

# Switzerland's Greenhouse Gas Inventory 1990–2007

National Inventory Report 2009

Submission of 15 April 2009  
under the United Nations Framework Convention on Climate  
Change and under the Kyoto Protocol



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

**Federal Office for the Environment FOEN**

Swiss Confederation

**Published and distributed by:**

Federal Office for the Environment FOEN

Climate, Economics and Environmental Observation Division

3003 Bern, Switzerland

[www.environment-switzerland.ch/climate](http://www.environment-switzerland.ch/climate)

[www.climatereporting.ch](http://www.climatereporting.ch)

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Bern, 15 April 2009

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## Table of Contents

<b>Table of Contents</b> .....	<b>5</b>
<b>Glossary</b> .....	<b>9</b>
<b>Executive Summary</b> .....	<b>13</b>
<b>Inventory Preparation in Switzerland</b> .....	13
<b>Trend Summary: National GHG Emissions and Removals</b> .....	14
<b>Overview of Source and Sink Category Estimates and Trends</b> .....	16
<b>Acknowledgements</b> .....	<b>18</b>
<b>1. Introduction</b> .....	<b>19</b>
1.1. Background Information on Swiss Greenhouse Gas Inventories .....	19
1.2. Institutional Arrangements for Inventory Preparation .....	19
1.3. Process for Inventory Preparation .....	22
1.4. Methodologies .....	23
1.5. Key Categories .....	25
1.5.1. Methodology .....	25
1.5.2. KCA without LULUCF categories .....	26
1.5.3. Combined KCA without and with LULUCF categories .....	32
1.6. Quality Assurance and Quality Control (QA/QC) .....	37
1.6.1. The Quality Management System .....	37
1.6.2. Treatment of Confidential Data .....	39
1.7. Uncertainty Evaluation .....	39
1.7.1. Tier 1 and Tier 2 analysis .....	39
1.7.2. Data Used .....	40
1.7.3. Uncertainty Estimates .....	40
1.7.4. Results of Tier 1 Uncertainty Evaluation .....	41
1.7.5. Results of Tier 2 Uncertainty Evaluation (Monte Carlo) .....	46
1.7.6. Comparison of Tier 1 and Tier 2 Results .....	50
1.8. Completeness Assessment .....	51
<b>2. Trends in Greenhouse Gas Emissions and Removals</b> .....	<b>53</b>
2.1. Aggregated Greenhouse Gas Emissions 2007 .....	53
2.2. Emission Trends by Gas .....	55
2.3. Emission Trends by Sources and Sinks .....	57
2.4. Emission Trends for Indirect Greenhouse Gases and SO <sub>2</sub> .....	62
<b>3. Energy</b> .....	<b>65</b>
3.1. Overview .....	65
3.1.1. Greenhouse Gas Emissions .....	65

3.1.2.	CO <sub>2</sub> Emission Factors.....	69
3.1.3.	Feedstocks .....	69
3.1.4.	Correction of Fuel Consumption Related to Liechtenstein .....	69
3.1.5.	Disaggregation of the energy consumption .....	70
3.2.	Source Category 1A – Fuel Combustion Activities .....	71
3.2.1.	Source Category Description.....	71
a)	Energy Industries (1A1).....	71
b)	Manufacturing Industries and Construction (1A2) .....	71
c)	Transport (1A3).....	72
d)	Other Sectors (1A4 – Commercial/Institutional, Residential, Agriculture/ Forestry) .....	73
e)	Other / Mobile (Off-road): Construction, Garden/Hobby, Industry and Military (1A5b).....	74
3.2.2.	Methodological Issues .....	74
	General Issues .....	74
a)	Energy Industries (1A1).....	75
b)	Manufacturing Industries and Construction (1A2) .....	80
c)	Transport (1A3).....	92
d)	Other Sectors (Commercial, Residential, Agriculture, Forestry; 1A4) .....	106
e)	Other / Mobile (Off-road): Construction, Garden/Hobby, Industry and Military (1A5b).....	111
3.2.3.	Uncertainties and Time-Series Consistency.....	112
3.2.4.	Source-Specific QA/QC and Verification .....	115
3.2.5.	Source-Specific Recalculations .....	117
3.2.6.	Source-Specific Planned Improvements.....	117
3.3.	Source Category 1B – Fugitive Emissions from Fuels .....	118
3.4.	Source Category International Bunker Fuels.....	121
3.5.	CO <sub>2</sub> Emissions from Biomass.....	122
3.6.	Comparison of Sectoral Approach with Reference Approach .....	123
<b>4.</b>	<b>Industrial Processes .....</b>	<b>125</b>
4.1.	Overview.....	125
4.2.	Source Category 2A – Mineral Products .....	126
4.3.	Source Category 2B – Chemical Industry.....	130
4.4.	Source Category 2C – Metal Production .....	133
4.5.	Source Category 2D – Other Production.....	137
4.6.	Source Category 2E – Production of Halocarbons and SF <sub>6</sub> .....	138
4.7.	Source Category 2F – Consumption of Halocarbons and SF <sub>6</sub> .....	139
4.8.	Source Category 2G – Other.....	147
<b>5.</b>	<b>Solvent and Other Product Use .....</b>	<b>149</b>

5.1.	Overview.....	149
5.2.	Source Category 3A – Paint Application .....	150
5.3.	Source Category 3B – Degreasing and Dry Cleaning .....	152
5.4.	Source Category 3C – Chemical Products, Manufacture and Processing .....	153
5.5.	Source Category 3D – Other .....	155
<b>6.</b>	<b>Agriculture .....</b>	<b>159</b>
6.1.	Overview.....	159
6.2.	Source Category 4A – Enteric Fermentation .....	161
6.3.	Source Category 4B – Manure Management .....	168
6.4.	Source Category 4C – Rice Cultivation .....	175
6.5.	Source Category 4D – Agricultural Soils .....	175
6.6.	Source Category 4E – Burning of savannas.....	184
6.7.	Source Category 4F – Field Burning of Agricultural Residues .....	184
<b>7.</b>	<b>Land Use, Land-Use Change and Forestry.....</b>	<b>187</b>
7.1.	Overview.....	187
7.2.	Methodical Approach and Activity Data .....	190
7.3.	Source Category 5A – Forest Land .....	210
7.4.	Source Category 5B – Cropland.....	235
7.5.	Source Category 5C – Grassland.....	237
7.6.	Source Category 5D – Wetlands .....	243
7.7.	Source Category 5E – Settlements .....	245
7.8.	Source Category 5F – Other Land .....	248
<b>8.</b>	<b>Waste.....</b>	<b>249</b>
8.1.	Overview.....	249
8.2.	Source Category 6A – Solid Waste Disposal on Land .....	254
8.3.	Source Category 6B – Wastewater Handling .....	259
8.4.	Source Category 6C – Waste Incineration .....	262
8.5.	Source Category 6D – Other .....	265
<b>9.</b>	<b>Recalculations.....</b>	<b>268</b>
9.1.	Explanations and Justifications for Recalculation.....	268
9.2.	Implications for Emission Levels 1990 and 2006 .....	271
9.3.	Implications for Emissions Trends, including Time Series Consistency.....	272
	<b>References .....</b>	<b>273</b>
	<b>References to EMIS database comments .....</b>	<b>289</b>
	<b>Annexes .....</b>	<b>291</b>
	<b>Annex 1: Key Category Analysis (KCA).....</b>	<b>291</b>
	<b>A1.1 Methodology.....</b>	<b>291</b>
	<b>A1.2 KCA Tier 1 2007 without LULUCF categories.....</b>	<b>292</b>

