oil	CO2	2049.8	855.144	0.29866	
1A3e. Transport Other Transportation	all fuels	CO2	4302.3	4,343.469	0.29497	
2A1. Mineral Products Cement Production		CO2	15145.8	13,208.179	0.28511	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CO2	1599.7	527.897	0.28352	
1A1a Public electricity and Heat production	all fuels	N2O	3658.4	3,607.671	0.21979	
1A3b. Transport Road Transportation	all fuels	N2O	608.4	1,096.924	0.21631	
3D.Total Solvent and Other Product Use		N2O	2088.5	1,174.007	0.19482	
6B Wastewater Handling	Domestic and Commercial Wastewater	N2O	2223.5	2,341.791	0.18752	
6 A3 Other - Composting		CH4	49.8	556.367	0.18647	
2A2. Mineral Products Lime Production		CO2	6135.0	5,502.059	0.17043	
6 A3 Other - Composting		N2O	14.0	362.939	0.12713	
1A2f. Manufacturing Industries and Construction Other	all fuels	N2O	1391.7	792.106	0.12626	
2C2. Ferroalloys Production	Ferroalloys	CO2	429.0	2.750	0.12625	
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	N2O	702.5	230.101	0.12514	
2B4 Chemical Industry	Carbide Production	CO2	443.2	17.526	0.12510	
1A4b. Other Sectors Residential	all fuels	CH4	1200.4	678.347	0.11068	
2A7. Glass Production		CO2	755.5	925.464	0.11064	
4A.1. Enteric Fermentation	Dairy Cattle	CH4	12653.6	10,083.882	0.10573	
4B1. Manure Management	Non-Dairy Cattle	CH4	2128.6	1,476.719	0.09722	
4B13. Manure Management Other	Dairy Cows	N2O	1275.9	779.663	0.09643	
4D3. Agricultural Soils	Indirect Emissions	N2O	14906.4	12,462.902	0.08657	
2F. Industrial Processes	Consumptio n of Halocarbons and SF6	PFC´s	197.9	394.044	0.08383	
1A4b. Other Sectors Residential	all fuels	N2O	801.9	438.670	0.07918	
4B8. Manure Management	Swine	CH4	1620.6	1,545.506	0.07833	
4B13. Manure Management Other	Other Cattle	N2O	1390.6	932.188	0.07529	
4A.2. Enteric Fermentation	other animals	CH4	1444.1	1,390.655	0.07467	
1A5 Other Include Military fuel use under this category	all fuels	CH4	236.8	5.188	0.06836	
2B5 Chemical Industry	other	N2O	298.5	67.766	0.06401	
4B13. Manure Management Other	other animals	N2O	211.1	308.985	0.04914	
2C3. Aluminium Production		CO2	1011.9	705.953	0.04479	
4B1. Manure Management	Dairy Cattle	CH4	1906.3	1,682.786	0.04325	

IPCC Source Categories	Activity	Emissions Of	Base Year [Gg CO_2 Equi.]#	2006 [Gg CO_2 Equi.]#	Prozent Absolute	Key Source Decission
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CH4	176.9	25.744	0.04315	
5, Land-Use Change and Forestry		N2O	374.9	421.610	0.04131	
1A1b. Petroleum Refining	all fuels	N2O	210.7	64.751	0.03906	
4B13. Manure Management Other	Poultry	N2O	533.0	543.810	0.03860	
5.F Other Land		CO2	530.8	530.824	0.03455	
4B13. Manure Management Other	Swine	N2O	682.1	470.878	0.03199	
1A2f. Manufacturing Industries and Construction Other	all fuels	CH4	180.9	60.434	0.03180	
2E. Production of Halocarbons and SF6	Fugitive emissions	SF6	167.3	215.100	0.02818	
4B2. Manure Management	other animals	CH4	225.5	249.045	0.02321	
1A3a. Transport Civil Aviation	Aviation Gasoline	N2O	18.2	78.113	0.02285	
1.B.2.a. (all) Fugitive Emissions from Fuels, Oil	Oil	CH4	226.6	130.221	0.02010	
2A7. Bricks and Tiles Production	limesto-input	CO2	531.1	392.429	0.01559	
1A5 Other Include Military fuel use under this category	all fuels	N2O	64.4	10.478	0.01532	
5.G Other (please specify)		CO2	163.6	93.132	0.01483	
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	N2O	158.3	104.004	0.00932	
4D2. Agricultural Soils	Animal Production	N2O	1682.4	1,396.696	0.00619	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	N2O	25.6	6.177	0.00537	
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CH4	27.1	8.005	0.00515	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CO2	3.6	17.109	0.00511	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	N2O	17.8	5.233	0.00339	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	N2O	2.9	9.347	0.00251	
1B1b. Fugitive Emissions from Fuels Solid Fuel Transformation	Solid Fuels	CH4	18.1	8.541	0.00228	
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CH4	54.6	50.338	0.00201	
1A3c. Transport Railways	all fuels	N2O	12.6	5.327	0.00182	
1A3e. Transport Other Transportation	all fuels	CH4	9.8	4.471	0.00128	
1A3d. Transport Navigation	Diesel Oil	N2O	8.6	3.582	0.00125	
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	CH4	3.8	0.450	0.00095	
1A4a. Other Sectors Commercial/Institutional	all fuels	N2O	144.2	115.661	0.00094	
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	N2O	40.5	30.685	0.00092	
1A1b. Petroleum Refining	all fuels	CH4	13.3	8.549	0.00085	
1A3c. Transport Railways	all fuels	CH4	2.3	0.577	0.00048	
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CH4	0.5	1.759	0.00047	
1A3e. Transport Other Transportation	all fuels	N2O	26.5	23.030	0.00047	

IPCC Source Categories	Activity	Emissions Of	Base Year [Gg CO_2 Equi.]#	2006 [Gg CO_2 Equi.]#	Prozent Absolute	Key Source Decission
2C1. Metal Production Iron and Steel Production	other	CH4	3.9	2.079	0.00041	
2C5. Other		HFC 134a	0.0	1.102	0.00040	
1A3d. Transport Navigation	Diesel Oil	CH4	1.7	0.582	0.00029	
1A3a. Transport Civil Aviation	Aviation Gasoline	CH4	0.8	1.410	0.00027	
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CH4	1.2	0.242	0.00026	
1A1a Public electricity and Heat production	all fuels	CH4	138.2	112.780	0.00020	
2B5 Chemical Industry	other	CH4	0.3	0.397	0.00007	
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 key-category analysis pursuant to the Tier -2 approach is based on the results of uncertainties determination pursuant to Tier 2. Last year, for the first time, uncertainties for the German greenhouse-gas inventory were determined pursuant to the Tier-2 approach, using Monte Carlo simulation (cf. in this regard NIR 2007, Chapter 1.7 and in the Annex, Chapter 18). The results provided extensive confirmation of the results of the pertinent Tier-1 analyses. At the same time, however, N_2O emissions from soils were included, assessment of which is subject to very large uncertainties. The next Tier-2 analysis will carried out for the 2010 report, since the required pertinent detailed uncertainties are determined only every three years.

12.1.4 Evaluation

The results presented are based on a highly detailed analysis carried out in conformance with regulations. A total of 39 key categories (28 Level for base year; 26 Level for 2006; 35 Trend) were identifed for the year 2006 (total for both Tier 1 procedures). These source categories are treated as key categories for all greenhouse gases, without regard for the components that are ultimately responsible for such classification. Combination of all results of the analyses shows that a total of 97.0 % of greenhouse-gas emissions (not including LULUCF) in 2006 were released by the key categories. The identified key categories include different shares of the various greenhouse gases, with respect to the relevant total emissions of the gases (not including LULUCF): CO2: 99.1 %; CH4: 83.9 %; N2O: 75.7 %; HFCs: 100 %; PFCs: 32.3 % and SF_6: 96.0 %.

The result is summarised in Table 129 below.

Table 129: Key categories for Germany (base year & 2006) pursuant to the Tier 1 Level and Trend Approach

IPCC Source Categories	Activity	Emissions Of	Level Base Year	Level Base Year (w/o Sinks)	Level 2006	Level 2006 (w/o Sinks)	Trend 2006	Trend 2006 (w/o Sinks)
1A1a Public electricity and Heat production	all fuels	CH_4						
1A1a Public electricity and Heat production	all fuels	CO_2	•	•	•	•	•	•
1A1a Public electricity and Heat production	all fuels	N_2O						
1A1b. Petroleum Refining	all fuels	CH_4						
1A1b. Petroleum Refining	all fuels	CO_2	•	•	•	•	•	•
1A1b. Petroleum Refining	all fuels	N_2O						
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CH_4						
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	CO_2	•	•	•	•	•	•
1A1c. Manufacture of Solid Fuels and Other Energy Industries	all fuels	N_2O						
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CH_4						
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	CO_2	•	•	•	•	•	•
1A2a. Manufacturing Industries and Construction Iron and Steel	all fuels	N_2O						
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CH_4						
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	CO_2						
1A2b. Manufacturing Industries and Construction Non-Ferrous Metals	all fuels	N_2O						
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CH_4						
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	CO_2						
1A2d. Manufacturing Industries and Construction Pulp, Paper and Print	all fuels	N_2O						
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	CH_4						
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	CO_2					•	•
1A2e. Manufacturing Industries and Construction Food Processing	all fuels	N_2O						
1A2f. Manufacturing Industries and Construction Other	all fuels	CH_4						
1A2f. Manufacturing Industries and Construction Other	all fuels	CO_2	•	•	•	•	•	•
1A2f. Manufacturing Industries and Construction Other	all fuels	N_2O						
1A3a. Transport Civil Aviation	Aviation Gasoline	CH_4						
1A3a. Transport Civil Aviation	Aviation Gasoline	CO_2			•	•	•	•
1A3a. Transport Civil Aviation	Aviation Gasoline	N_2O						
1A3b. Transport Road Transportation	all fuels	CH_4					•	•
1A3b. Transport Road Transportation	all fuels	CO_2	•	•	•	•	•	•
1A3b. Transport Road Transportation	all fuels	N_2O						
1A3c. Transport Railways	all fuels	CH_4						
1A3c. Transport Railways	all fuels	CO_2					•	•
1A3c. Transport Railways	all fuels	N_2O						
1A3d. Transport Navigation	Diesel Oil	CH_4						
1A3d. Transport Navigation	Diesel Oil	CO_2						
1A3d. Transport Navigation	Diesel Oil	N_2O						

IPCC Source Categories	Activity	Emissions Of	Level Base Year	Level Base Year (w/o Sinks)	Level 2006	Level 2006 (w/o Sinks)	Trend 2006	Trend 2006 (w/o Sinks)
1A3e. Transport Other Transportation	all fuels	CH4						
1A3e. Transport Other Transportation	all fuels	CO2						
1A3e. Transport Other Transportation	all fuels	N2O						
1A4a. Other Sectors Commercial/Institutional	all fuels	CH4					●	●
1A4a. Other Sectors Commercial/Institutional	all fuels	CO2	●	●	●	●	●	●
1A4a. Other Sectors Commercial/Institutional	all fuels	N2O						
1A4b. Other Sectors Residential	all fuels	CH4						
1A4b. Other Sectors Residential	all fuels	CO2	●	●	●	●	●	●
1A4b. Other Sectors Residential	all fuels	N2O						
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CH4						
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	CO2	●	●	●	●	●	●
1A4c. Other Sectors Agriculture/Forestry/Fisheries	all fuels	N2O						
1A5 Other Include Military fuel use under this category	all fuels	CH4						
1A5 Other Include Military fuel use under this category	all fuels	CO2	●	●			●	●
1A5 Other Include Military fuel use under this category	all fuels	N2O						
1B1a. Fugitive Emissions from Fuels Coal Mining and Handling	Solid Fuels	CH4	●	●			●	●
1B1b. Fugitive Emissions from Fuels Solid Fuel Transformation	Solid Fuels	CH4						
1B1c. Fugitive Emissions from Fuels Other (Abandoned Mines)	Solid Fuels	CH4					●	●
1.B.2.a. (all) Fugitive Emissions from Fuels, Oil	Oil	CH4						
1.B.2.a. (all) Fugitive Emissions from Fuels, Oil	Oil	CO2						
1.B.2.b. (all) Fugitive Emissions from Fuels, Natural Gas	Natural Gas	CH4	●	●	●	●	●	●
1B2c. Fugitive Emissions from Fuels Venting and Flaring	Venting and Flaring	CH4						
1.B.2.d. Other	Stadtgas	CH4						
2A1. Mineral Products Cement Production		CO2	●	●	●	●		
2A2. Mineral Products Lime Production		CO2	●	●	●	●		
2A4. Soda Ash		CO2						
2A7. Bricks and Tiles Production	limesto-input	CO2						
2A7. Glass Production		CO2						
2B1. Chemical Industry	Ammonia production	CO2	●	●		●	●	●
2B2 Chemical Industry	Nitric Acid Production	N2O	●	●	●	●	●	●
2B3 Chemical Industry	Adipic Acid Production	N2O	●	●			●	●
2B4 Chemical Industry	Carbide Production	CO2						
2B5 Chemical Industry	other	CH4						
2B5 Chemical Industry	Other	CO2	●	●	●	●	●	●
2B5 Chemical Industry	other	N2O						
2C1. Metal Production Iron and Steel Production	other	CH4						
2C1. Metal Production Iron and Steel Production	Steel (integrated production)	CO2	●	●	●	●	●	●
2C2. Ferroalloys Production	Ferroalloys	CO2						

IPCC Source Categories	Activity	Emissions Of	Level Base Year	Level Base Year (w/o Sinks)	Level 2006	Level 2006 (w/o Sinks)	Trend 2006	Trend 2006 (w/o Sinks)
2C3. Aluminium Production		CO2						
2C3. Aluminium Production		PFC´s					•	•
2C4. SF6 Used in Aluminium and Magnesium Foundries		SF6					•	•
2C5. Other		HFC 134a						
2E. Production of Halocarbons and SF6	production of HCFC-22	HFC´s					•	•
2E. Production of Halocarbons and SF6		PFC´s						
2E. Production of Halocarbons and SF6	Fugitive emissions	SF6						
2F. Industrial Processes	Consumption of Halocarbons and SF6	HFC´s			•	•	•	•
2F. Industrial Processes	Consumption of Halocarbons and SF6	PFC´s						
2F. Industrial Processes	Consumption of Halocarbons and SF6	SF6	•	•			•	•
3D.Total Solvent and Other Product Use		N2O						
4A.1. Enteric Fermentation	Dairy Cattle	CH4	•	•	•	•		
4A.1. Enteric Fermentation	Non-Dairy Cattle	CH4	•	•	•	•	•	•
4A.2. Enteric Fermentation	other animals	CH4						
4B13. Manure Management Other	Dairy Cows	N2O						
4B13. Manure Management Other	other animals	N2O						
4B13. Manure Management Other	Other Cattle	N2O						
4B13. Manure Management Other	Poultry	N2O						
4B13. Manure Management Other	Swine	N2O						
4B1. Manure Management	Dairy Cattle	CH4						
4B1. Manure Management	Non-Dairy Cattle	CH4						
4B2. Manure Management	other animals	CH4						
4B8. Manure Management	Swine	CH4						
4D1. Agricultural Soils	Direct Soil Emissions	N2O	•	•	•	•		•
4D2. Agricultural Soils	Animal Production	N2O						
4D3. Agricultural Soils	Indirect Emissions	N2O	•	•	•	•		
4D4. Agricultural Soils	Other	CH4						
4G. Other	Other	N2O						
5, Land-Use Change and Forestry		N2O						
5.A Forest Land		CO2	•		•		•	
5.B Cropland		CO2	•	•	•	•	•	•
5.C Grassland		CO2	•	•	•	•	•	•
5.F Other Land		CO2						
5.G Other (please specify)		CO2						
6 A1 Managed Waste Disposal on Land		CH4	•	•	•	•	•	•
6B Wastewater Handling	Domestic and Commercial Wastewater	CH4					•	•

IPCC Source Categories	Activity	Emissions Of	Level Base Year	Level Base Year (w/o Sinks)	Level 2006	Level 2006 (w/o Sinks)	Trend 2006	Trend 2006 (w/o Sinks)
6B Wastewater Handling	Domestic and Commercial Wastewater	N2O						
6 A3 Other - Composting		CH4						
6 A3 Other - Composting		N2O						

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 differ in part in terms of their representation, delimitation and aggregation. Against this background, in the early 1970s, associations of the Germany energy industry, along with economic research institutions, formed the Working Group on Energy Balances (AGEB), aimed at evaluating statistics from all areas of the energy industry on the basis of uniform criteria, combining the data into a well-rounded picture, and making these 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 2005):

- Bundesverband der deutschen Gas- and Wasserwirtschaft e.V. (BGW) (Association of the German Gas and Water Industry), Berlin and Brussels,
- 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 Elektrizitätswirtschaft- VDEW - e.V. (Electricity Industry Association), Berlin,
- Verband der Industriellen Energie- and Kraftwirtschaft e.V. (VIK) (Association of Industrial Energy and Power Producers), Essen, and
- 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 cooperation 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 130. In a number of categories, furthermore, experts personally provide relevant data – in categories, for example, such as non-energetic consumption by the chemicals industry.