<b>A1.3 KCA Tier 1 2007 including LULUCF categories .....</b>	<b>296</b>
<b>A1.4 KCA Tier 2 2007 without LULUCF categories.....</b>	<b>300</b>
<b>A1.5 KCA Tier 2 2007 including LULUCF categories .....</b>	<b>304</b>
<b>Annex 2: Detailed discussion of methodology and data for estimating CO<sub>2</sub> emissions from fossil fuel combustion .....</b>	<b>308</b>
<b>A2.1 Carbon Dioxide (CO<sub>2</sub>).....</b>	<b>308</b>
<b>A2.2 Sulphur Dioxide (SO<sub>2</sub>).....</b>	<b>310</b>
<b>Annex 3: Other detailed methodological descriptions for individual source or sink categories .....</b>	<b>312</b>
<b>A3.1 Sector Energy .....</b>	<b>312</b>
<b>A3.2 Industrial Processes .....</b>	<b>332</b>
<b>A3.3 Agriculture .....</b>	<b>333</b>
<b>Annex 4: CO<sub>2</sub> Reference Approach and comparison with Sectoral Approach, and relevant information on the national energy balance .....</b>	<b>337</b>
<b>Annex 5: Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded .....</b>	<b>337</b>
<b>Annex 6: Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information.....</b>	<b>337</b>
<b>Annex 7: Supplementary Information to the Uncertainty Analysis .....</b>	<b>338</b>
<b>A7.1 Uncertainty Evaluation Tier 1.....</b>	<b>338</b>
<b>A7.2 Uncertainty Evaluation Tier 2 (Monte Carlo Simulation) .....</b>	<b>339</b>
<b>Annex 8: Supplementary Information under Article 7, paragraph 1 of the Kyoto Protocol.....</b>	<b>351</b>
<b>A8.1 Greenhouse gas inventory information .....</b>	<b>351</b>
<b>A8.2 Information on emission reduction units, certified emission reductions, temporary certified emission reductions, long-term certified emission reductions, assigned amount units and removal units .....</b>	<b>361</b>
<b>A8.3 Changes in national systems in accordance with Article 5, paragraph 1 .....</b>	<b>363</b>
<b>A8.4 Changes in national registries .....</b>	<b>364</b>

## Glossary

AD	Activity data
AEF	Area expansion factor
AREA1	Swiss Land Use Statistics 1979/85 (ASCH1 data re-evaluated according to the AREA set of land-use and land-cover categories)
AREA2	Swiss Land Use Statistics 1992/97 (ASCH2 data re-evaluated according to the AREA set of land-use and land-cover categories)
AREA3	Swiss Land Use Statistics, third survey 2004/09
ART	Agroscope Reckenholz-Tänikon Research Station (formerly FAL)
ASCH1	Swiss Land Use Statistics, first survey 1979/85
ASCH2	Swiss Land Use Statistics, second survey 1992/97
BEF, BCEF	biomass expansion factor, biomass conversion and expansion factor
Carbotech	Environmental Projects / Consulting / Analysis, Basel
Carbura	Swiss Central Office for the Import of Liquid Fuels
cemsuisse	Association of the Swiss Cement Industry
CC	Combination category
CH <sub>4</sub>	Methane, 1995 IPCC GWP: 21 (UNFCCC 2006b, Table 1)
CEPE	Centre for Energy Policy and Economics, Swiss Federal Institute of Technology, Zurich
CHP	Combined heat and power production
CO	Carbon monoxide
CO <sub>2</sub> , CO <sub>2</sub> eq	Carbon dioxide, carbon dioxide equivalent
CORINAIR	CORe INventory of AIR emissions (under the European Topic Centre on Air Emissions and under the European Environment Agency)
CRF	Common reporting format
CSS	Mix of special waste with saw dust; used as fuel in cement kilns
DBH	Diameter (of trees) at breast height
EF	Emission factor
EMEP	European Monitoring and Evaluation Programme (under the Convention on Long-range Transboundary Air Pollution )
EMIS	Swiss national air pollution database
EMPA	Swiss Federal Laboratories for Material Testing and Research
DETEC	Depart. of the Environment, Transport, Energy and Communications
FAL	Swiss Federal Research Station for Agroecology and Agriculture (since 2006: ART)
FCCC	Framework Convention on Climate Change
FOCA	Federal Office of Civil Aviation
FOEN	Federal Office for the Environment (former name SAEFL until 2005)

FOITT	Federal Office of Information Technology, Systems and Telecommunication
Gg	Gigagram ( $10^9$ g = 1'000 tons)
GHG	Greenhouse gas
GL, GPG	Guidelines, Good Practice Guidance
GWP	Global Warming Potential
ha	hectare
HFC	Hydrofluorocarbons (e.g. HFC-32 difluoromethane)
HFO	Heavy fuel oil
IDM	FOEN Internal Document Management System
IDP	Inventory Development Plan
INFRAS	Consulting, policy analysis and research group, Zurich
IPCC	Intergovernmental Panel on Climate Change
KCA	key category analysis
kha	kilo hectare
LFO	Light fuel oil (Gas oil)
LPG	Liquefied Petroleum Gas (Propane/Butane)
LTO	Landing-Takeoff-Cycle (Aviation)
LULUCF	Land Use, Land-Use Change and Forestry
METEOTEST	Independent company for applied meteorology, air pollution control and geoinformatics, Bern
MSW	Municipal solid waste
NCV	Net calorific value
NFI 1, NFI 2, NFI 3	First (1983-1985), Second (1993-1995) and Third (2004-2006) National Forest Inventory
NIR	National Inventory Report
NIS	National Inventory System
NMVOC	Non-methane volatile organic compounds
N <sub>2</sub> O	Nitrous oxide; 1995 IPCC GWP: 310 (UNFCCC 2006b, Table 1)
NO <sub>x</sub>	Nitrogen oxides
PCDD/PCDF	Polychlorinated Dibenzodioxins and -furanes
PFC	Perfluorinated carbon compounds (e.g. Tetrafluoromethane)
SAEFL	Swiss Agency for the Environment, Forests and Landscape (since 2006: Federal Office for the Environment FOEN)
SF <sub>6</sub>	Sulphur hexafluoride, 1995 IPCC GWP: 23'900 (UNFCCC 2006b, Table 1)
SFOE	Swiss Federal Office of Energy
SFSO	Swiss Federal Statistical Office
SGCI/SSCI	Schweizerische Gesellschaft für Chemische Industrie / Swiss Society of Chemical Industries

SGIA	Swiss Gas Industry Association
Sigmaplan	Private planning office, Bern
SO <sub>2</sub>	Sulphur dioxide
SVGW/SSIG/SGWA	Schweizerischer Verein des Gas- und Wasserfaches / Société Suisse de l'Industrie du Gaz et des Eaux / Swiss Gas and Water Industry Association
SWISSMEM	Swiss Mechanical and Electrical Engineering Industries (Schweizer Maschinen-, Elektro- und Metallindustrie)
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
VSAI/AISA	Vereinigung Schweizer Automobil-Importeure / Association Importateurs Suisses d'Automobiles
VTG	Luftwaffe (Swiss Air Force Administration)
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research



## Executive Summary

### *Inventory Preparation in Switzerland*

On 10 December 1993, Switzerland ratified the United Nations Framework Convention on Climate Change (UNFCCC). Since 1996, the submission of its national greenhouse gas inventory has been based on IPCC guidelines. From 1998 onwards, the inventories have been submitted in the Common Reporting Format (CRF).

On 9 July 2003, Switzerland ratified the Kyoto Protocol under the UNFCCC. The Swiss National Inventory System (NIS) according to Article 5.1 of the Kyoto Protocol has been implemented and is fully operational.

The 2009 inventory submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol includes the National Inventory Report on hand, the greenhouse gas inventory 1990–2007, the Kyoto Protocol LULUCF tables 2000–2007 and, as a supplement, the update of the Description of the Quality Management System.

The Federal Office for the Environment (FOEN) is in charge of compiling the emission data and bears overall responsibility for Switzerland's national greenhouse gas inventory. In addition to the FOEN, the Swiss Federal Office of Energy (SFOE), the Agroscope Reckenholz-Tänikon Research Station ART and the Federal Office of Civil Aviation (FOCA) participate directly in the compilation of the inventory. Several other administrative offices and research institutions are involved in inventory preparation.

In preparing the National Inventory Report, Switzerland took into account the findings of the in-country review of the inventory submitted in 2004 (FCCC/WEB/IRI/2004/CHE; UNFCCC 2004), the centralized review of the inventory submitted in 2005 (FCCC/ARR/2005/CHE; UNFCCC 2006), and the in-country review of the inventory submitted in 2006 (FCCC/ARR/2006/CHE; UNFCCC 2007). The findings of the centralized review of the inventories submitted in 2007 and 2008 (FCCC/ARR/2008/CHE) could only partially be included in the present submission (it was still unpublished at editorial deadline).

Chapter 1, the Introduction, provides an overview of Switzerland's institutional arrangements for producing the inventory, and the process and methodologies used for inventory preparation.

The data sources used to compile the national inventory and to estimate greenhouse gas emissions and removals are: the Swiss national air pollution database (EMIS), national energy statistics, data from industry associations, as well as further statistics and models for road transportation, off-road vehicles and machinery, agriculture, land use, land-use change and forestry (LULUCF) and waste. Emissions are calculated according to methodologies recommended by the IPCC and contained in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c), in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000), and for LULUCF in the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003). Furthermore, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) have been consulted in a few cases. (However, the nomenclature of the Revised 1996 IPCC Guidelines have been used throughout the current NIR.) The data in the EMIS database are pre-processed in order to enable transfer to the CRF Reporter required for reporting under the UNFCCC and under the Kyoto Protocol.

All inventory data are assembled and prepared for input into the CRF Reporter by the GHG Inventory Core Group, which is responsible for ensuring the conformity of the inventory with the Updated UNFCCC Reporting Guidelines on Annual Inventories (UNFCCC 2006b) and the 2008 Kyoto Protocol Reference Manual (UNFCCC 2008). In the preparation of this report, the Inventory Group was supported by consultants. Their mandate included editing of the NIR, and an analysis of the consistency between the emission modelling and the

recommendations of the IPCC Good Practice Guidance. Furthermore, the consultants carried out the key category analyses and the uncertainty analyses, and were involved in inventory improvement, e.g. by performing tasks contained in the Inventory Development Plan.

The inventory quality management system is designed to comply with the objectives of good practice guidance, i.e. to ensure and improve transparency, consistency, comparability, completeness, accuracy and confidence in national GHG emission and removal estimates. The QA/QC Officer is responsible for enforcement of the defined quality standards. The National Inventory System complies with the ISO 9001:2000 standard (Quality Management System) and is certified by the Swiss Association for Quality and Management Systems (SQS).

A National Inventory System Supervisory Board was established by decision of the FOEN Directorate in summer 2006. The Board oversees activities related to the GHG Inventory and to the National Registry.

Moreover, Chapter 1 provides information on key categories and uncertainties: 36 key categories are identified for inventory year 2007, 21 of which are in the energy sector. For the base year 1990, there are 24 key categories, 16 of them from the energy sector. For the emission data of 2007 excluding LULUCF, an uncertainty analysis Tier 1 was carried out resulting in a **level uncertainty of 3.83%** of the total GHG emissions (excluding LULUCF). The **trend uncertainty is 3.64%** meaning that the change of the base year (1990) to 2007, reported as -2.74%, lies with a probability of 95% between -6.38% and +0.90%. If the LULUCF sector is included, the uncertainty increases up to 4.15% (level) and 5.01% (trend). Note that a Tier 2 (Monte Carlo) analysis of the inventory 2006 as published in FOEN (2008) estimated a level uncertainty of 4.0% and a trend uncertainty of 2.8%. The Tier 2 analysis will be performed every second year; it therefore has not been updated for the 2007 inventory.

Chapter 2 provides an analysis of trends in Switzerland's greenhouse gas emissions by sources and removals by sinks.