Table 130: 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, revenue and energy supplies of mining and manufacturing companies - Series 6.4 Power generation 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 **Association of German Power Utilities (VDEW)** VDEW annual statistics VDEW surveys on the 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 Forestry** Diesel consumption by 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 **Bundesverband der deutschen Gas- and Wasserwirtschaft e.V. (BGW) (Association of the German Gas and Water Industry) Gas Statistics – Annual Reports** Gas statistics – 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 63). 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***, as 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 transformation of one substance into another – 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 generation 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 differentiated in accordance with 12 different types of plants.

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 district heat plants	13
Mine power stations	14
Other industrial thermal power stations	15
Nuclear power stations	16
Hydroelectric power stations	17
Thermal power stations, district heat 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 district heat plants	27
Mine power stations	28
Other industrial thermal power stations	29
Nuclear power stations	30
Hydroelectric power stations	31
Thermal power stations, district heat 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 CHP stations	15
District heat 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 CHP stations	27
District heat 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 63: Line structure of Energy Balances until 1994 and as of 1995

Non-energy consumption, as a component of the consumption balance, is shown as a total, without allocation to plant 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 63 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

Category	Energy resource
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 dust coal
	Hard lignite
Other solid fuels	Firewood
	Peat
	Sewage sludge
Petroleum	Oil
	Gasoline
	Raw gasoline
	Jet kerosine
	Schw. Flkr. [??]
	Diesel
	Heating oil, light.
	Heating oil, heavy.
	Petrol coke
	Other petroleum products
Gases	LP gas
	Refinery gas
	Coke-oven gas
	Blast-furnace
	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

Category	Energy resource
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 64: 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 64. 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. Furthermore, the DIW, which is responsible for preparing Energy Balances, reports that as of the 2003 Energy Balance a further change in the energy-resource structure is to be expected. This will not have an consequences for emissions reporting, however, since the reported data for the years 2003-2005 is based on preliminary Energy Balances, prepared by Federal Environment Agency, with the structure used for 1995-1999 (cf. Chapter 13.3).

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 provisional Energy Balances onwards from 2003 by the Federal Environment Agency (UBA)

At present, the final Energy Balances show a backlog of three years compared with the ”due” balance year (previous year). In order to meet the requirements of up-to-date emissions reporting, the Federal Environment Agency has prepared provisional Energy Balances for the years 2003 to 2005 on the basis of detailed evaluation tables by 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.

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.

These figures are used to prepare the provisional Energy Balances for the years 2003 through 2005.

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 are 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 to the Energy Balance data (electricity generation in public thermal power stations, heat generation in public thermal power stations and heat generation in public district-heat stations).

A similar procedure is adopted for waste incineration in industrial thermal power plants. In this case, the difference between a) the sum of the Energy Balance data and the data for secondary 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 in proportion with the divisions in pertinent Energy Balance data (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).

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 is 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.

For the 2007 report, it is now possible to report natural gas inputs in compressor stations as of report year 1995, in the framework of the Energy Balance, and in line with it. These fuel inputs are listed, along with natural gas inputs in coking plants, in Energy Balance line 33 (energy consumption in coking plants). A personal communication from the Working Group on Energy Balances has made it possible to separate the two natural gas inputs.

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 63 and Figure 64.

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.

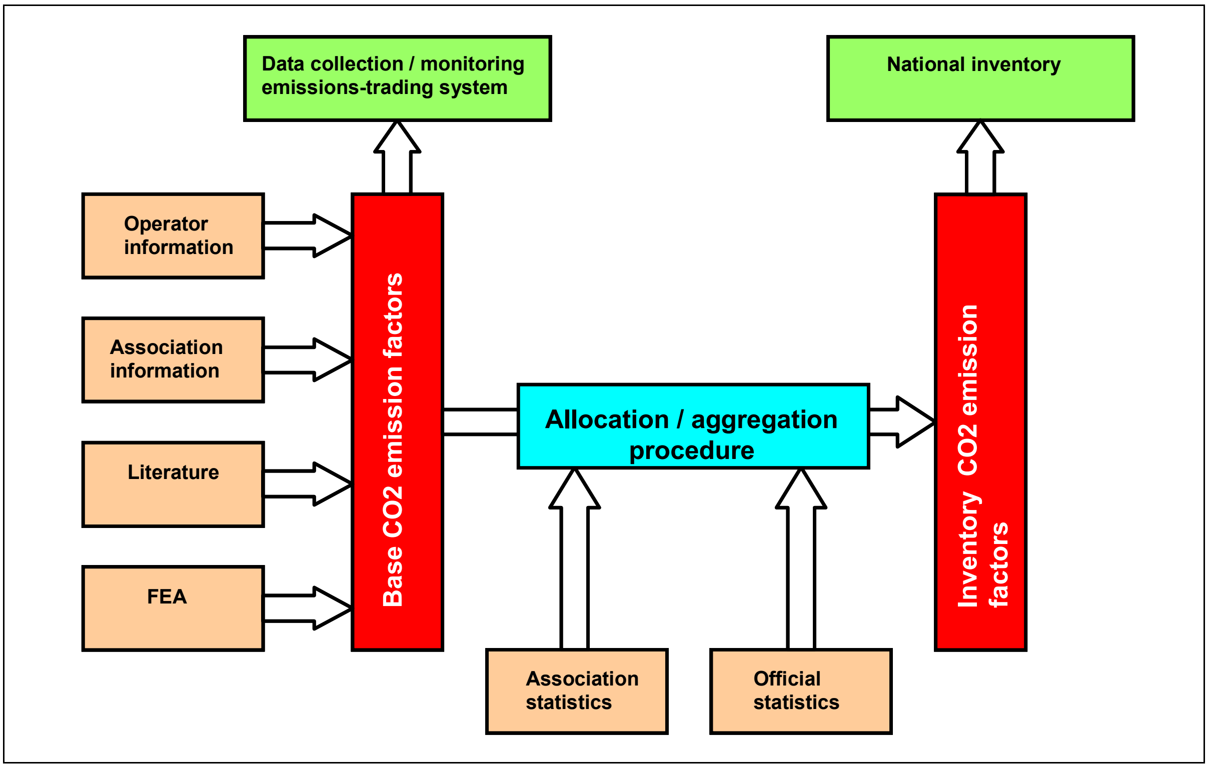
13.7 CO_2 emission factors

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 plant operators, to ensure that determination of plant-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 plant 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 65: Base and inventory emission factors for CO_2

With this in mind, a consistent concept for CO_2 emission factors was developed (Figure 65).

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 system (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 includes 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.

The basic emission factors for CO_2, with the help of structural data from association statistics and (quasi-) official statistics, 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 base 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), along with data on energy-consumption structures, the CO_2 emission factors are determined at the differentiation level required for national CO_2 inventories (cf. Table 131).

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, differented 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 consisted 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-heat plants.

Through subtraction of amounts of crude lignite used in public power stations, and of amounts used in product production, from total production and import amounts (imports are significant only in connection with use of hard lignite in Bavaria), a difference is obtained that represents crude lignite use by industry and commerce, trade and services. This figure, in turn, can then be broken down 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 131 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 131: 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
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
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
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
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
Ballast hard coal *old German Länder*	90.0	90.0	90.0	90.0	90.0												
Lignite																	
Raw lignite																	
Public district heat 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
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
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:																	
Rhineland	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
Hesse	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	111.0	NO	NO	NO
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
Central Germany (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
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
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
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
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

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
Petroleum																	
Crude oil	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
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
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
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
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
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
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
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
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
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
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
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
Gases																	
Coking-plant and city gas *Germany*						40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	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
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
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
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

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
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
Industrial waste [2] *Germany*						74.5	74.8	74.0	74.0	74.1	73.4	73.3	73.2	72.9	72.1	72.1	72.1
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
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
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
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
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
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
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
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
Sewage sludge	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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

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 132: 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
	[kg CO_2/ t (raw material or product)]																
2.A.1 Production of cement clinkers	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0	530.0
2.A.2 Production of burnt lime	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0	785.0
2.A.2 Production of dolomite lime	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0	913.0
2.A.3 Use of limestone	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
2.A.4 Production of soda ash	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.A.7 Production of wall bricks	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1
2.A.7 Production of roof tiles	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.6
2.A.7 Production of container glass	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0	192.0
2.A.7 Production of flat glass	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0	208.0
2.A.7 Production of household and table glassware	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0
2.A.7 Production of special glass (mix)	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
2.A.7 Production of glass fibres (mix)	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0	198.0
2.A.7 Production of rock wool (mix)	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0	299.0
2.A.7 Production of glass (undifferentiated mix, new German Länder)	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0	174.0
2.B Production of ammonia	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0	1815.0
2.B Production of calcium carbide	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0	138.0
2.B Production of calcium carbide (new German Länder)	688.0	688.0	688.0	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.B Coke burn-off in catalyst regeneration	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0	62.0
2.C.1 Production of electric steel	8.5	8.0	7.5	7.0	7.0	6.5	6.5	6.0	5.5	5.0	5.0	4.8	4.8	4.8	4.8	4.8	4.8
2.C.1 Production of oxygen steel *	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0	1307.0
2.C.1 Production of oxygen steel, limestone input	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
2.C.2 Ferroalloys production	1500.0	1222.0	944.0	527.0	249.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0
2.C.2 Ferroalloys production (New German Länder)	1500.0	1500.0	1500.0	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.C.3 Production of foundry aluminium	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0	1367.0

* 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 last year's inventory report.

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 last year's inventory report. 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

The problems in 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 previously reported figures 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 now 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 assigned quantities, were explicity 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 Causes), 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 was 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" applies to 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 tpyes 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 in 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.[56] This set comprised a total of 229 power stations. It did not include the Greifswald and Rheinsberg power stations, nor did it include hydroelectric and storage power stations.

The lignite sector was subdivided by regions into the Lausitz and Mitteldeutschland coal fields, since the two fields differ in their CO_2 emission factors, and the differences have to be taken into account for calculation of CO_2 emissions.

The new power-station database, with parameters as described above, was then used for recalculations, oriented to specific power-station types, covering all fuels used for electricity

[56] 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.

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 the regional breakdown of the lignite sector into the Mitteldeutschland and Lausitz coal fields. This quantitative energy data relative to stationary combustion systems, in time series, is being 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 133: 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**
		↓ **EB line 13**	↓ **EB line 13**	↓ **EB line 14**	↓ **EB line 15**		↓ **EB line 15**		↓ **EB line 15**	

Table 134: 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**
		↓ **EB line 73**	↓ **EB line 45 / 73**	↓ **EB line 73**		↓ **EB line 73**		↓ **EB line 45**	

Table 135: 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**
		↓ **EB line 18**	↓ **EB line 18**	↓ **EB line 18**	↓ **EB line 18**		↓ **EB line 18**		↓ **EB line 18**	

Table 136: 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 137: 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 from 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*
- 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
> Low-temperature coke	TJ		*64*	*0*	*0*	*165*	*11*	*0*			
> High-temperature coke	TJ		*0*	*0*	*0*	*0*	*0*	*0*			
- Hard coal	TJ	11,835	1,282	0	2,090	1,503	907	0	6,053	1,881	4,172
- Hard-coal coke	TJ		0	0	0	0	0	0	0	0	0
- Hard-coal briquettes	TJ		0	0	0	0	0	0	0	0	0
- Firewood	TJ		0	0	0	0	0	0	0	0	0
- Heating oil, light	TJ	1,217	0	245	0	0	0	0	972	302	670
- Heating oil, heavy	TJ	16,028	13,820	0	50	504	0	3	1,650	513	1,137
- Diesel fuel	TJ		0	0	0	0	0	0	0	0	0
- Natural gas	TJ	32,724	20,956	0	2	3,891	150	501	7,224	2,245	4,979
> imported natural gas	TJ		*13,268*	*0*	*1*	*1,641*	*0*	*501*			
> Domestic natural gas	TJ		*7,688*	*0*	*1*	*2,250*	*150*	*0*			
- LP gas	TJ		0	0	0	0	0	0	0	0	0
- Gas from sewage treatment	TJ		0	0	0	0	0	0	0	0	0
- Other gases	TJ	5,973	134	0	205	223	0	2,931	2,479	770	1,709
> Burnable gas	TJ		0	0	0	0	0	0	0	0	0
> Coking plant / 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 petroleum products	TJ		0	0	0	0	0	0	0	0	0
> Lignite tar			0	0	0	0	0	0	0	0	0
> Industrial waste		896	391	0	136	167	11	190	0	0	0

Table 138: Fuel inputs in the transformation sector (auxiliary energy / Energy Balance line 45) (new German Länder, 1990)

	Units	Corrected EB line 45	Heat production in large combustion systems of power stations of the lignite-mining sector	Production of hard-coal coke	Heat production in large combustion systems of refinery power stations	Total (transformation for power stations)	Other process combustion
Industrial heat production	**TJ**		**118,198**		**44,878**	**163,076**	
Fuel for final energy	**TJ**	**224,150**	**149,953**	**3,053**	**54,031**	**207,037**	**17,113**
- Crude lignite	TJ	156,976	138,673	0	18,303	156,976	0
> Lausitz coal field	TJ		*88,405*		*0*	*88,405*	
>Mitteldeutschland coal field	TJ		*50,268*		*18,303*	*68,571*	
- Lignite briquettes	TJ	306	306	0	0	306	0
> Lausitz coal field	TJ		*72*		*0*	*72*	
>Mitteldeutschland coal field	TJ		*234*		*0*	*234*	
- 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
> Low-temperature coke	TJ		*2,462*		*58*	*2,520*	
> 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
> Burnable gas	TJ	9,598	0	1,527	0	1,527	8,071
> Coking plant / 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 139: 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 (Process Combustion)	Units	Corrected EB line 73	Calcium carbide production	Production of iron, steel and malleable cast iron	Glass production	Manufacturing of coarse ceramics	Lime production	Production of non-ferrous heavy metals	Manufacturing of pig iron	Production of Siemens-Martin steel	Sinter production	Manufacturing of rolled steel	Cement production	Sugar manufacturing	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														
- 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
> Low-temperature coke	TJ														
> 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
> Burnable gas	TJ	2,803		0	0	0	0	0	0	0	0	0	0	0	0
> Coking plant / 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 140: 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*	
- 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
> Low-temperature coke	TJ			*0*	*215*	*6,199*	*944*				
> 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
> Burnable gas		2,803	0	0	0	1,988	0		0	0	815
> Coking plant / city gas	TJ	24,762	2,940	0	251	0	0	7,000	2,720	4,280	14,571
> Refinery gas		1,392	0	0	0	0	0		0	0	1,392
- Blast furnace gas	TJ	11,417	5,013	0	0	1,479	0		0	0	4,924
- Special fuels	TJ	8,674	0	0	219	3,252	521	3,870	1,503	2,366	812
> Other petroleum products		301	0	0	0	0	0		0	0	301
> Lignite tar	TJ	511	0	0	0	0	0		0	0	511
> Industrial waste		7,862	0	0	219	3,252	521	3,870	1,503	2,366	0

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 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.
3. Final energy consumption in relevant energy-intensive processes identified for the base year was determined, with the help of Statistical Yearbooks and data from an unpublished *Fachserie* ("technical series") for the years 1991 through 1994.
4. Additional fuel-consumption figures were determined via calculations.

For example, fuel consumption for industrial processes, as documented on the basis of the aforementioned sources, is deducted from the sum values for the relevant fuels as listed in Energy Balance line 73 in the Energy Balances for the years 1991 through 1994.

The difference remaining, in the various years, between the fuel consumption identified for these processes and the "total" values listed for the various fuels in the relevant Energy Balance is distributed proportionately among the remaining time series. For this remainder, as well as for all other fuel inputs in power stations, heating boilers and other industrial boilers, the following calculation approach is applied:

- The reference values used for dividing up fuel inputs in stationary combustion systems in the years 1991 through 1994 are the new time-series data through 1990, in their allocation to EB lines 13-15, 18, 45 and 73.
- The values for the various fuels as listed in the Energy Balances for the years 1991 – 1994 are allocated in keeping with the proportional allocations for the various fuels in the 1990 Energy Balance.

- Proportional allocation was not carried out in cases in which the 1991-1994 Energy Balances list a fuel-consumption figure, in their specific lines, that is listed as zero in the revised 1990 Energy Balance (multiplication by zero). In such cases, the fuel-consumption figures shown in the relevant Energy Balance cells for the years 1991 through 1994 were used. This approach ensures that all of the fuels listed in the Energy Balances of subsequent years are taken into account.

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 141 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 141 shows inputs, for coal briquetting, in lignite plants in the Lausitz and Mitteldeutschland regions, while Table 141 shows consumption for drying heat. These figures, when combined with the average net calorific values for the various relevant regions, 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 141: Lignite production by mining districts

		1990	1991	1992	1993	1994
Lignite production	kt	248,900	167,700	129,400	115,600	101,800
Lausitz	kt	168,000	116,800	93,100	87,400	79,400
Mitteldeutschland	kt	80,900	50,900	36,300	28,200	22,400
Removal from stocks, including import/export balance	kt	4,338	3,704	2,908	2,162	797
Lignite production & removal from stocks (by production quantities, broken down by mining districts)						
Lausitz	kt	170,928	119,380	95,192	89,035	80,022
Mitteldeutschland	kt	82,310	52,024	37,116	28,727	22,575
Lignite consumption	kt	253,238	171,404	132,308	117,762	102,597
Lignite consumption, by districts						
Consumption in the Lausitz district, in ...	kt	170,928	119,380	95,192	89,035	80,022
Briquetting plants (briquetting coal)	kt	45,644	25,960	14,677	11,974	9,497
Power stations of the lignite industry of the Lausitz district	kt	23,533	17,240	10,431	9,119	7,556
Power stations of VEAG	kt	80,020	62,500	60,800	60,548	57,488
Other power stations	kt	9,008	5,686	3,552	3,035	2,757
Industrial boilers	kt	7,415	5,641	4,005	3,269	2,106
Sales to public and commerce, trade services	kt	5,308	2,352	1,728	1,089	618
Consumption in the Mitteldeutschland district, in ...	kt	82,310	52,024	37,116	28,727	22,575
Briquetting plants (briquetting coal)	kt	29,506	12,058	7,034	5,075	2,864
Power stations of the lignite industry of the Mitteldeutschland district	kt	8,570	7,342	6,301	5,438	4,898
Power stations of VEAG	kt	15,880	12,700	10,128	8,639	8,025
Other power stations	kt	16,354	11,908	8,151	5,826	4,314
Industrial boilers	kt	9,444	6,989	4,830	3,397	2,300
Sales to public and commerce, trade services	kt	2,556	1,027	672	352	174

Source: Annual reports for the years 1991 through 1994 on development of the lignite industry in the new German Länder, Federal Ministry of Economics (BMWA, n.y.).

The following Table 141 provides an overview of fuel inputs for drying coal briquettes and coal dust, in the Lausitz and Mitteldeutschland mining districts.

Table 142: 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
Boiler efficiency	**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 generated 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 generating drying heat.

14.1.1.5.2 Energy-intensive industrial processes

The following tables (Table 143 through Table 150) 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 143: 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 EBZ 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 144: 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 Environmental Agency (unpublished special analysis of the Federal Statistical Office for 1993/1994)

** Following offsetting with equivalent for blast-furnace gas

Table 145: 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 146: 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 Environmental Agency (unpublished special analysis of the Federal Statistical Office for 1993/1994)

Table 147: 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 Environmental Agency (unpublished special analysis of the Federal Statistical Office for 1993/1994)

Table 148: Sugar, glass and coarse ceramics

Since no reliable sources and statistics were available to the Leipzig Institute for Energy and the Environment (IE Leipzig), the values reported to date by the Federal Environmental Agency for 1990 through 1994 remain unchanged.

Table 149: 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 150: 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 calculatio

After the calculation procedure has been carried out for all structural elements, the elements are now 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 (Chapter 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 operating plants 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 plants, in terms of percentage shares for various plant 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 divided 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-heat 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 in accordance with the fuel used. Aggregated emission factors are formed first for the reference year 1995.
4. Projections for 2000 and 2010
   For description of continuing technological development, technology-specific emission factors are again determined. These are derived from characterisation of modern technologies. An increasing contribution of low-emissions technologies to total relevant activity, thus, can be represented by suitably changing the percentage shares for the technologies under consideration. Applicable immission-control laws are used as a framework for updating for the year 2000. It is assumed that the requirements of the amended TA Luft (Technical Instructions on Air Quality Control) and of the EU directive on large combustion systems will be met by the reference year 2010.

The above-described methods, beginning with characterisation of the emissions behaviour of relevant combustion technologies and gradually leading to aggregated factors at various regional and source-category-specific levels, make it possible to represent the required factors transparently.

The chosen methods for deriving emission factors for a given reference year are shown in Figure 66 below.

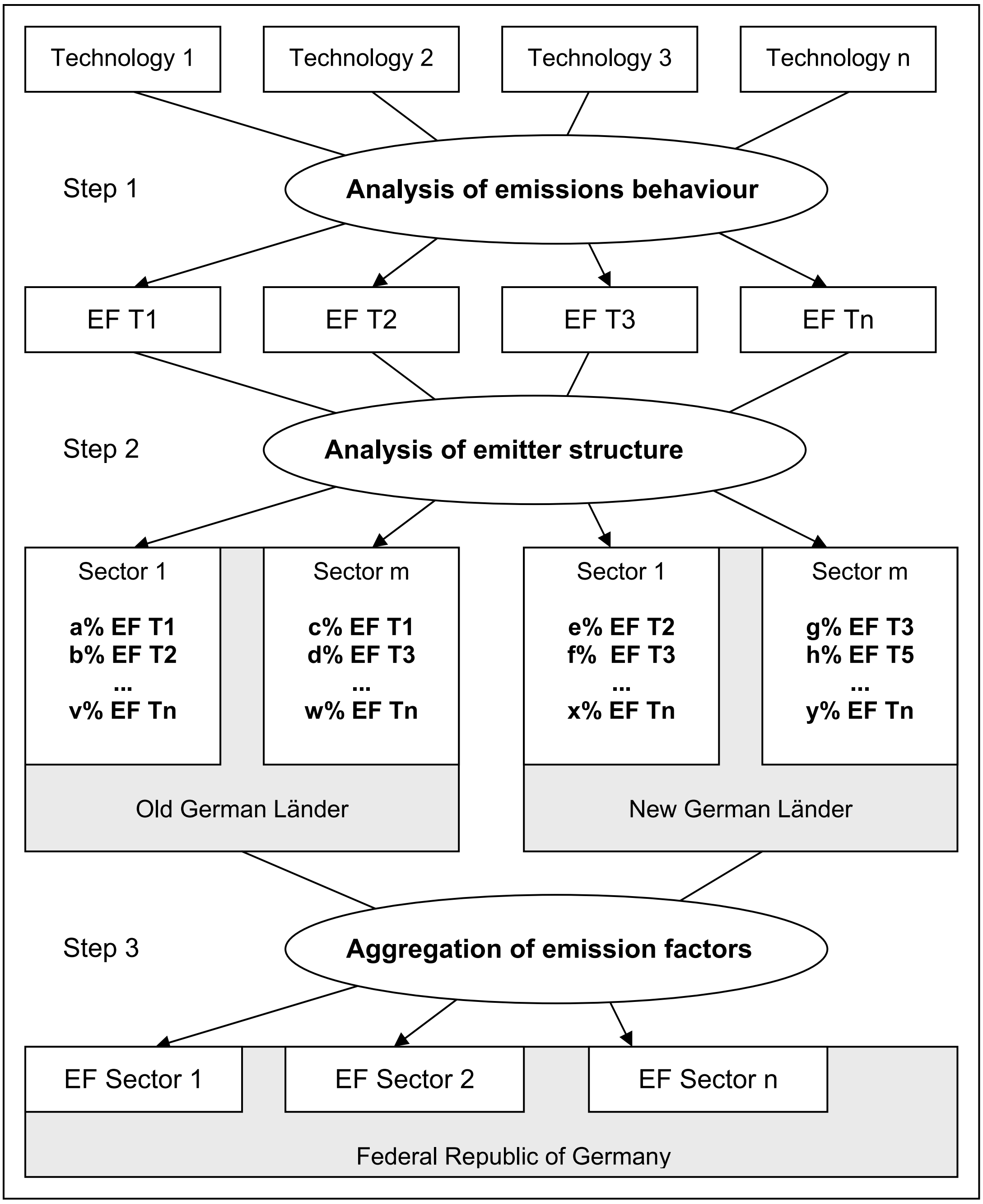


Figure 66: Methods for calculating emission factors

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. This will then make 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 %[57]. 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 calculation 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 installations subject to abbreviated (K) or complete (V) declarations. For each of the three groups of installations, evaluation and derivation of emission factors is carried out, using the example data from Baden-Württemberg and with separation by measurements and assumptions.

Table 151 provides an overview of the installation types in question and lists the relevant numbers under the 4th BimSchV and the relevant type of declaration required.

Table 151: Installation types pursuant to Annex of 4th BImSchV

Index	**Large Combustion Plants**		**Type of declaration required**
1 01 1	Power Stations	≥ 50 MW for solid, liquid and gaseous fuels	V
1 02A 1	Combustion plants	≥ 50 MW for solid and liquid fuels	V
1 02B 1	Combustion plants	≥ 50 MW for gaseous fuels	V
Index	**TA Luft Installations**		**Type of declaration required**
1 02A 2	Combustion plants	1 - < 50 MW solid and liquid fuels (except for heating oil EL)	V
1 02B 2	Combustion plants	5 - < 50 MW heating oil EL	K
1 02C 2	Combustion plants Combustion plants	10 - < 50 MW for natural gas 10 - < 50 MW except for natural gas installations	K V
1 03 1	Combustion plants	> 1 MW other fuels	V
Index	**Gas turbine installations**		**Type of declaration required**
1 05 1	Gas turbines Gas turbines	≥ 50 MW for natural gas ≥ 50 MW except for natural gas installations	K V
1 05 2	Gas turbines Gas turbines	< 50 MW for natural gas < 50 MW except for natural gas installations	K V

In the analyses, emissions data is differentiated by combustion technologies. Table 152 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.

57 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 152: Classification of sources by type of combustion system

Technology	
Type	**Type meaning**
110	Combustion plants for solid fuels / waste
111	Filled-shaft combustion plants
112	Combustion plants with belt feed
113	Combustion plants with pneumatic feed
114	Combustion plants with bottom feed
115	Combustion plant with mechanically moving grid
116	Dust combustion with dry-ash removal
117	Dust combustion with wet-ash removal
118	Fluidised-bed combustion
120	Combustion systems for liquid fuels / waste
121	With vaporizer burner
122	With pressurised atomiser burner
123	With steam-atomiser burner
124	With rotating atomiser burner
125	With air-atomiser burner
130	Combustion plants for gaseous fuels / waste
131	With atmospheric gas burner
132	With gas-blower burner
141	Multiple-fuel combustion plants
142	Mixed combustion plants
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 determined 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:

$$u^2(x_i) = (a_+ - a_-)^2 / 12 \qquad \text{(A1)}$$

For actual physical reasons, 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 %.

$$u_{gesamt} = \sqrt{u_1^2 + u_2^2 + ... + u_n^2} \quad \text{(A3)}$$

Quantification of the uncertainties of emission factors for combustion plants

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 plants, combustion plants 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 plants (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 conversion.