Chapters 3 to 8 provide principal source and sink category estimates. Only few input data have been updated, resulting in very small changes in the base year emissions (1990) and marginal changes of single emissions in other years.

Chapter 9 explains and justifies recalculations that have been performed since the previous inventory submission to the UNFCCC secretariat in 2008 (FOEN 2008). The recalculations result in a marginal decrease of the total base year (1990) emissions of -0.17% in CO<sub>2</sub> equivalents. For the year 2006 emissions, there is an even smaller decrease of -0.07% without emissions and removals from LULUCF. If the LULUCF sector is included, due to major recalculations in this sector, there is a considerable increase of 6.42% in the total national emissions of 2006.

### ***Trend Summary: National GHG Emissions and Removals***

In 2007, Switzerland emitted approximately 51'265 Gg (kilotonnes) CO<sub>2</sub> equivalent, corresponding to 6.73 tonnes CO<sub>2</sub> equivalent per capita (CO<sub>2</sub>: 5.73 tonnes per capita), to the atmosphere, excluding emissions and removals from the sector Land Use, Land-Use Change and Forestry (LULUCF)<sup>1</sup>.

For 2007, 36 key categories were identified in the country's emission level and trend analysis, covering 97.9% of total CO<sub>2</sub> equivalent greenhouse gas (GHG) emissions. 36.2% of total GHG emissions derived from the two most important key source categories: CO<sub>2</sub> from gasoline combustion – Transport (source category 1A3b, road transportation) and CO<sub>2</sub> from

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<sup>1</sup> Inhabitants in Switzerland in 2007: 7.617 million

liquid fuel combustion – Other Sectors (source category 1A4b, residential). Note that the emissions of transport (1A3) and heating (1A4 Other Sectors) together cause 63% of Switzerland's GHG emissions (excl. LULUCF).

Table E-1 shows Switzerland's annual GHG emissions by individual GHGs from 1990 (base year) to 2007. Despite clear trends in some GHG emissions (see below), there is no significant trend in the total emissions of the period 1990–2007. Year-to-year variations of total emissions are mainly caused by changing winter temperatures and their effect on CO<sub>2</sub> emissions from fuel combustion (source category 1A4). In 2007, total gross GHG emissions (excluding LULUCF) show a decrease of -2.74% compared to the level recorded for 1990 (see also Table E-2).

Table E-1 Summary of Switzerland's GHG emissions in CO<sub>2</sub> equivalent (Gg), 1990–2007 (from CRF Tables 10s5 and 10s5.2).

Greenhouse Gas Emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO <sub>2</sub> equivalent (Gg)									
CO <sub>2</sub> emissions including net CO <sub>2</sub> from LULUCF	42'144	44'466	45'004	40'357	37'308	38'016	39'472	40'809	42'873	43'423
CO <sub>2</sub> emissions excluding net CO <sub>2</sub> from LULUCF	44'504	46'142	46'161	43'578	42'826	43'322	44'002	43'324	44'560	44'802
CH <sub>4</sub> emissions including CH <sub>4</sub> from LULUCF	4'356	4'325	4'212	4'072	3'980	3'963	3'906	3'837	3'772	3'720
CH <sub>4</sub> emissions excluding CH <sub>4</sub> from LULUCF	4'348	4'324	4'212	4'072	3'978	3'960	3'904	3'826	3'770	3'719
N <sub>2</sub> O emissions including N <sub>2</sub> O from LULUCF	3'624	3'640	3'614	3'567	3'563	3'491	3'538	3'366	3'367	3'349
N <sub>2</sub> O emissions excluding N <sub>2</sub> O from LULUCF	3'613	3'632	3'606	3'560	3'555	3'483	3'530	3'354	3'360	3'343
HFCs	0	0	6	13	29	169	209	270	315	362
PFCs	100	85	69	30	18	15	17	24	28	40
SF <sub>6</sub>	144	146	148	126	112	95	92	130	159	146
<b>Total (including LULUCF)</b>	<b>50'369</b>	<b>52'662</b>	<b>53'053</b>	<b>48'165</b>	<b>45'010</b>	<b>45'749</b>	<b>47'234</b>	<b>48'436</b>	<b>50'514</b>	<b>51'039</b>
<b>Total (excluding LULUCF)</b>	<b>52'709</b>	<b>54'330</b>	<b>54'202</b>	<b>51'379</b>	<b>50'517</b>	<b>51'043</b>	<b>51'754</b>	<b>50'928</b>	<b>52'192</b>	<b>52'412</b>

Greenhouse Gas Emissions	2000	2001	2002	2003	2004	2005	2006	2007	Change base year to 2007 (%)
	CO <sub>2</sub> equivalent (Gg)								
CO <sub>2</sub> emissions including net CO <sub>2</sub> from LULUCF	44'645	44'894	44'147	43'293	45'642	46'897	46'646	42'982	2.0%
CO <sub>2</sub> emissions excluding net CO <sub>2</sub> from LULUCF	43'900	44'682	43'771	44'877	45'347	46'038	45'575	43'636	-1.9%
CH <sub>4</sub> emissions including CH <sub>4</sub> from LULUCF	3'669	3'681	3'621	3'518	3'498	3'516	3'506	3'513	-19.4%
CH <sub>4</sub> emissions excluding CH <sub>4</sub> from LULUCF	3'669	3'680	3'618	3'514	3'498	3'516	3'505	3'511	-19.2%
N <sub>2</sub> O emissions including N <sub>2</sub> O from LULUCF	3'366	3'343	3'328	3'254	3'254	3'225	3'233	3'241	-10.6%
N <sub>2</sub> O emissions excluding N <sub>2</sub> O from LULUCF	3'360	3'337	3'321	3'246	3'248	3'220	3'228	3'235	-10.5%
HFCs	422	496	521	574	640	629	609	630	
PFCs	93	53	51	88	75	57	74	77	-23.1%
SF <sub>6</sub>	203	235	211	195	182	205	181	175	22.1%
<b>Total (including LULUCF)</b>	<b>52'399</b>	<b>52'701</b>	<b>51'878</b>	<b>50'922</b>	<b>53'291</b>	<b>54'530</b>	<b>54'250</b>	<b>50'617</b>	<b>0.49%</b>
<b>Total (excluding LULUCF)</b>	<b>51'648</b>	<b>52'483</b>	<b>51'493</b>	<b>52'494</b>	<b>52'990</b>	<b>53'665</b>	<b>53'173</b>	<b>51'265</b>	<b>-2.74%</b>

With regard to the distribution of emissions by individual greenhouse gases, CO<sub>2</sub> is the largest single contributor to emissions, accounting for 85.1% of total gross GHG emissions (excluding LULUCF) in 2007 (1990: 84.4%). The share of CH<sub>4</sub> decreased from 8.2% (1990) to 6.8% (2007). Over the same period, the share of N<sub>2</sub>O decreased from 6.9% to 6.3%, while the share of synthetic gases increased from 0.5% to 1.7%.

Table E-2 Switzerland's total gross GHG emissions (excluding LULUCF) and the contribution of individual gases in CO<sub>2</sub> equivalent (Gg), selected years.

Greenhouse Gas Emissions (excluding LULUCF)	1990		1995		2000		2005		2006		2007	
	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%
CO <sub>2</sub>	44'504	84.4%	43'322	84.9%	43'900	85.0%	46'038	85.8%	45'575	85.7%	43'636	85.1%
CH <sub>4</sub>	4'348	8.2%	3'960	7.8%	3'669	7.1%	3'516	6.6%	3'505	6.6%	3'511	6.8%
N <sub>2</sub> O	3'613	6.9%	3'483	6.8%	3'360	6.5%	3'220	6.0%	3'228	6.1%	3'235	6.3%
HFCs	0	0.0%	169	0.3%	422	0.8%	629	1.2%	609	1.1%	630	1.2%
PFCs	100	0.2%	15	0.0%	93	0.2%	57	0.1%	74	0.1%	77	0.2%
SF <sub>6</sub>	144	0.3%	95	0.2%	203	0.4%	205	0.4%	181	0.3%	175	0.3%
<b>Total (excluding LULUCF)</b>	<b>52'709</b>	<b>100%</b>	<b>51'043</b>	<b>100%</b>	<b>51'648</b>	<b>100%</b>	<b>53'665</b>	<b>100%</b>	<b>53'173</b>	<b>100%</b>	<b>51'265</b>	<b>100%</b>

Figure E-1 shows the shares of 2007 emissions contributed by individual greenhouse gases. As the shares of emissions contributed by the individual gases have remained relatively constant, the diagram is also representative of the other years in the period 1990–2007.

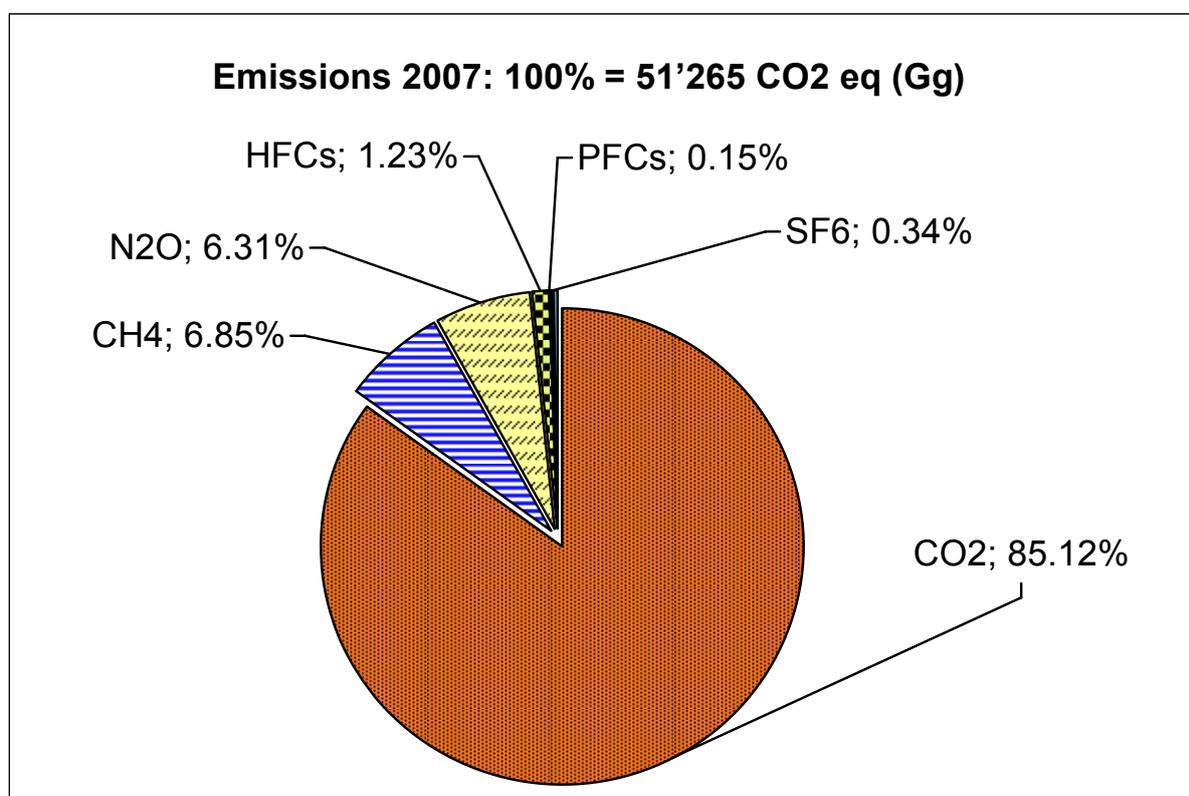


Figure E-1 Contribution of individual gases to Switzerland's GHG emissions (excluding LULUCF) in 2007. 100% = 51'265 Gg CO<sub>2</sub> eq.

### Overview of Source and Sink Category Estimates and Trends

Table E-3 and Figure E-2 show the GHG emissions and removals by the main source and sink categories. The energy sector is by far the largest source of national emissions, accounting for 81.9% of the total GHG emissions. There are slight decreasing trends in the source categories 3. Solvent and other product use, 4. Agriculture and 6. Waste, but there is no significant trend in total emissions over the period 1990–2007 due to the dominating emissions of the energy sector with its year-to-year variability caused by changing winter temperatures and their effect on CO<sub>2</sub> emissions from fuel combustion.

Table E-3 Switzerland's GHG emissions and removals by source and sink categories in CO<sub>2</sub> equivalent (Gg), 1990–2007 (from CRF Tables 10s5 and 10s5.2).