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 153 summarises the emission factors shown in Tables 3, 4 and 5 of Annex E of the research project RENTZ et al (2002):

Table 153: Methane emission factors for combustion systems < 50 MW thermal output and for gas turbines, pursuant to RENTZ et al, 2002

Plant type	Fuel	German 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	269
		NBL, Central German district	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 Total for Federal Republic of Germany

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):

$CaCO_3 + SO_2 + 1/2O_2 + H_2O \Longrightarrow CaSO_4.2H_2O + CO_2$

This equation can be used to derive the limestone/plaster molar 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 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. With the limestone-input figures determined from these figures, process-related CO_2 emissions can be determined via the molar ratio of $CaCO_3$ to CO_2, pursuant to the reaction equation given above. The results of the calculation are shown in the following Table. These result include the now complete figures for plaster production in all years between 1990 and 2005 (previously, figures were available only for individual years). As a result of the new calculation, the CO_2 emissions differ slightly form the values reported in the NIR 2007. Due to a lack of current data, we have adopted the 2005 value, without any change, for 2006.

Table 154: CO_2 emissions from flue-gas desulphurisation in public power stations

Figures in Gg	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 from flue-gas desulphur-isation in public power stations	701	747	718	749	718	784	1,003	1,023	1,179	1,140
Figures in Gg	2000	2001	2002	2003	2004	2005	2006			
CO_2 from flue-gas desulphur-isation in public power stations	1,358	1,287	1,326	1,411	1,395	1,382	1,382			

Source: updated calculation 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 behind the flue-gas desulphurisation plants and the 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.3a)

14.1.3.2 Derivation of activity rates for road transport (1.A.3b)

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 155 below.

Table 155: Energy balances, 1990-2005

Year	Region	Line	Petrol	Petroleum	Diesel fuel	LP gas	Biodiesel
Energy input in road transports, pursuant to energy balances 1990-2002 (last revision: 08/2006), 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	1,108,726	100	9,306
2001	D	62	1,199,318	600	1,098,488	100	13,032
2002	D	62	1,166,381	600	1,105,842	100	20,460
Provisional figures pursuant to evaluation tables							
2003	D	62	1,109,000	600	1,078,382	100	29,784
2004	D	62	1,074,121	600	1,114,597	100	44,676
2005	D	62	1,008,357	600	1,073,613	100	70,737

Sources: Evaluation tables, last revision 09/2004,
Data of the Working Group on renewable-energy statistics (Arbeitsgemeinschaft Erneuerbare Energien Statistik) and
NWV-Mineralölwirtschaftszahlen 2005 (petroleum statistics) (MWV 2006);
ABL = old German Länder; NBL = new German Länder; D = Germany.

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 traffic, 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 156).

Table 156: Net calorific values for petrol and diesel fuel

Year	Petrol	Diesel fuel
1990-1992	43.543 MJ/kg	42.704 MJ/kg
As of 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 gasoline consumption for all vehicle categories and gasoline sales pursuant to the Energy Balance.
- The correction factor for gasoline is then also used to bring fuel consumption of vehicles with diesel engines, including automobiles and other vehicles <= 3.5 t (light utility 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 utility vehicles and busses.
- The correction factor for heavy utility 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 157 below summarises the correction factors used.

Table 157: Correction factors for adjustment to the Energy Balance

Year	Region	Petrol	Diesel fuel (incl. Bio-Fuels)	
		Automobiles, light duty vehicles, motorcycles	Automobiles, light duty vehicles, motorcycles	Other
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	1.199
1996	D	0.988	0.990	1.177
1997	D	0.990	0.994	1.176
1998	D	0.988	0.992	1.239
1999	D	0.996	1.001	1.300
2000	D	0.971	0.979	1.322
2001	D	0.965	0.976	1.222
2002	D	0.963	0.980	1.180
2003	D	0.953	0.980	1.114
2004	D	0.966	1.005	1.053
2005	D	0.966	1.030	0.936

Remarks: 1994 correction factors for ABL (old German Länder) and NBL (new German Länder) as for D as a whole

14.1.3.2.2 Allocation of biodiesel, petroleum and LP gas to the structural elements

In the Energy Balance, biodiesel, petroleum and LP gas are listed in the transport sector; for this reason, they have not been included in TREMOD, to date, as separate categories. For purposes of importing into CSE, the results for these fuels are thus derived additionally. To this end, the energy consumption, pursuant to the Energy Balance, is allocated to the relevant structural elements in keeping with the specifications of the Federal Environment Agency:

- Biodiesel is allocated to all structural elements with diesel engines, in keeping with their percentage shares of consumption of conventional diesel fuel.
- 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 156) 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, petroleum and LP gas

For all structural elements, the emission factors for biodiesel and petroleum, in keeping with the Federal Environment Agency's specifications, are set to the same values as those for conventional diesel fuel. Exceptions:

- The CO_2 emission factor for biodiesel is set to "0"

- The SO_2 emission factor for Petroleum: in those years in which diesel fuel has a higher value, this factor is set to 24 kg/TJ. 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 158: Emission factors for automobiles that run on LP gas

Gas	Technology	Structural element	EB line	Units	1995-2001
CH_4	Automobile	SV PKWO KOIO	EB line 62	kg/TJ	3
CO	Automobile	SV PKWO KOIO	EB line 62	kg/TJ	350
CO_2	Automobile	SV PKWO KOIO	EB line 62	kg/TJ	65,000.00
N_2O	Automobile	SV PKWO KOIO	EB line 62	kg/TJ	1.7
NH_3	Automobile	SV PKWO KOIO	EB line 62	kg/TJ	0.5
NMVOC	Automobile	SV PKWO KOIO	EB line 62	kg/TJ	157
NO_X	Automobile	SV PKWO KOIO	EB line 62	kg/TJ	975
SO_2	Automobile	SV PKWO KOIO	EB line 62	kg/TJ	1.7

14.1.3.4 Expansion to include natural gas as a fuel

TREMOD updating includes the option of listing natural gas as a fuel, if the Working Group on Energy Balances (AGEB) lists natural gas as a transport fuel in future. In the present interface, this is possible only if the allocation criteria are precisely defined, in a manner similar to that used for biodiesel, natural gas and petroleum:

- Listing of the affected structural elements and their respective percentage shares of consumption
- Listing of emission factors for the relevant structural elements

Furthermore, general data tables could now be defined into which these figures could be explicitly entered. The minimum requirements are listed in the following tables (Table 159 and Table 160):

Table 159: Entry structure for natural gas: Structural element's percentage share of energy consumption

Material	Structural element	Share/year
Natural gas	e.g. SV BUS MTIO	60%
Natural gas	...	...
Natural gas	Total	100%

Table 160: Entry structure for natural gas: Emission factors

Gas	Structural element	Units	Values / reference year
CH_4	z.B. SV BUS MTIO	kg/TJ	
CO	z.B. SV BUS MTIO	kg/TJ	
CO_2	z.B. SV BUS MTIO	kg/TJ	
N_2O	z.B. SV BUS MTIO	kg/TJ	
NH_3	z.B. SV BUS MTIO	kg/TJ	
NMVOC	z.B. SV BUS MTIO	kg/TJ	
NO_X	z.B. SV BUS MTIO	kg/TJ	
SO_2	z.B. SV BUS MTIO	kg/TJ	

Alternatively, the percentage shares for structural elements can be given in a form similar to that used for existing structures (as is done for petroleum and biodiesel). To this end, a suitable calculation rule would have to be defined and developed (for example, breakdown of natural gas by the vehicle categories BUS, LNF and SNF on municipal roads, in keeping with the various categories' shares of diesel-fuel consumption). This approach is more complex, and it is more difficult to adapt to changed allocation rules, but it offers the advantage that the percentage shares do not have to be defined explicitly, for each year, in a table.

Since it is difficult to specify a relevant calculation rule at present, natural-gas tables should be added to the current interface; these tables could then be filled as necessary. Such tables will also be integrated into the final version if necessary. In future, an attempt should be made to integrate the fuels biodiesel, petroleum, LP gas and natural gas directly within TREMOD, however.

14.1.3.5 Derivation of data for western and eastern Germany, 1994

TREMOD distinguishes between old and new German Länder only until 1993. Since CSE also requires such differentiation for 1994, a relevant breakdown must be made using simplifying assumptions. The parameters 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 parameters, 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 correspond to the relevant values for all of Germany in 1994.

With these assumptions, the aforementioned conditions are met. A third condition is not met, however: the plausibility of emissions results in the time series, in each case, for the old/new German Länder. For this condition to be fulfilled, the 1994 should be remodelled in TREMOD; this should be done via separate derivation of vehicle stocks and mileages for the old and new German Länder, followed by recalculation of emissions on the basis of this data.

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)

14.2.3.1 Metal production: Iron and steel production (2.C.1, 1.A.2.a)

14.2.3.1.1 Determination of total emissions

The total emissions for the iron and steel industry are determined as the sum of emissions from reducing agents and fuels used by the sector. In the process, steel production is considered in a one step. Pig-iron production is not balanced separately (cf. also Chapter 3.1.4 and 4.3.1).

In terms of methods, this procedure for determining total emissions corresponds to that previously used for determining iron and steel industry emissions as reported under 1.A.2.

14.2.3.1.2 Determination of process-related emissions

In the interest of maintaining congruence with data of the German Emissions Trading Authority (DEHSt), in sector 2.C.1, "Iron and steel industry", process-related CO_2 emissions from steel production are calculated, as in the Ordinance on allocations for emissions trading (Zuteilungsverordnung für den Emissionshandel; ZuV on the basis of the Greenhouse Gases Emissions Trading Act (TEHG)) with the help of the factor for an ideal blast-furnace process (SCHOLZ, 2003).

An emission factor of 1.307 t CO_2 / t product results. This factor is obtained by multiplying the factor for the ideal blast-furnace process, 356.5 kg C per tonne of pig iron, by 44/12 (the CO_2-to-C mass relationship).

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.

Emissions from electrode combustion and limestone inputs are determined separately and then, in a final step, added to other the process-related emissions.

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) steel-works lime (CaO) is used – inter alia, as a slag former – in actual refining of raw steel in oxygen-steel or electric-steel processes. Limestone inputs in sinter and pig-iron production are published annually in iron and steel sector statistics (DESTATIS Fachserie 4, Reihe 8.1). These statistics provide the basis for the limestone inputs in sinter and pig-iron production shown in the following table. Since no data are yet available for 2005, the values for 2004 have been carried over to the next year.

Table 161: Limestone inputs in sinter and pig-iron production

Lime-stone inputs [kT]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Sinter	4,681	4,566	4,152	3,988	4,281	4,426	4,273	4,507	4,526	4,190	4,381	4,240	4,091	4,202	4,371	4,371
Pig iron	705	726	669	632	701	703	649	725	707	654	723	684	689	691	703	703

Source: Calculations from the "limestone balance" project ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02)

Multiplying the activity rates for limestone inputs by the IPCC default value for limestone produces the following CO_2-emissions figures.

Table 162: CO_2 emissions from limestone inputs in sinter and pig-iron production

[Gg CO_2]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Sinter and Pig iron	2,370	2,328	2,121	2,033	2,192	2,257	2,166	2,302	2,302	2,132	2,246	2,166	2,103	2,152	2,233	2,233

Source: Calculations from the "limestone balance" project ("Kalksteinbilanz"; UBA 2006, FKZ 20541217/02)

14.2.3.1.3 Determination of energy-related emissions

Energy-related CO_2 emissions are obtained as the difference between total emissions and process-related emissions (not including emissions from electrode combustion and limestone inputs).

The pertinent difference is formed in 2 steps.

Firstly, the emission factors for all of the reducing agents used in blast furnaces are set to zero on the energy side.

In a second step, a corrective time series in the CSE is used to add non-process-related blast-furnace emissions to energy-related emissions under 1.A.2.a. For this operation, fuel-specific allocation is hardly feasible, and it would not enhance accuracy anyway.

All natural-gas inputs in blast furnaces (wind heaters) are reported together with energy-related emissions.

All emission factors for inputs of blast-furnace gas (also in power stations and in sinter production) are set to zero, since the relevant emissions were already taken into account in connection with production of blast-furnace gas in blast furnaces (process-related emissions in 2.C.1). (In the 2005 National Inventory Report, CO_2 emissions from blast-furnace gas in the iron and steel industry were reported in sector 1.A.2.)

This approach ensures that no double-counting takes place.

Table 163: 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 electric steel	Iron, steel and malleable 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 combustion				P	

E: energy-related (emissions reported in 1.A.2);
P: process-related (emissions reported in 2.C.1)
Note: 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 CO2 emissions; it only generates energy-related CO2 emissions

14.2.3.1.4 Secondary fuels

In the iron and steel industry, secondary fuels are used as substitute reducing agents, in place of coke, only in pig-iron production via the blast-furnace process. To date, these materials have not yet been included in national statistics and the Energy Balance. Relevant production figures and fuel-use amounts have been taken from statistics of the Wirtschaftsvereinigung Stahl steel-industry association. 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). The relevant types, amounts, energy inputs and CO_2 emission factors were provided by the Wirtschaftsvereinigung Stahl steel-industry association.

Table 164: Secondary-fuel inputs in blast furnaces: CO_2 emission factors and their biogenic components

Secondary fuel (Designation in the CSE)	CO_2 emission factor [kg/ TJ]	Biogenic mass fraction [%]
Animal fat	71,380	100
Recycled plastics	74,630	0

At the same time, emissions from use of secondary fuels in the blast-furnace process are not reported under 1.A.2.a.; instead, they are subsumed within process-related emissions in 2.C.1.

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 integrated 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 sulphitz pulp mills are normally only integrated – i.e. part of paper-production chains. In most cases, paper production includes both mechanical pulping and used-paper processing, although in some cases such processes 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 the circulation of 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 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; figures of 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, loc. cit.)

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 in 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, loc. cit.).

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; loc. cit.)

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, in removal of air from containiners for washing wood chips, as well as from other containers. 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 reducing 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 a renewable resource). The best available technologies for auxiliary boilers are described below.

Recycled fibre

In general, processes that use recycled fibres (processes for processing used paper) can be divided into two main categories:

- Processes that use solely mechanical cleaning, i.e. processes that used 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 newprint, 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 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)

For information about reporting in this area, cf. Chapter 7.

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 expert hearing that will adjust the estimated uncertainties as necessary, thereby placing them on a broader, more reliable basis.

Table 165: Estimated uncertainties for waste landfilling

	Definition of time series						Uncertainties data					
		Source description					Base year 1990 [4]		2002			
No.	CRF	For example, module name or suitable aggregate within the listed CRF code [1]	Further source differentia-tion if applicable[2]	CSE time series ID if applicabl e	Value type (EF / EM / AR)	If EF / EM: Gas	Uncertainty [+/-%] [3]	Distri-bution type [5]	Uncertainty [+/-%] [3]	Distri-bution 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	No reliable results from studies of raw waste in MB-waste-treatment facilities	
4	6A1	Waste landfilling			DOC_F	CH_4	+/-30%	N	+/-30%	N		
5	6A1	Waste landfilling			MCF(x) (bei 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, low with respect to other uncertainties	
9	6A1	Waste landfilling			OX	CH_4	+50% -35%	L	+50% -35%	L	Corresponds to 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)

Under the IPCC method, percentage levels of aerobic and anaerobic wastewater and sewage-sludge treatment should be determined via characterisation of wastewater and sewage-sludge treatment systems at the national level.

Evaluation of national inventory reports shows that the various Länder have used widely differing approaches to determine their Länder-specific emission factors. In some countries, the available data is not adequate to permit direct use of the IPCC method, and thus such countries have used alternative calculation methods or aggregated values. The evaluation reveals the following:

- A few countries list specific methane conversion factors for national treatment systems (Czech Republic, U.S., Finland; cf. Table 166). In addition, sub-categorisation of wastewater systems is not standardised.
- In some countries, it is assumed that wastewater treatment normally occurs, either aerobically or anaerobically, in closed systems with methane collection, but that small quantities of methane can still escape in exceptional situations. In such cases, very low MCF are chosen for treatment of municipal wastewater (Finland, Czech Republic).
- The UK uses a national method based on characterisation of sludge-treatment processes.
- In some countries, emission factors are determined not via organic load, percentage level of anaerobic treatment and MCF – as called for by the IPCC – but via population equivalents (Canada, Austria, Germany).
- Only Austria explicitly differentiates its emission factors by mechanical, biological and other treatment.

Table 166: Reported methane conversion factors in national inventory reports

MCF	Tschechische Republik	Finnland	USA
Management of household and commercial wastewater		0.025	0.05
aerobically treated municipal wastewater	0.05		
anaerobically treated municipal wastewater	0.5		
on-site treatment	0.15		
untreated household and commercial wastewater			
discharge into rivers	0.05		
septic tanks			0.5
Industrial wastewater treatment		0.01	
aerobically treated industrial wastewater	0.06		
anaerobically treated industrial wastewater	0.7		
untreated industrial wastewater	0.05		
differs by sector			0.05 – 0.77
Sludge treatment			
aerobic treatment of sludge from municipal wastewater	0.1		
anaerobic treatment of sludge from municipal wastewater	0.5		
aerobic treatment of sludge from industrial wastewater	0.1		
anaerobic treatment of sludge from industrial wastewater	0.3		

Source: National inventory reports

Further information on determination of methane emissions from wastewater and sewage-sludge treatment of other countries is provided by (ÖKO-INSTITUT, 2004b).

14.6.3 Determination of nitrous oxide emissions from wastewater treatment (6.B.2)

The IPCC Guidelines describe a method for estimating nitrous oxide emissions from wastewater treatment (IPCC, 1996a: Chapter 6.5). An evaluation of experience gained by other countries (further information in ÖKO-INSTITUT, 2004b) shows that all countries that determine nitrous oxide emissions from wastewater treatment either use the IPCC method or made country-specific adjustments to the IPCC method:

- One exception is Belgium, which determines emissions on the basis of the EMEP/CORINAIR manual.
- Some countries also determine nitrous oxide emissions from industrial wastewater, although the IPCC does not describe any method for this (Austria, New Zealand, Sweden and, in future, U.S.).
- The most important relevant country-specific adjustments include consideration of industrial wastewater (see above), determination of nitrogen loads in wastewater-treatment systems instead of determination of daily human protein intake (Sweden) and consideration of other nitrogen sources in municipal wastewater (U.S.).
- In those countries in which nitrous oxide emissions are determined, inter alia, via nitrogen fractions in protein, the IPCC default value is used.
- All countries use the IPCC default value in cases in which the emission factor (kg N_2O-N/kg wastewater N) is relevant for determination of nitrous oxide emissions.
- Data on average per-capita protein intake comes either from national studies and data (UK, Australia) or from the FAO database (U.S., Austria, etc.); such data varies widely. The protein intake for the UK, which was determined via a national survey, is much lower than the others; this is due to the method by which the average value was determined. Table 167 lists average daily protein intake, along with the pertinent data source, for those countries that list this data item explicitly in their national inventory reports.

Table 167: Average daily and annual protein intake

Country	Protein [kg/person & year]	Protein [kg/person & day]	Data source
UK	8.65	0.024	National Food Survey (DEFRA, 2001). The data is based on a survey of food consumption at home and thus is likely to be a low estimate.
Australia	36.28	0.099	Australian Institute of Health and Welfare (de Looper and Bhatia
USA	41 (1996)	0.112	FAO database
	41 x1.75	0.197	Adjustment via comprehensive method
Sweden	32.85	0.090	National data
Canada	40.15	0.110	No data source listed
Germany	34.68	0.095	FAO database (average, 1990-2001)
New Zealand	4.75	0.013	With respect to nitrogen in wastewater
Belgium			FAO database
Czech Republic	25.00	0.068	No data source listed

Source: National inventory reports

15 ANNEX 4: CO_2 REFERENCE APPROACH AND COMPARISON WITH THE SECTORAL APPROACH, AND RELEVANT INFORMATION ON THE NATIONAL ENERGY BALANCE

Information on the CO_2 reference approach, a comparison with the sectoral approach and relevant information on the national energy balance 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. This work summarises CRF Table 9(a), which contains a detailed overview of non-included sources and sinks.

Table 168: Completeness – overview of sources and sinks whose emissions are not estimated (NE)

GHG	Source/sink category (2)	Explanation
CH4	1.B.1.A Coal Mining and Handling	will be checked
CH4	1.B.2.A Oil	no data available yet/will be checked
CH4	1.B.2.C Venting and Flaring	no data available yet/will be checked
CH4, CO2, 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).
CH4, CO2, N2O	1.AA.3.B Road Transportation	no data available for use of natural gas
CH4, N2O	1.AA.3.B Road Transportation	no data available for emissions from lubricants
CH4, CO2, N2O	1.AA.3.C Railways	German Energy Balance does no longer provide such data
CH4, CO2, N2O	1.C1.B Marine	no data available for lubricant-use in International Navigation
CH4	Abandoned Mines	will be checked
CO2	1.B.1.A Coal Mining and Handling	will be checked
CO2	1.B.1.B Solid Fuel Transformation	will be checked
CO2, N2O	1.B.2.A Oil	no data available yet
CO2	1.B.2.B Natural Gas	will be checked/no data available yet
CO2, N2O	1.B.2.C Venting and Flaring	no data available yet/will be checked
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).
CO2	1.C1.B Marine	no data available for lubricant-use in International Navigation
CH4	2.C.1.4 Coke, 2.C.2, 2.C.3	will be checked
CO2	2.C.1.4 Coke	will be checked
SF6	Other non-specified	Will be checked.
CO2	3.A , 3.B, 3.C, 3.D 5	Germany is not converting the emissions of NMVOC in an Calculation in CO2-emissions.
CH4	4.A Enteric Fermentation, 4.B Manure Management	Mules and Asses: The official statistic does not consider the numbers of mules and asses. Inofficial numbers amount to 6000 til 8000 asses and 500 mules. Therefore the emissions of CH4 and N2O for manure management and enteric fermentation are negligible.
Carbon	5.A.1 Forest Land remaining Forest Land	Changes in dead organic matter and soils: cf. NIR chapter 7.1.1.1.2 for further explanation: For greenhouse-gas inventories, it was assumed that stocks under existing forest do not change (corresponds to "Tier 1").
Carbon	5.A.2. Land converted to Forest Land	Changes in dead organic matter and soils: 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.1 Cropland remaining Cropland, 5.C.1 Grassland remaining Grassland	No reporting on dead organic matter pools is required for category 5.B.1. Cropland remaining Cropland and 5.C.1 Grassland remaining Grassland.
Carbon	5.B.2. Land converted to Cropland, 5.C.2. Land converted to Grassland	Dead organic matter: Pursuant to GPG LULUCF (IPCC, 2003), reporting under the categories"cropland" and "grassland" includes reporting on carbon-stock changes in soil and biomass stocks.
Carbon	5.D.1 Wetlands remaining Wetlands, 5.E.1 Settlements remaining Settlements	Emissions from this source category are currently not being reported according appendix 3a.3 IPCC GPG.
Carbon	5.D.2 Land converted to Wetlands, 5.E.2 Land converted to Settlements	Emissions from this source category are currently not being reported for all pools. For detailed information cf. CRF tables related to CRF 5.
Carbon	5.F. Other Land	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 soilcondition survey (BZE), can be provided, results have not been included in the CRF tables.
CH4, N2O	5.A. Forest Land	No reliable data is available for reporting of non-CO2-emissions from drainage of forest soils.
N2O	5.B. Land converted to Cropland	Soil: Differentiation between organic and mineral soils. Possibility for reporting of separated categories will be checked.

GHG	Source/sink category (2)	Explanation
CH4, N2O	5.C.2. Land converted to Grassland, Biomass burning	Emissions of other ghg were considered negligible, since areas burned are small cf. NIR 7.1.1.1.3
CH4, N2O	5.D Wetlands, 5.E Settlements	Emissions from this source category are currently not being reported according appendix of IPCC GPG.
CH4, N2O	5.F Other Land	Emissions are not estimated according chapter 3.7 of the IPCC GPG for LULUCF.
CO2	5.G Other	Germany reports emissions of CO2 due to liming of forest soils under this category, other categories are not to be considered.
CH4	Forest Land, Grassland converted to Other Land-Use Categories	No reliable data is available for reporting on CH4, NOx, CO, NMVOC emissions so far.
CO2, CH4, N2O	Harvested Wood Products	Emissions from this source category are currently not being reported according appendix of IPCC GPG.
N2O	6.B.1 Industrial Wastewater	N2O emissions from 'domestic and commercial wastewater' and emissions from 'industrial wastewater' have not been estimated. The IPCC 1996 Guidelines solely refer to the estimation of N2O emissions from human sewage.
N2O	6.B.2.1 Domestic and Commercial (w/o human sewage)	N2O emissions from 'domestic and commercial wastewater' (other than from human sewage) and emissions from 'industrial wastewater' have not been estimated. The IPCC 1996 Guidelines solely refer to the estimation of N2O emissions from human sewage.

Table 169: Completeness – overview of sources and sinks that are included elswhere (IE)

GHG	Source/sink category	Allocation as per IPCC Guidelines	Allocation used by the Party	Explanation
CO2	1.AA.3.A Civil Aviation	included under Emissions from Jet Kerosene		included in: Jet Kerosene, Emissions
CO2	2.A.3 Limestone and Dolomite Use	A.3: limestone and dolomite use	1.A.1.a, 2.A.1 and 2.A.2, 2.A.4, 2.A.7, 2.C.1	Result of a national limestone balance: data of limestone and dolomite use is estimated and reported under the using categories, see the chapter in NIR 2.A.3 for more explanations.
CO2	2.A.4.2 Soda Ash Use		using categories: for example glass production	emissions of use are estimated in using categories
HFCs, PFCs, SF6	2.F Consumption of Halocarbons and SF6			The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions.
PFCs	2.C.3 Aluminium Production	The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions		The potential emissions of production, import, export and destroyed amounts are all reported together under total potential emissions
SF6	2.C.5 Magnesium production	SF6 emissions are reported under 2.C.4 Aluminium and Magnesium Foundries		SF6 emissions are reported under 2.C.4 Aluminium and Magnesium Foundries
Carbon	5.B.2.3 Wetlands converted to Cropland, 5.B.2.4 Settlements converted to cropland			To source category 5.F, all those areas have been assigned that do not belong in the categories forest, cropland or grassland; pursuant to GPG LULUCF (IPCC, 2003) (Wetlands, Settlements).
Carbon	5.D.2.1, 5.E.2.1 Forest Land converted to Wetlands and Settlements			For new federal states, estimates of net changes in forest area since 1993 only are available. Therefore, it was not possible to estimate the areas converted from forest to any other land use category. For old federal states, all conversions of forest land since 1987 to any other land-use category, such as cropland, grassland, wetlands and settlement are reported here, since the present CRF provides no appropriate place to report these aggregate estimates.
CO2	5.A. Forest Land, Biomass burning			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.
CO2	5.B. Cropland, 5.C Grassland			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.
CO2	C from lime to forest			As data cannot be differentiated with regard to types of application (dolomite or lime) dolomite use is included on limestone use.

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 relative to 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) have 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 relative to 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 "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 concerned 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.

3. *For preparation of the national inventory, data are used, for calculation of emissions and reductions, that 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 are prepared on an annual basis. In addition, quality assurance in keeping with the requirements of Art. 12 of the ground rules shall be carried out. Furthermore, reliable documentation (record-keeping) and archiving are 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, are 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 (UBA) takes 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 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 will 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 Assigned Amount Units (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, an income position (Einnahmetitel) shall be established within departmental budget 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 budget plans. The departments' additional requests 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 concerned departments, that is to be established pursuant to Paragraph 2 of the principles paper met for the first time on 18 December 2007. The main purpose of this first meeting was to discuss the status of implementation of the state secretaries' resolution and to determine relevant further procedures, especially procedures in connection with reporting for 2008. Table 170 shows the status of implementation of this resolution. A proposal relative to "Minimum requirements for quality control and quality assurance in greenhouse-gas-emissions reporting" ("Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasberichterstattung") has been submitted for discussion and approval by the relevant departments (cf. Chapter 17.2.1.10).