Greenhouse Gas Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO <sub>2</sub> equivalent (Gg)										
1. Energy	42'086	44'081	44'235	41'880	40'974	41'651	42'530	42'030	43'270	43'486
2. Industrial Processes	3'258	2'912	2'745	2'438	2'617	2'554	2'410	2'268	2'380	2'470
3. Solvent and Other Product Use	468	448	429	406	390	371	348	324	299	294
4. Agriculture	5'903	5'907	5'833	5'755	5'706	5'638	5'655	5'499	5'468	5'410
6. Waste	994	982	961	901	830	824	811	807	776	753
<b>Total (excluding LULUCF)</b>	<b>52'709</b>	<b>54'330</b>	<b>54'202</b>	<b>51'379</b>	<b>50'517</b>	<b>51'039</b>	<b>51'754</b>	<b>50'928</b>	<b>52'192</b>	<b>52'412</b>
5. Land Use, Land-Use Change and Forestry	-2'340	-1'668	-1'149	-3'214	-5'508	-5'294	-4'521	-2'492	-1'678	-1'373
<b>Total (including LULUCF)</b>	<b>50'369</b>	<b>52'662</b>	<b>53'053</b>	<b>48'165</b>	<b>45'010</b>	<b>45'745</b>	<b>47'234</b>	<b>48'436</b>	<b>50'514</b>	<b>51'039</b>

Greenhouse Gas Source and Sink Categories	2000	2001	2002	2003	2004	2005	2006	2007	2007/1990
CO <sub>2</sub> equivalent (Gg)									%
1. Energy	42'433	43'197	42'309	43'430	43'788	44'390	43'953	41'966	-0.3%
2. Industrial Processes	2'789	2'897	2'840	2'876	3'034	3'081	3'041	3'058	-6.1%
3. Solvent and Other Product Use	282	265	253	244	230	230	229	231	-50.7%
4. Agriculture	5'411	5'416	5'391	5'285	5'259	5'282	5'287	5'346	-9.4%
6. Waste	733	708	700	659	679	682	663	663	-33.3%
<b>Total (excluding LULUCF)</b>	<b>51'648</b>	<b>52'483</b>	<b>51'493</b>	<b>52'494</b>	<b>52'990</b>	<b>53'665</b>	<b>53'173</b>	<b>51'265</b>	<b>-2.7%</b>
5. Land Use, Land-Use Change and Forestry	751	218	385	-1'572	300	865	1'076	-647	-72.3%
<b>Total (including LULUCF)</b>	<b>52'399</b>	<b>52'701</b>	<b>51'878</b>	<b>50'922</b>	<b>53'291</b>	<b>54'530</b>	<b>54'250</b>	<b>50'617</b>	<b>0.5%</b>

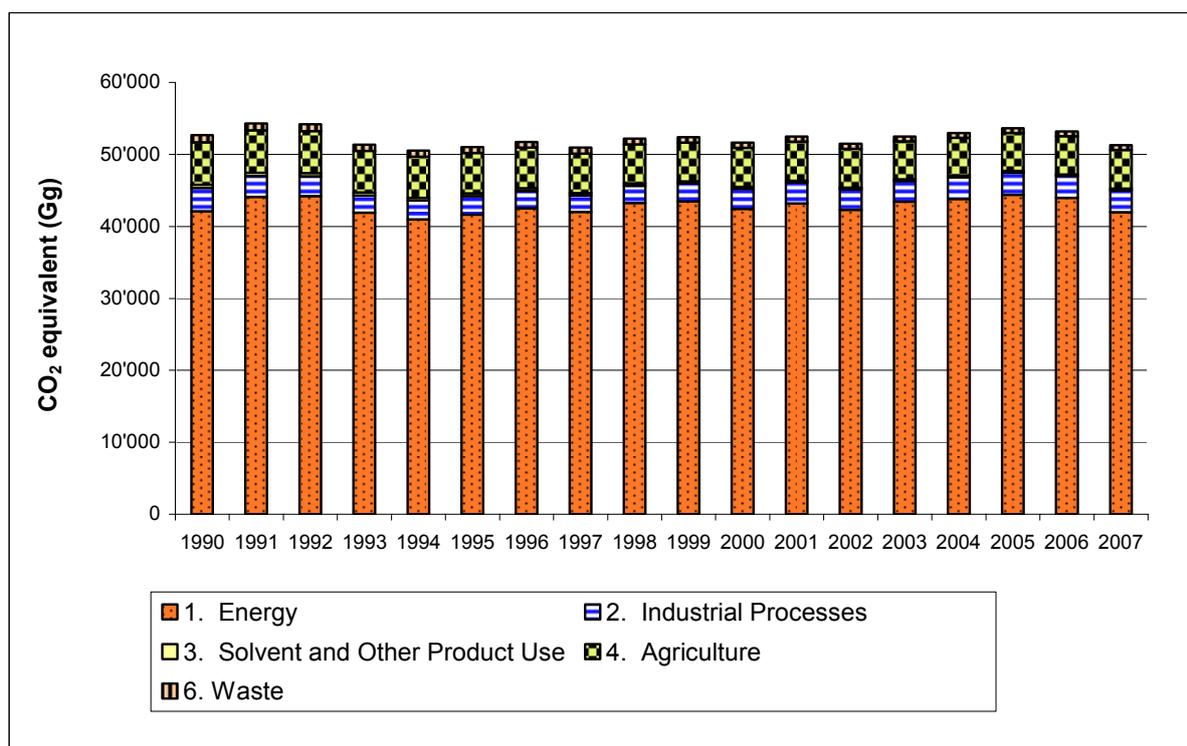
Figure E-2 Switzerland's greenhouse gas emissions in CO<sub>2</sub> equivalent (Gg) by main source categories, 1990–2007 (Total excluding LULUCF).

Table E-4 shows the contributions of individual sectors to total gross emissions for selected years in more detail. Between 1990 and 2007, the relative contribution of sector 1 Energy increased from 79.8% to 81.9%, whereas decreases were seen from 6.2% to 6.0% for sector

2 Industrial Processes, from 11.2% to 10.4% for sector 4 Agriculture, and from 1.9% to 1.3% for sector 6 Waste.

Table E-4 Switzerland's total gross GHG emissions (excluding LULUCF) in CO<sub>2</sub> equivalent (Gg) and the contribution of individual source categories, selected years.

Source and Sink Categories	1990		1995		2000		2005		2006		2007	
	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%
1. Energy	42'086	79.8%	41'651	81.6%	42'433	82.2%	44'390	82.7%	43953	82.7%	41966	81.9%
2. Industrial Processes	3'258	6.2%	2'554	5.0%	2'789	5.4%	3'081	5.7%	3041	5.7%	3058	6.0%
3. Solvent and Other Product Use	468	0.9%	371	0.7%	282	0.5%	230	0.4%	229	0.4%	231	0.5%
4. Agriculture	5'903	11.2%	5'638	11.0%	5'411	10.5%	5'282	9.8%	5287	9.9%	5346	10.4%
6. Waste	994	1.9%	824	1.6%	733	1.4%	682	1.3%	663	1.2%	663	1.3%
<b>Total (excluding LULUCF)</b>	<b>52'709</b>	<b>100.0%</b>	<b>51'039</b>	<b>100.0%</b>	<b>51'648</b>	<b>100.0%</b>	<b>53'665</b>	<b>100.0%</b>	<b>53'173</b>	<b>100.0%</b>	<b>51'265</b>	<b>100.0%</b>

## Acknowledgements

The GHG inventory preparation is a joint effort which is based on input from many federal agencies, institutions, associations, companies and individuals. Their effort was essential for the successful completion of the present inventory report.