Table 170: Status of implementation of the state secretaries' resolution relative to the National System

Co-operation with:	Status
All areas	**18. December 2007:** First meeting of the co-ordinating committee Resolution-ready proposal relative to minimum requirements for data recording, QC/QA and archiving in the National System (outside of UBA)
BMWi	**Energy area:** **July 2007:** Discussion between UBA and BMWi regarding the required schedule for data delivery **December 2007:** Submission, by BMWi, of a catalogue of specifications pertaining to the call for tenders for preparation of energy balances from 2007 until the end of the commitment period, with such specifications taking required scheduling into account to the greatest degree possible **Area of industrial processes / solvent use:** **June 2007:** Provision, by UBA, of overview tables relative to data requirements **July 2007:** Answering, by UBA, of BMWi's questions regarding data flows. Preliminary clarification, with industry representatives, regarding basic willingness to conclude concrete agreements **Beginning of March 2008:** BMWi provides a list to UBA showing status at the individual-item level **March 2008:** Invitation to association discussions relative to concrete agreements
BMI / Destatis	**June 2007:** Discussion, between UBA and Destatis, on procedures for managing secrecy of statistical data **July 2007:** Confidential data can be submitted to UBA only on the basis of a relevant legal provision; BMI, BMJ and BfDI must be involved (decision by the Destatis management) **August until November 2007:** Destatis, BMI, BMJ and BfDI engage in discussion, in writing, regarding the problems connected with maintaining secrecy. UBA participates in discussion of the manner in which data is to be processed further. **20 December 2007:** Clarification of open question, in the framework of a video conference (BMI, BMJ, BMU, BfDI, UBA, Destatis) on 20 December 2007. Result: Basic agreement regarding the need for a solution via a legal provision. **20 December 2007:** Discussion involving BMU/UBA, BMI/Destatis, BMJ and BfdI, with basic agreement regarding the need for a solution via legal provisions. A perspective for a concrete legal provision relative to the secrecy problems provides the basis for completing the draft of the planned administrative agreement, between UBA and Destatis, on data transfer. DESTATIS and the Federal Agricultural Research Institute (FAL) plan an additional administrative agreement via which statistical data from agricultural statistics would be processed and the results would be forwarded to UBA. In this case, the secrecy problems can be solved by dividing responsibility for calculations between FAL and DESTATIS. **First quarter of 2008:** the administrative agreements between DESTATIS and UBA/FAL should be in place.
EURO-CONTROL	Draft of an agreement on data exchange; revised draft goes to the Federal Foreign Office, following legal co-ordination in the BMU.
BMVBS	The BMVBS has agreed that Eurocontrol may forward flight data directly to UBA. Consequently, an agreement with Eurocontrol must be concluded, to provide a basis for data exchange. BMVBS has announced a research project that will seek to prepare a scientifically founded model that, in the context of reporting on greenhouse gases, addresses the still-open question of differentiation of transports, with regard to individual road categories. A call for proposals for this project will be issued in early 2008. The BMVBS has been requested to provide input for eliminating the data problems with regard to railway transports outside of the Deutsche Bahn network (German railways) (especially with regard to increasing freight traffic, and to breakdowns in terms of electric and diesel power). The Federal Environment Agency (UBA) will prepare the draft of the relevant departmental agreement and submit it in the short term.
BMVg	No further action required on the basis of the resolution.
BMU / UBA	Ensuring that data surveys relative to F gases and solvents are carried out, via long-term contracts. Relevant commissioning is being prepared.
BMELV	**April 2007:** A first concept for forest monitoring with regard to implementation of Article 3 (4) KP has been prepared. As noted in March 2007, the requirement persists for presentation of an integrated concept for functioning monitoring in the LULUCF area, pursuant to Art 3.3 and 3.4 KP, and with regard to the UN Framework Convention on Climate Change, as well as for complete reporting for the report tables under the FCCC and the Kyoto Protocol. A concept for the planned National System in the agricultural sector (taking account of subordinate authorities, and co-operation with the Federal Statistical Office) remains to be completed. **1 January 2008:** Establishment of a new working unit, entitled "Emissions Reporting", in the newly founded Johann-Heinrich-von Thünen Institute, which in future will handle all emissions-reporting issues relative to CRF 4 and 5.

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 1.2.5.1), 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 ministries BMU, BMI, BMVg, BMF, BMWi, BMVBS and BMELV, 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 (2005/166/EC) implementing Decision No 280/2004/EC of the European Parliament and of the Council* 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 categories. For other source categories, not all source-category-specific QC procedures have to be implemented. In addition, not all measures have to be carried out on an annual basis. Data-collection methods, for example, 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 category – yes/no; uncertainties – high/low)
- The time of the last detailed QC/QA measure for the source category, and the results of such measure
- Changes in methods or the pertinent database
- Results of annual inventory review in keeping with the UN Framework Convention on Climate Change and the Kyoto Protocol
- Available resources for execution of QC/QA measures

Good practice calls for establishing a QC/QA plan and then reviewing and updating it each year after the latest inventory has been prepared.

On the basis of the results of annual inventory review, and of the results of QC/QA measures of which it is aware, the Single National Entity prepares an improvement plan for the entire inventory. On this basis, in turn, it derives proposals for a binding inventory plan for the next report year. Such proposals are then submitted to the co-ordinating committee for approval. The QC/QA co-ordinator, working in co-operation with the QSE co-ordinator in the Single National Entity, defines the procedures, scheduling and scope for inclusion of his institution's QC/QA measures in the inventory plan for the overall inventory.

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 with regard to data combination and carrying out plausibility checks with the help of external data sources and earlier calculations. Suppliers of emissions calculations have to carry out additional QC measures – for example, checking formulae for emissions calculation.

Required quality controls should be recorded in checklists. Such lists should include at least the checking measures carried out, the results of checking, any pertinent corrections made and the name of the person(s) responsible for the measures. Annex 2 of the present document includes a sample checklist of the Federal Environment Agency.

Not all quality controls have to be carried out on an annual basis; some may be implemented at longer regular intervals. This applies especially to aspects of data collection that do not change from year to year. Requirements pertaining to the frequency and completeness of QC measures are more stringent for key categories than for other source categories. It should be ensured that all source categories undergo detailed quality control at least periodically.

17.2.1.6 Source-category-specific quality control

Available resources permitting, particularly relevant source categories (such as key categories), in addition to undergoing Tier 1 procedures, should undergo Tier 2 quality control with regard to determination of activity rates, emissions and uncertainties (cf. Chapter 8.7 *Good Practice Guidance*). The chapters of the *IPCC Good Practice Guidance* that pertain to the various individual source categories (Chapters 1-5) include additional guidelines 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 plant-specific activity data, it is good practice to review the methods and QC/QA standards applied to data collection. Where such methods and standards do not meet minimum requirements, the advisability of using the data should be reconsidered and the uncertainties should be adjusted as necessary.

With regard to **emissions data**, it is good practice to review the emission factors that have been used. Such efforts include using national emission factors for key categories and reviewing the validity of IPCC standard factors under the applicable national circumstances. Where emissions data are obtained via direct measurements, it is good practice to review the relevant measurement methods and the quality standards applied. Emissions data and emission factors should be reviewed in light of data from previous years, and from independent sources, and any resulting discrepancies should be explained.

Quality control for uncertainties includes checking to determine whether calculations are free of errors and whether documentation for reproduction of results is adequate. In use of experts' assessments, the pertinent experts' qualifications and estimation methods should be reviewed and documented.

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) "*include a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Reviews, preferably by independent third parties, should be performed upon a finalised inventory following the implementation of QC procedures. Reviews:*

- Verify that data quality objectives were met,
- Ensure that the inventory represents the best possible estimates of emissions and sinks given the current state of scientific knowledge and data available, and
- Support the effectiveness of the QC programme".

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

The general requirement applies that 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, cut-off points, 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, where inventory reviewers consider such disclosure to be necessary to ensure that emissions calculations are transparent and clear. In individual cases, the extent to which such disclosure actually must involve disclosure of individual data items should be clarified 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, at the Federal Environment Agency the specific provisions of in-house directive (Hausanordnung) No. 11/2005 apply. 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 led to the development of the Quality System of Emissions Inventories (QSE), via which the points mentioned in Chapter 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" within the Federal Environment Agency. In the Federal Environment Agency's organisational diagramme, this responsibility is listed under the heading: "Contact agencies of 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 binding.

17.2.1.10.2.2 Reporting procedures

In many cases, complex activities comprise numerous different, but related and cumulative, 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 67). Additional relevant information is provided in the QSE manual, Chapter 4.3.

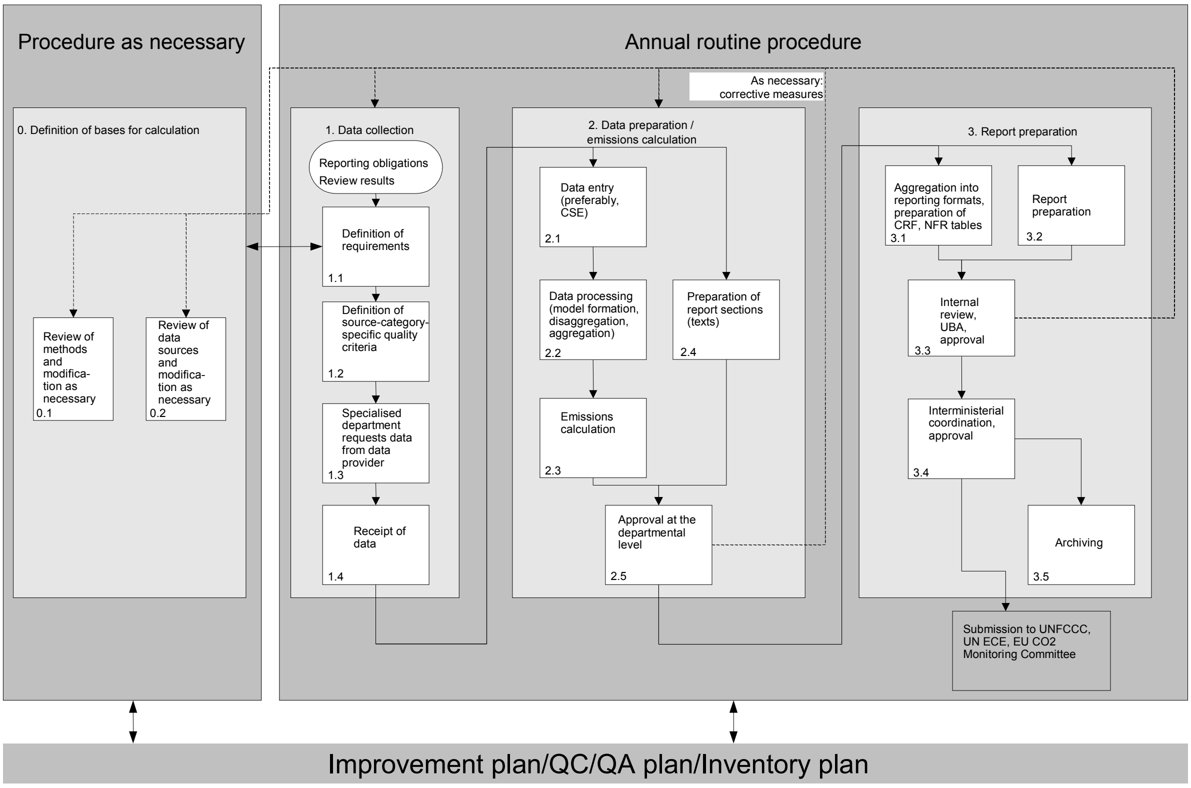


Figure 67: Overview of the overall emissions-reporting process

Via a role concept, suitable responsibilities were 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. Specialised representative 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 in 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 68), 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

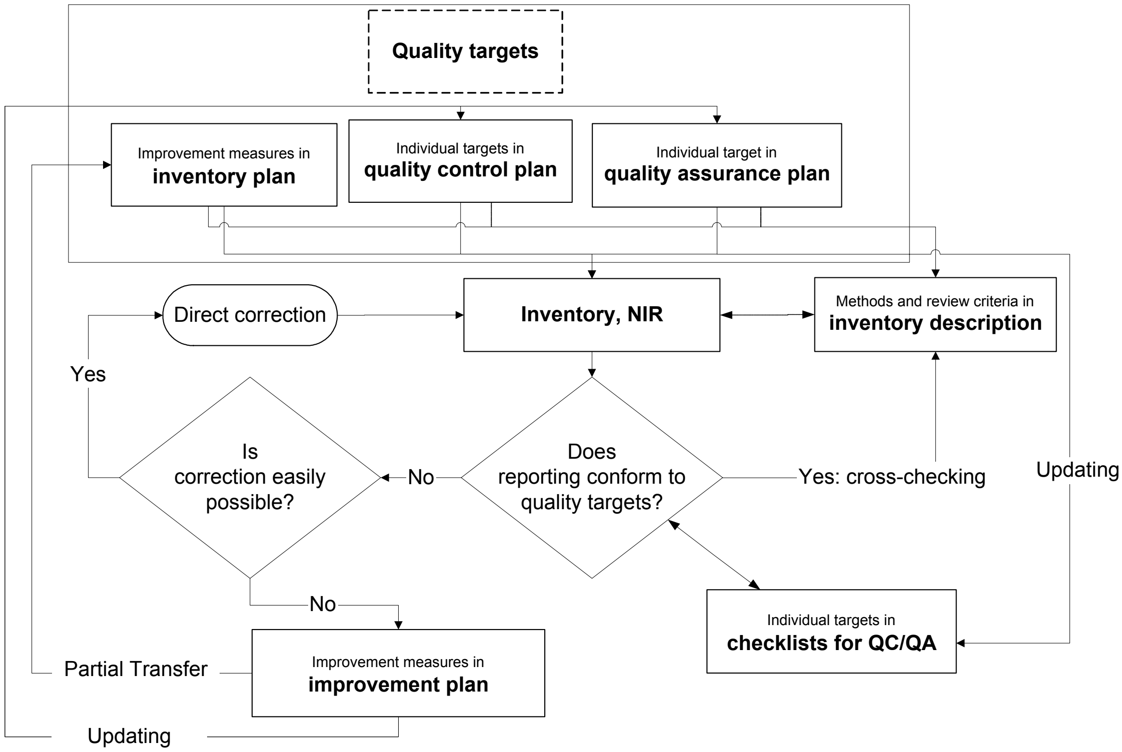


Figure 68: Control and documentation in the framework of the NaSE and the QSE

The **quality aims** 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 goals, 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 goals 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 concrete goals. Every effort should be made to attain such individual goals. When a goal is attained, such achievement is noted and recorded in the checklists. The possible entries for such records include "yes" (the goal was attained), "not relevant" (the goal 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 attain the goal).

Each checklist includes a general section that reflects all Tier 1 QC requirements from IPCC Good Practice Guidance and that is carried out in connection with every instance of reporting. In addition, each checklist contains a source-category-specific section (Tier 2) that provides concrete aims for the relevant key category area.

Checklists are provided only for the first five roles within the role concept. Where different roles are responsible for different main and sub- processes of emissions reporting (cf. Chapter 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 use of the "four-eyes" principle. The specialised contact persons (FAP) have the task of ensuring that the emissions calculations and textual work of the responsible experts (FV) are of the proper quality.

In its section on "Expert Peer Review", the IPCC notes that the (above-described) formal procedure selected by the Federal Environment Agency can complement, but not replace, expert peer review (Good Practice Guidance; Chapter 8.8). In one solution found for addressing the justified call for inclusion of external experts, within the framework of available resources, detailed review of specific issues is carried out by external third parties via research projects and studies. In general, the two sides involved (i.e. FV and FAP) jointly manage the process of commissioning third parties. In another means found for addressing the need for third-party inclusion, workshops on the National System are held at irregular intervals. For such workshops, national experts are invited to come to the Federal Environment Agency for discussion with Federal Environment Agency experts (FV) on current inventory issues relative to selected source categories.

No audits have been carried out in the Federal Environment Agency to date, and none are planned at present. According to the Good Practice Guidance, audits are not absolutely required.

17.2.1.10.6 Documentation (record-keeping) 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 Environmental 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 171. 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" ("Allgemeinen Mindestanforderungen an die Qualitätskontrolle und Qualitätssicherung bei der Treibhausgasemissionsberichterstattung") apply.

Table 171: 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 the most important requirements. Detailed information has been removed in the interest of clarity.

Table 172: 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 recorded.
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 recorded.
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 recorded.	
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 recorded.
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 (Chapter 7.3.2.2), and the procedure has been clearly and logically recorded.
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 recorded 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 recorded 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 their source-category coverage.	Where the EF and the AR do not agree, extrapolation was carried out and taken into account in the uncertainties. All steps have been recorded 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 recorded.
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 recorded.	
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 recorded 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 recorded.	
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 (Chapter 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 recorded.
1.4	Receipt of data	The assumptions on which the uncertainties determinations are based have been clearly and logically recorded .	
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 recorded.	

Main process: 2. Data preparation / emissions calculation

Process No.	Sub-process name	Individual goal	Optional goal
2.1	Data entry (preferably into CSE)	The EF and the uncertainties for the EF are complete.	Any gaps have been properly, clearly and logically explained and duly recorded.
2.1	Data entry (preferably into CSE)	The origins of EF data, and the EF uncertainties, have been completely substantiated.	Lacking or incomplete substantiation of data origin has been properly, clearly and logically explained and duly recorded.
2.1	Data entry (preferably into 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 recorded.
2.1	Data entry (preferably into CSE)	The AR and the uncertainties for the AR are complete.	Any gaps have been properly, clearly and logically explained and duly recorded.
2.1	Data entry (preferably into CSE)	The origins of AR data, and the AR uncertainties, have been completely substantiated.	Lacking or incomplete substantiation of data origin has been properly, clearly and logically explained and duly recorded.

Process No.	Sub-process name	Individual goal	Optional goal
2.1	Data entry (preferably into 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 recorded.
2.1	Data entry (preferably into 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 Chapter 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 recorded.
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 recorded.	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 recorded.	Any EF and AR that contribute to extreme implied EF have been properly, clearly and logically explained, and duly recorded, 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 recorded.
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 substantiation of data origin has been properly, clearly and logically explained and duly recorded.

17.3 The database system for emissions – Central System of Emissions

Since 1998, the UBA has developed a central national database – the *Central System of Emissions (CSE)* – as a technical tool for inventory preparation. The CSE implements the diverse requirements pertaining to emissions calculation and reporting, and it automates essential work stages. The CSE facilitates inventory planning reporting (e.g. emissions calculation, recalculation and error analysis) as well as inventory management (e.g. archiving, annual evaluation of data) and data-level quality management (cf. UBA 2003a, Decor project manual). The CSE should make it possible to fulfill the key requirements of transparency, consistency, completeness, comparability and accuracy on the data level.

In order to ensure fulfillment of these key requirements, careful attention is given to documentation within the CSE. In the CSE, records are kept of persons responsible for processing, of data sources and calculation procedures, of uncertainties relative to time series, of the date of each last change and of the persons who use such changes. The system has a history-management function that archives deleted entries. This facilitates the tracking and reconstruction of data, thereby also enabling independent review by third parties. Supporting mechanisms are provided or developed at data level for the performance of quality assurance (e.g. system for detecting uncertainties, plausibility checks). Above all, transparency is achieved by ensuring that data is recorded in the same structure in which it is provided, and that all processing and transformations into reporting format occur only in the CSE, in the interest of clarity. In this way, the CSE is capable of administering detailed technology-specific activity data and emission factors that can be processed, via calculation rules (calculation methods), into aggregate, source-category-specific values for the reporting formats. Aggregation of individual CSE time series for the CRF report lines is described in Annex 3 and Chapter 14f – in each case, with regard to individual source categories. In addition to aggregation and model formation for calculations, the CSE also supports scenario and forecast calculation.

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 CSE. In addition to being input directly, aggregate figures may also be imported from existing databases via a standard interface (e.g. TREMOD, GAS-EM). The aim is for technical experts responsible for content to enter inventory data directly into the CSE wherever possible or, at least, for the CSE administrator to import such data via the import interface. This applies to in-house UBA employees as well as to external parties involved in the National System. In order to achieve this, fundamental preparations have been carried out since 2001:

- 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 UBA were given direct access to the CSE via the UBA 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 UBA employees.
- Since 2005 qualitative and quantitative information about data uncertainties has 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 observed.

The CSE's operational launch in 2002 fulfilled the principal technical requirements for compliance with the Kyoto requirements for inventories; the next stage now is to bring emissions-calculation and data-collection procedures completely into line with the CSE.

Other future tasks for the Central System for Emissions include comprehensive application of the database for:

- Integration of the Reference Approach within the CSE,
- Adaptation of the CSE to data-secrecy requirements,
- Preparation of forecasts and scenarios to facilitate future estimates on compliance with reduction obligations and to facilitate identification of additional measures needed for target attainment.

17.3.1 Documentation of calculations in CalQlator

To support transparent documentation of calculations, the Federal Environment Agency has developed a calculation tool for the CSE; this tool went into operation at the end of 2003. CalQlator makes it possible to store complex calculation methods in a user-friendly form in the database. It supports derivation of equations for linking entered values within calculations; once a formula has been entered, all calculation steps can be traced, and single changes trigger consistent recalculation of entire time series. Via a function for definition of inequalities, CalQlator can also be used for quality assurance – for example, via definition of checking parameters for maximum deviations. In January 2004, a first group of UBA staff received an introductory training course on CalQlator.

17.3.2 Data transfer between the TREMOD and CSE databases

In 1999/2000, an interface was programmed for transfer of emissions data, for the source category *road transport*, from the TREMOD (Transport Emission Estimation Model) database into the CSE database; in 2003, this interface was adapted to an upgraded version of the CSE database.

The current CSE import format is described in detail in Annex 6 (Chapter 17.2.2) of the NIR 2007.

18 ANHANG 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. Efforts to obtain such a complete data set, which is required for calculations, are gleaning relevant values from adjustment procedures, with the help of IPCC Conservativeness Factors[58]. Systematic and complete experts' assessments are being hampered by the following issues, however:

- The fact that most activity rates are taken from data sources that are outside 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 an external database (examples include the BEC, 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 173.

[58] FCCC/SBSTA/2003/10/Add.2, Annex III, p 24-27

Table 173: Table 6.2 of the IPCC Good Practice Guidance – details

IPCC Source Category	Fuel Category	Gas	Year t emissions [Gg]	Year t emissions [Gg CO_2-equiv.]	Activity data uncertainty [%]	Emission factor uncertainty [%]	Combined uncertainty [%]	Combined uncertainty as % of total national emissions in year t [%]	Tier 1 Level assessment [%]
Total				**1,10E+06**				**12,48%**	**100,00%**
1A1a	Solid Fuels	CO2	2.83E+05	2.83E+05	6.12%	1.60%	6.32%	1.64%	6.05%
1A1a	Other Fuels	CO2	1.26E+04	1.26E+04	9.91%	0.97%	9.96%	0.11%	0.42%
1A1a	Gaseous Fuels	CO2	3.03E+04	3.03E+04	2.91%	1.09%	3.11%	0.09%	0.32%
1A1a	Solid Fuels	N2O	1.05E+01	3.27E+03	6.12%	26.38%	27.08%	0.08%	0.30%
1A1a	Liquid Fuels	CO2	5.05E+03	5.05E+03	3.01%	1.46%	3.34%	0.02%	0.06%
1A1a	Other Fuels	N2O	4.14E-01	1.28E+02	9.91%	29.11%	30.75%	0.00%	0.01%
1A1a	Biomass	CO2	1.77E+02	1.77E+02	21.55%	1.79%	21.62%	0.00%	0.01%
1A1a	Solid Fuels	CH4	4.11E+00	8.62E+01	6.12%	26.72%	27.41%	0.00%	0.01%
1A1a	Gaseous Fuels	N2O	1.13E-01	3.51E+01	2.91%	28.01%	28.16%	0.00%	0.00%
1A1a	Liquid Fuels	N2O	5.44E-02	1.69E+01	3.01%	29.13%	29.29%	0.00%	0.00%
1A1a	Gaseous Fuels	CH4	7.39E-01	1.55E+01	2.91%	18.43%	18.66%	0.00%	0.00%
1A1a	Other Fuels	CH4	2.49E-01	5.22E+00	9.91%	24.26%	26.20%	0.00%	0.00%
1A1a	Liquid Fuels	CH4	1.59E-01	3.34E+00	3.01%	24.30%	24.49%	0.00%	0.00%
1A1a	Biomass	CH4	9.74E-04	2.05E-02	21.55%	38.90%	44.47%	0.00%	0.00%
1A1b	Liquid Fuels	CO2	1.93E+04	1.93E+04	3.24%	0.54%	3.29%	0.06%	0.21%
1A1b	Gaseous Fuels	CO2	7.28E+02	7.28E+02	5.16%	0.58%	5.19%	0.00%	0.01%
1A1b	Liquid Fuels	N2O	1.96E-01	6.09E+01	3.24%	39.54%	39.68%	0.00%	0.01%
1A1b	Solid Fuels	CO2	1.92E+02	1.92E+02	10.93%	1.00%	10.97%	0.00%	0.01%
1A1b	Liquid Fuels	CH4	3.91E-01	8.22E+00	3.24%	39.51%	39.64%	0.00%	0.00%
1A1b	Gaseous Fuels	N2O	3.43E-03	1.06E+00	5.16%	75.00%	75.18%	0.00%	0.00%
1A1b	Solid Fuels	N2O	2.40E-03	7.45E-01	10.93%	75.00%	75.79%	0.00%	0.00%
1A1b	Gaseous Fuels	CH4	1.43E-02	3.01E-01	5.16%	41.38%	41.70%	0.00%	0.00%
1A1b	Solid Fuels	CH4	1.44E-03	3.03E-02	10.93%	75.00%	75.79%	0.00%	0.00%
1A1c	Solid Fuels	CO2	1.53E+04	1.53E+04	7.43%	3.63%	8.27%	0.12%	0.43%
1A1c	Gaseous Fuels	CO2	2.30E+03	2.30E+03	14.68%	3.22%	15.03%	0.03%	0.12%
1A1c	Solid Fuels	N2O	7.01E-01	2.17E+02	7.43%	33.61%	34.42%	0.01%	0.03%
1A1c	Biomass	CO2	4.28E+01	4.28E+01	29.15%	5.00%	29.58%	0.00%	0.00%
1A1c	Liquid Fuels	CO2	1.54E+02	1.54E+02	2.88%	2.33%	3.70%	0.00%	0.00%
1A1c	Gaseous Fuels	N2O	3.76E-02	1.16E+01	14.68%	32.54%	35.70%	0.00%	0.00%
1A1c	Solid Fuels	CH4	2.68E-01	5.62E+00	7.43%	36.25%	37.00%	0.00%	0.00%
1A1c	Gaseous Fuels	CH4	1.04E-01	2.19E+00	14.68%	32.54%	35.70%	0.00%	0.00%
1A1c	Liquid Fuels	N2O	2.20E-03	6.82E-01	2.88%	33.30%	33.43%	0.00%	0.00%
1A1c	Liquid Fuels	CH4	7.17E-03	1.50E-01	2.88%	26.30%	26.46%	0.00%	0.00%
1A1c	Biomass	CH4	2.11E-03	4.44E-02	29.15%	75.00%	80.47%	0.00%	0.00%
1A2	Gaseous Fuels	CO2	5.44E+04	5.44E+04	5.38%	2.25%	5.83%	0.29%	1.07%

IPCC Source	Fuel Category	Gas	Year t emissions	Year t emissions	Activity data	Emission factor	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Tier 1 Level assessment
Category			[Gg]	[Gg CO_2-equiv.]	uncertainty [%]	uncertainty [%]	[%]	[%]	[%]
1A2	Other Fuels	CO2	1.63E+04	1.63E+04	17.00%	3.15%	17.29%	0.26%	0.95%
1A2	Solid Fuels	CO2	2.47E+04	2.47E+04	3.33%	1.27%	3.56%	0.08%	0.30%
1A2	Liquid Fuels	CO2	1.74E+04	1.74E+04	2.18%	1.61%	2.71%	0.04%	0.16%
1A2	Biomass	CO2	2.05E+03	2.05E+03	8.70%	1.83%	8.89%	0.02%	0.06%
1A2	Other Fuels	N2O	5.84E-01	1.81E+02	17.00%	56.63%	59.13%	0.01%	0.04%
1A2	Solid Fuels	N2O	1.15E+00	3.56E+02	3.33%	16.06%	16.40%	0.01%	0.02%
1A2	Gaseous Fuels	N2O	5.54E-01	1.72E+02	5.38%	27.47%	27.99%	0.00%	0.02%
1A2	Liquid Fuels	N2O	3.61E-01	1.12E+02	2.18%	16.59%	16.74%	0.00%	0.01%
1A2	Solid Fuels	CH4	2.72E+00	5.70E+01	3.33%	12.17%	12.62%	0.00%	0.00%
1A2	Gaseous Fuels	CH4	1.38E+00	2.89E+01	5.38%	23.10%	23.72%	0.00%	0.00%
1A2	Other Fuels	CH4	4.78E-01	1.00E+01	17.00%	47.21%	50.17%	0.00%	0.00%
1A2	Liquid Fuels	CH4	7.21E-01	1.51E+01	2.18%	16.60%	16.74%	0.00%	0.00%
1A2	Biomass	N2O	2.56E-02	7.94E+00	8.70%	27.97%	29.29%	0.00%	0.00%
1A2	Biomass	CH4	7.11E-02	1.49E+00	8.70%	24.17%	25.69%	0.00%	0.00%
1A3a	Liquid Fuels	CO2	5.29E+03	5.29E+03	50.00%	2.00%	50.04%	0.24%	0.89%
1A3a	Liquid Fuels	N2O	2.52E-01	7.81E+01	50.00%	75.00%	90.14%	0.01%	0.02%
1A3a	Liquid Fuels	CH4	6.71E-02	1.41E+00	50.00%	50.00%	70.71%	0.00%	0.00%
1A3b	Liquid Fuels	CO2	1.49E+05	1.49E+05	2.13%	0.63%	2.23%	0.30%	1.12%
1A3b	Biomass	CO2	5.63E+03	5.63E+03	3.55%	17.75%	18.10%	0.09%	0.34%
1A3b	Liquid Fuels	N2O	3.42E+00	1.06E+03	2.13%	23.80%	23.90%	0.02%	0.09%
1A3b	Liquid Fuels	CH4	7.34E+00	1.54E+02	2.13%	15.87%	16.01%	0.00%	0.01%
1A3b	Biomass	N2O	1.19E-01	3.70E+01	3.55%	26.62%	26.86%	0.00%	0.00%
1A3b	Biomass	CH4	6.05E-02	1.27E+00	3.55%	17.75%	18.10%	0.00%	0.00%
1A3c	Liquid Fuels	CO2	1.27E+03	1.27E+03	11.00%	2.00%	11.18%	0.01%	0.05%
1A3c	Liquid Fuels	N2O	1.72E-02	5.33E+00	11.00%	75.00%	75.80%	0.00%	0.00%
1A3c	Liquid Fuels	CH4	2.75E-02	5.77E-01	11.00%	50.00%	51.20%	0.00%	0.00%
1A3d	Liquid Fuels	CO2	8.55E+02	8.55E+02	11.00%	2.00%	11.18%	0.01%	0.03%
1A3d	Liquid Fuels	N2O	1.16E-02	3.58E+00	11.00%	75.00%	75.80%	0.00%	0.00%
1A3d	Liquid Fuels	CH4	2.77E-02	5.82E-01	11.00%	50.00%	51.20%	0.00%	0.00%
1A3e	Gaseous Fuels	CO2	1.53E+03	1.53E+03	6.33%	3.54%	7.25%	0.01%	0.04%
1A3e	Liquid Fuels	CO2	2.82E+03	2.82E+03	1.29%	2.77%	3.05%	0.01%	0.03%
1A3e	Liquid Fuels	N2O	4.65E-02	1.44E+01	1.29%	69.20%	69.21%	0.00%	0.00%
1A3e	Gaseous Fuels	N2O	2.78E-02	8.61E+00	6.33%	35.36%	35.92%	0.00%	0.00%
1A3e	Liquid Fuels	CH4	1.58E-01	3.33E+00	1.29%	55.36%	55.37%	0.00%	0.00%
1A3e	Gaseous Fuels	CH4	5.45E-02	1.14E+00	6.33%	35.36%	35.92%	0.00%	0.00%
1A4a	Gaseous Fuels	CO2	2.59E+04	2.59E+04	8.05%	2.68%	8.48%	0.20%	0.74%
1A4a	Liquid Fuels	CO2	1.91E+04	1.91E+04	9.45%	2.84%	9.87%	0.17%	0.64%
1A4a	Biomass	CO2	2.37E+03	2.37E+03	28.86%	49.50%	57.30%	0.12%	0.46%