The Federal Office for the Environment would like to acknowledge the valuable support it has received from the many contributors to this document. In particular, it would like to thank all the data suppliers also including the Office of Environmental Protection of the Principality of Liechtenstein for providing its fossil fuel consumption, the experts and the national as well as the international reviewers.

# 1. Introduction

## 1.1. Background Information on Swiss Greenhouse Gas Inventories

On 10 December 1993, Switzerland ratified the United Nations Framework Convention on Climate Change (UNFCCC). Since 1996, the submission of its national greenhouse gas inventory has been based on IPCC guidelines. From 1998 onwards, the inventories have been submitted in the Common Reporting Format (CRF): In 2004, Switzerland started submitting a yearly National Inventory Report (NIR) under the UNFCCC.

On 9 July 2003, Switzerland ratified the Kyoto Protocol under the UNFCCC. November 2006 saw the submission of Switzerland's Initial Report under Article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006h). The Swiss National Inventory System (NIS) according to Article 5.1 of the Kyoto Protocol has been implemented and is fully operational. On 6 December 2007, the NIS quality management system was certified to comply with ISO 9001:2000 requirements (SQS 2008). The April 2008 submission of the Swiss GHG inventory (FOEN 2008) has been Switzerland's first submission under both the UNFCCC and the Kyoto Protocol.

The 2009 inventory submission under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol includes the NIR on hand, the greenhouse gas inventory 1990–2007, the Kyoto Protocol LULUCF tables 2000–2007 (FOEN 2009) and, as a supplement, the update of the Description of the Quality Management System (FOEN 2009a).

## 1.2. Institutional Arrangements for Inventory Preparation

The Swiss National Inventory System (NIS) is developed and managed under the auspices of the Federal Department of the Environment, Transport, Energy and Communications (DETEC). It is hosted by a DETEC agency, the Federal Office for the Environment (FOEN). As stipulated in the Ordinance on the Internal Organization of DETEC of 13 December 2005, this agency has the lead within the federal administration regarding climate policy and its implementation.

As part of a comprehensive project (Swiss Climate Reporting Project), the FOEN directorate mandated its Economics, Research and Environmental Observation Division in early 2004 to design and establish the NIS in order to ensure full compliance with the reporting requirements of the UNFCCC and the Kyoto Protocol by 2006. Having regard to the provisions of Art. 5, paragraph 1 of the Kyoto Protocol, the project encompassed the following elements:

- arrangements with partner institutions, relating to
  - roles and responsibilities,
  - participation in the inventory development process,
  - data use, communication and publication,
- Inventory Development Plan,
- setting-up of a QA/QC system,
- official consideration and approval of data,
- upgrading and updating of the national air pollution database (EMIS),

- data documentation and storage.

The project came to an end with the establishment of Switzerland's Initial Report under Article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006h) and its formal approval by the Federal Council in November 2006.

Figure 1-1 gives a schematic overview of the institutional setting of the NIS.

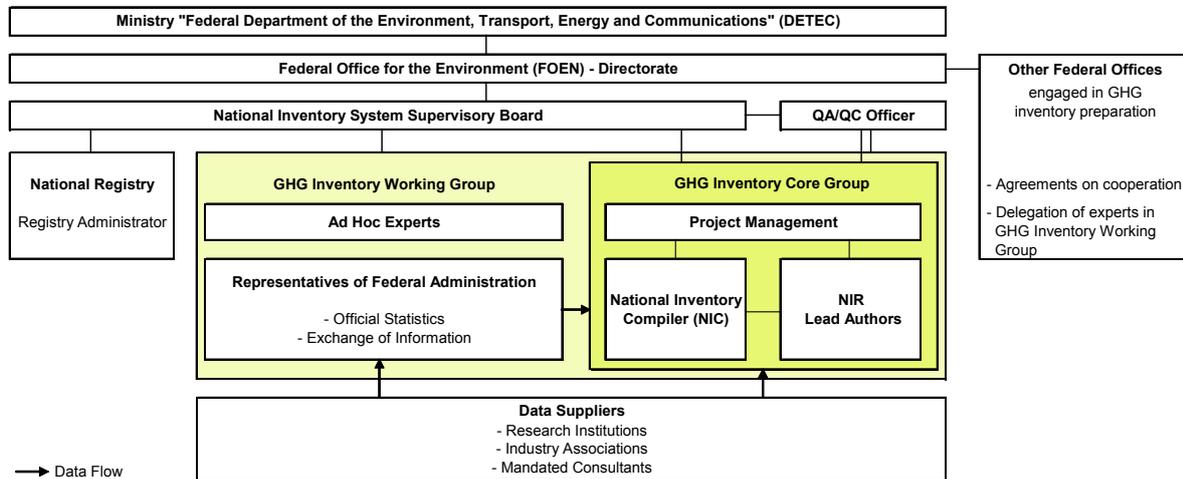


Figure 1-1 Institutional setting of the National Inventory System.

The **NIS Supervisory Board** was established by decision of the FOEN Directorate in summer 2006. The Board oversees activities related to the GHG Inventory and to the National Registry. It is independent of the inventory preparation process and, by its composition, combines technical expertise and political authority. According to its mandate, the main tasks of the NIS Supervisory Board are:

- official consideration of the annual inventory submission and recommendation of the inventory for official approval by the FOEN Directorate;
- assessment and approval of the recalculation of inventory data;
- handling of any issues arising from the UNFCCC review process that cannot be resolved at the level of the Inventory Project Management;
- facilitation of any non-technical negotiation, consideration or approval processes involving other institutions within the federal administration.

The **QA/QC Officer** is responsible for enforcement of the defined quality standards. He / she also advises the NIS Supervisory Board on matters relating to the conformity of the inventory with reporting requirements. His / her tasks and competencies are described in detail in the Description of the Quality Management System (FOEN 2009a), annexed to this report.

The **GHG Inventory Working Group** encompasses all technical personnel involved in the inventory preparation process or representing institutions that play a significant role as suppliers of data. The group as a whole meets at least once per year to take stock of the state of the inventory, discuss priorities in the inventory development process, and to address specific issues of general interest that arise, e.g., from domestic or international reviews.