IPCC Source	Fuel Category	Gas	Year t emissions	Year t emissions	Activity data	Emission factor	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Tier 1 Level assessment
Category			[Gg]	[Gg CO_2-equiv.]	uncertainty [%]	uncertainty [%]	[%]	[%]	[%]
1A4a	Solid Fuels	CO2	9.77E+02	9.77E+02	6.34%	2.72%	6.90%	0.01%	0.02%
1A4a	Biomass	N2O	2.09E-02	6.48E+00	28.86%	148.50%	151.28%	0.00%	0.00%
1A4a	Solid Fuels	N2O	4.91E-02	1.52E+01	6.34%	45.32%	45.76%	0.00%	0.00%
1A4b	Biomass	CO2	2.36E+04	2.36E+04	29.14%	49.99%	57.86%	1.25%	4.62%
1A4b	Gaseous Fuels	CO2	5.70E+04	5.70E+04	12.46%	3.00%	12.82%	0.67%	2.46%
1A4b	Liquid Fuels	CO2	5.62E+04	5.62E+04	11.05%	2.87%	11.42%	0.59%	2.16%
1A4b	Solid Fuels	CO2	4.06E+03	4.06E+03	5.48%	1.84%	5.78%	0.02%	0.08%
1A4b	Solid Fuels	N2O	3.20E-01	9.92E+01	5.48%	30.72%	31.21%	0.00%	0.01%
1A4b	Biomass	N2O	1.89E-04	5.87E-02	29.14%	100.00%	104.16%	0.00%	0.00%
1A4c	Biomass	CO2	1.07E+03	1.07E+03	27.86%	47.79%	55.32%	0.05%	0.20%
1A4c	Liquid Fuels	CO2	5.53E+03	5.53E+03	2.96%	2.12%	3.64%	0.02%	0.07%
1A4c	Gaseous Fuels	CO2	8.07E+02	8.07E+02	8.05%	2.68%	8.48%	0.01%	0.02%
1A4c	Solid Fuels	CO2	1.64E+02	1.64E+02	6.37%	2.73%	6.93%	0.00%	0.00%
1A4c	Liquid Fuels	N2O	6.40E-02	1.98E+01	2.96%	32.33%	32.46%	0.00%	0.00%
1A4c	Liquid Fuels	CH4	3.98E-01	8.35E+00	2.96%	46.18%	46.28%	0.00%	0.00%
1A4c	Solid Fuels	N2O	8.25E-03	2.56E+00	6.37%	45.52%	45.96%	0.00%	0.00%
1A5a	Gaseous Fuels	CO2	5.13E+02	5.13E+02	9.00%	3.00%	9.49%	0.00%	0.02%
1A5a	Liquid Fuels	CO2	2.50E+02	2.50E+02	3.62%	2.71%	4.52%	0.00%	0.00%
1A5a	Solid Fuels	CO2	1.30E+01	1.30E+01	7.00%	3.00%	7.62%	0.00%	0.00%
1A5a	Solid Fuels	N2O	6.37E-04	1.98E-01	7.00%	50.00%	50.49%	0.00%	0.00%
1A5b	Liquid Fuels	CO2	7.70E+02	7.70E+02	4.04%	1.97%	4.49%	0.00%	0.01%
1A5b	Liquid Fuels	N2O	2.86E-02	8.87E+00	4.04%	98.42%	98.51%	0.00%	0.00%
1A5b	Liquid Fuels	CH4	2.47E-01	5.18E+00	4.04%	32.81%	33.06%	0.00%	0.00%
1B1b	Solid Fuels	CH4	4.07E-01	8.54E+00	2.50%	10.00%	10.31%	0.00%	0.00%
1B2a	Liquid Fuels	CH4	2.24E+00	4.71E+01	18.00%	37.50%	41.60%	0.00%	0.01%
2A1		CO2	1.32E+04	1.32E+04	7.00%	10.00%	12.21%	0.15%	0.54%
2A2		CO2	5.50E+03	5.50E+03	4.68%	10.42%	11.42%	0.06%	0.21%
2A7		CO2	1.32E+03	1.32E+03	4.55%	16.40%	17.02%	0.02%	0.08%
2B1		CO2	5.14E+03	5.14E+03	2.00%	50.00%	50.04%	0.23%	0.87%
2B2		N2O	2.74E+01	8.48E+03	5.00%	50.00%	50.25%	0.39%	1.44%
2B3		N2O	9.69E+00	3.00E+03	20.00%	7.00%	21.19%	0.06%	0.21%
2B4		CO2	1.75E+01	1.75E+01	5.00%	10.00%	11.18%	0.00%	0.00%
2B5		CO2	7.24E+03	7.24E+03	5.92%	17.99%	18.94%	0.13%	0.46%
2B5		N2O	2.19E-01	6.78E+01	5.92%	53.34%	53.66%	0.00%	0.01%
2B5		CH4	1.89E-02	3.97E-01	5.92%	2.00%	6.25%	0.00%	0.00%
2C1		CO2	4.49E+04	4.49E+04	1.02%	3.41%	3.56%	0.15%	0.54%
2C1		CH4	9.90E-02	2.08E+00	1.02%	10.00%	10.05%	0.00%	0.00%
2C2		CO2	2.75E+00	2.75E+00	5.00%	7.00%	8.60%	0.00%	0.00%

IPCC Source	Fuel Category	Gas	Year t emissions	Year t emissions	Activity data	Emission factor	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Tier 1 Level assessment
Category			[Gg]	[Gg CO_2-equiv.]	uncertainty [%]	uncertainty [%]	[%]	[%]	[%]
2C3		CO2	7.06E+02	7.06E+02	2.71%	15.00%	15.24%	0.01%	0.04%
2C3		CF4	2.54E-02	1.65E+02	2.71%	15.00%	15.24%	0.00%	0.01%
2C3		C2F6	2.55E-03	2.35E+01	2.71%	15.03%	15.28%	0.00%	0.00%
2C4		SF6	2.40E-02	5.73E+02	7.81%	1.50%	7.95%	0.00%	0.02%
2C5		HFC-134a	8.48E-04	1.10E+00	1.54%	1.50%	2.15%	0.00%	0.00%
2E1		HFC-23	2.30E-02	2.69E+02		3.00%	3.00%	0.00%	0.00%
2E2		SF6	9.00E-03	2.15E+02	0.00%	3.00%	3.00%	0.00%	0.00%
2E2		HFC-134a	1.35E-02	1.76E+01	0.00%	3.00%	3.00%	0.00%	0.00%
2E2		HFC-227ea	1.50E-03	4.35E+00	0.00%	3.00%	3.00%	0.00%	0.00%
2F1		HFC-134a	3.36E+00	4.37E+03	4.14%	15.57%	16.11%	0.06%	0.24%
2F1		HFC-143a	5.25E-01	2.00E+03	4.14%	16.24%	16.75%	0.03%	0.11%
2F1		HFC-125	5.70E-01	1.60E+03	4.14%	13.34%	13.97%	0.02%	0.08%
2F1		HFC-23	1.27E-02	1.48E+02	4.14%	16.69%	17.20%	0.00%	0.01%
2F1		C3F8	1.53E-02	1.07E+02	4.14%	17.87%	18.34%	0.00%	0.01%
2F1		C2F6	4.00E-03	3.68E+01	4.14%	19.42%	19.85%	0.00%	0.00%
2F1		HFC-32	4.56E-02	2.96E+01	4.14%	13.11%	13.74%	0.00%	0.00%
2F1		HFC-227ea	4.95E-03	1.43E+01	4.14%	24.95%	25.29%	0.00%	0.00%
2F1		HFC-152a	1.78E-02	2.49E+00	4.14%	19.44%	19.88%	0.00%	0.00%
2F2		HFC-134a	4.93E-01	6.41E+02	2.68%	4.17%	4.96%	0.00%	0.01%
2F2		HFC-152a	6.40E-01	8.96E+01	2.68%	1.97%	3.33%	0.00%	0.00%
2F2		HFC-227ea	3.31E-04	9.59E-01	2.68%	22.47%	22.63%	0.00%	0.00%
2F3		HFC-236fa	5.31E-04	3.34E+00	0.94%	6.43%	6.49%	0.00%	0.00%
2F3		HFC-227ea	1.11E-03	3.22E+00	0.94%	4.98%	5.06%	0.00%	0.00%
2F3		HFC-23	5.32E-06	6.22E-02	0.94%	22.07%	22.09%	0.00%	0.00%
2F4		HFC-134a	4.07E-01	5.29E+02	3.62%	14.61%	15.05%	0.01%	0.03%
2F4		HFC-227ea	2.43E-02	7.03E+01	3.62%	25.00%	25.26%	0.00%	0.01%
2F4		HFC-152a	1.16E-02	1.62E+00	3.62%	23.14%	23.42%	0.00%	0.00%
2F5		HFC-43-10mee	1.40E-03	1.82E+00	2.00%	2.00%	2.83%	0.00%	0.00%
2F6		CF4	1.73E-02	1.12E+02	15.02%	10.95%	18.59%	0.00%	0.01%
2F6		C2F6	1.09E-02	1.00E+02	15.02%	12.21%	19.36%	0.00%	0.01%
2F6		C3F8	5.10E-03	3.57E+01	15.02%	12.21%	19.36%	0.00%	0.00%
2F6		SF6	1.30E-03	3.10E+01	15.02%	12.19%	19.35%	0.00%	0.00%
2F6		HFC-23	2.01E-03	2.36E+01	15.02%	12.22%	19.36%	0.00%	0.00%
2F6		c-C4F8	1.80E-04	1.57E+00	15.02%	12.22%	19.37%	0.00%	0.00%
2F7		SF6	3.19E-02	7.63E+02	4.55%	7.02%	8.37%	0.01%	0.02%
2F8		SF6	7.23E-02	1.73E+03	9.64%	14.71%	17.58%	0.03%	0.10%
3DD		N2O	3.79E+00	1.17E+03	9.37%	46.83%	47.76%	0.05%	0.19%
4A1		CH4	1.13E+03	2.38E+04		5.42%	5.42%	0.12%	0.44%

IPCC Source	Fuel Category	Gas	Year t emissions	Year t emissions	Activity data	Emission factor	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Tier 1 Level assessment
Category			[Gg]	[Gg CO_2-equiv.]	uncertainty [%]	uncertainty [%]	[%]	[%]	[%]
4A2		CH4	6.25E-02	1.31E+00		10.00%	10.00%	0.00%	0.00%
4A3		CH4	2.11E+01	4.44E+02		10.00%	10.00%	0.00%	0.01%
4A4		CH4	8.50E-01	1.79E+01		10.00%	10.00%	0.00%	0.00%
4A6		CH4	1.28E+01	2.70E+02		10.00%	10.00%	0.00%	0.01%
4A8		CH4	6.26E+01	1.32E+03		6.43%	6.43%	0.01%	0.03%
4B1		CH4	2.21E+02	4.64E+03		10.77%	10.77%	0.05%	0.17%
4B1		N2O	8.53E+00	2.64E+03		13.51%	13.51%	0.03%	0.12%
4B2		N2O	9.47E-04	2.94E-01		21.21%	21.21%	0.00%	0.00%
4B2		CH4	3.54E-03	7.43E-02		20.00%	20.00%	0.00%	0.00%
4B3		N2O	9.08E-02	2.81E+01		29.66%	29.66%	0.00%	0.00%
4B3		CH4	5.02E-01	1.05E+01		30.00%	30.00%	0.00%	0.00%
4B4		N2O	1.30E-02	4.03E+00		35.36%	35.36%	0.00%	0.00%
4B4		CH4	2.04E-02	4.28E-01		30.00%	30.00%	0.00%	0.00%
4B6		N2O	8.92E-01	2.77E+02		49.34%	49.34%	0.01%	0.05%
4B6		CH4	1.93E+00	4.05E+01		30.00%	30.00%	0.00%	0.00%
4B8		CH4	1.47E+02	3.09E+03		12.95%	12.95%	0.04%	0.14%
4B8		N2O	3.04E+00	9.42E+02		14.14%	14.14%	0.01%	0.04%
4B9		N2O	3.51E+00	1.09E+03		13.33%	13.33%	0.01%	0.05%
4B9		CH4	1.88E+01	3.95E+02		17.37%	17.37%	0.01%	0.02%
4D3		N2O	7.06E+01	2.19E+04		441.10%	441.10%	8.81%	32.59%
4D4		N2O	5.15E+01	1.60E+04		581.63%	581.63%	8.47%	31.32%
5A -		CO2	9.86E+02	9.86E+02		50.00%	50.00%	0.05%	0.17%
5A -		N2O	1.61E-02	4.98E+00		25.00%	25.00%	0.00%	0.00%
5B -		CO2	2.50E+04	2.50E+04		25.00%	25.00%	0.57%	2.11%
5B -		N2O	1.36E+00	4.22E+02		25.00%	25.00%	0.01%	0.04%
5C -		CO2	1.88E+04	1.88E+04		22.25%	22.25%	0.38%	1.41%
5C -		N2O	1.01E+00	3.12E+02		25.00%	25.00%	0.01%	0.03%
5F -		CO2	5.31E+02	5.31E+02		25.00%	25.00%	0.01%	0.04%
5G -		CO2	9.31E+01	9.31E+01		25.00%	25.00%	0.00%	0.01%
6A -		CH4	4.58E+02	9.62E+03		12.50%	12.50%	0.11%	0.41%
6B -		N2O	7.55E+00	2.34E+03		75.00%	75.00%	0.16%	0.59%
6B -		CH4	5.50E+00	1.15E+02		45.30%	45.30%	0.00%	0.02%
6D -		CH4	2.65E+01	5.56E+02	3.95%	33.16%	33.39%	0.02%	0.06%
6D -		N2O	1.17E+00	3.63E+02	3.95%	45.02%	45.19%	0.01%	0.06%

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 very little or no uncertainties 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 last report year.