The **GHG Inventory Core Group** comprises the inventory experts employed at the FOEN or mandated on a regular basis, who are entrusted with specific, major responsibilities for inventory planning, preparation and/or management. All inventory data are assembled and

prepared for input into the CRF Reporter by the GHG Inventory Core Group, which is responsible for ensuring the conformity of the inventory with the Updated UNFCCC Reporting Guidelines on Annual Inventories (UNFCCC 2006b) and the 2008 Kyoto Protocol Reference Manual (UNFCCC 2008). The Core Group consists of

- the Inventory Project Management (with overall responsibility for the integrity of the inventory, communication of data, and information exchange with the UNFCCC secretariat);
- the National Inventory Compiler (responsible for the EMIS inventory data base and for the CRF tables);
- the NIR Lead Authors (responsible for the Inventory Report and carrying out centralized data assessments such as uncertainty analysis and key category analysis);
- selected sectoral experts.

The QA/QC Officer, albeit no formal member, attends the meetings of the Core Group.

The GHG Inventory Core Group coordinates and integrates the activities of data suppliers within and outside the FOEN as well as those of mandated experts. Further data suppliers contributing to the inventory are research institutions and industry associations (Table 1-1). The latter are obliged by Art. 46 of the Federal Law relating to the Protection of the Environment (Swiss Confederation 1983) to provide the authorities with the information needed to enforce the law and, if necessary, to carry out inquiries or to cooperate by providing information for inquiries. Further details of the function of the Core Group and the roles and responsibilities of its members are given in the Description of the Quality Management System (FOEN 2009a, Chapter 2.2.)

Table 1-1 Suppliers of raw and processed data: 1–14 provide annual updates, 15–20 provide sporadic updates. The IPCC nomenclature (IPCC 1997a) is used for the inventory categories (1A1 = Energy Industries, 1A2 = Manufacturing Industries and Construction etc.). RA = Reference Approach. For further abbreviations and acronyms see the glossary.

	Institution	Subject	Data supplied for inventory category...												References	
			1A1	1A2	1A3	1A4	1A5	1B	RA	2	3	4	5	6		
<b>Data suppliers (annual updates)</b>																
1	FOEN, Air Pollution Control	EMIS Database	x	x		x	x	x			x	x	x		x	EMIS 2009/ (NFR-Code)
2	FOEN, Waste and Raw Materials	Waste Statistics	x	x											x	FOEN 2008d, 2008g
3	FOEN, Forest Division	Forest Statistics											x			FOEN 2009b
4	SFOE	Swiss overall energy statistics	x	x	x	x		x	x						x	SFOE 2008
5	FOCA	Civil Aviation			x											FOCA 2006a, 2007, 2008
6	Swiss Air Force Administration	Military Aviation			x											VTG 2008
7	SFSO	Agriculture, LULUCF,											x	x		SFSO 1997, 2000a, 2002, 2005, 2008, 2008a
8	ART	Agriculture, LULUCF											x	x		ART 2008, 2008a
9	WSL	National Forest Inventory												x		EAFV/BFL 1988; Brassel and Brändli 1999; NFI 3 data (unpubl.)
10	CEPE/Basics AG	Energy Consumption		x		x										CEPE 2008; Basics 2008
11	Carbotech	Synthetic Gases								x						Carbotech 2009
12	Industry Associations: SGCI, Swissmem, VSAI etc.	Synthetic Gases								x						Carbotech 2009
13	Swiss Petroleum Association	Oil Statistics							x							EV 2008
14	cemsuisse	Cement, Clinker Production		x							x					Cemsuisse 2008

Data suppliers (sporadic updates)															
15	FOEN, Air Pollution Control	Off-road Database			x		x								INFRAS 2008
16	SGWA, SGIA	Gas Distribution Losses								x					SGIA 2008; SGWA 2007; Swissgas 2007; Xinmin 2004
17	EMPA	Various Emission Factors	x	x	x	x									EMPA 1999; SFOE 2001
18	INFRAS	On-road Emission Model			x										SAEFL 2004
19	INFRAS	Off-road Emission Model			x	x	x								INFRAS 2008
20	SigmaPlan, Meteotest	LULUCF											x		SigmaPlan 2008; Meteotest 2008

The formal arrangements (agreements, contracts, and documentations of roles and responsibilities) that have been established to consolidate and formalize cooperation between the relevant partners contributing to, or involved in, the GHG inventory preparation process are described in Chapter H.1.1 of Switzerland's Initial Report under Article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006h).

Information relating to the Swiss GHG Inventory is made publicly accessible through the FOEN-hosted website [www.climatereporting.ch](http://www.climatereporting.ch), where detailed contact information is also available.

### 1.3. Process for Inventory Preparation

The data needed to prepare the UNFCCC Greenhouse Gas Inventory in the CRF is collected by the various data suppliers. Since the individual data suppliers bear the main responsibility for the quality of data provided, they are also responsible for the collection of activity data and for the selection of emission factors and methods. However, the relevant guidelines, including Revised 1996 IPCC Guidelines (IPCC 1997a, 1997b, 1997c), IPCC Good Practice Guidance (IPCC 2000, IPCC 2003), are necessarily to be taken into account. Some data suppliers have further started to adopt the good practice guidance presented in the 2006 IPCC Guidelines (IPCC 2006). Diverse QA/QC activities (see Chapter 1.6 and, more detailed, FOEN 2009a) provide safeguards to maintain and successively improve the quality of inventory data.

The Air Pollution Control and Non-Ionizing Radiation Division at the FOEN maintains the EMIS database, which contains all the basic data needed to prepare the GHG inventory in the CRF. At the same time, background information on data sources, activity data, emission factors and methods used for emission estimation is documented in the data base and/or the NIR.

Figure 1-2 illustrates in a simplified manner the data collection and processing steps leading to the CRF tables required for reporting under the UNFCCC and under the Kyoto Protocol. From EMIS, an interface transfers the data to the CRF Reporter (Version 3.2.3) that generates the CRF tables that are to be submitted using the UNFCCC submission portal released in February 2009. Representative data from the CRF tables are shown in the NIR. The NIR authors and the reviewers control the correctness of the data transferred from CRF tables into the NIR. Figures and data tables shown in the NIR are exported from EMIS. The NIR authors check the correspondence between the exports and the CRF tables. A detailed illustration of the sectoral steps of inventory processing is given in the monitoring protocols of NIS core processes and sub-processes assembled in FOEN (2009a).

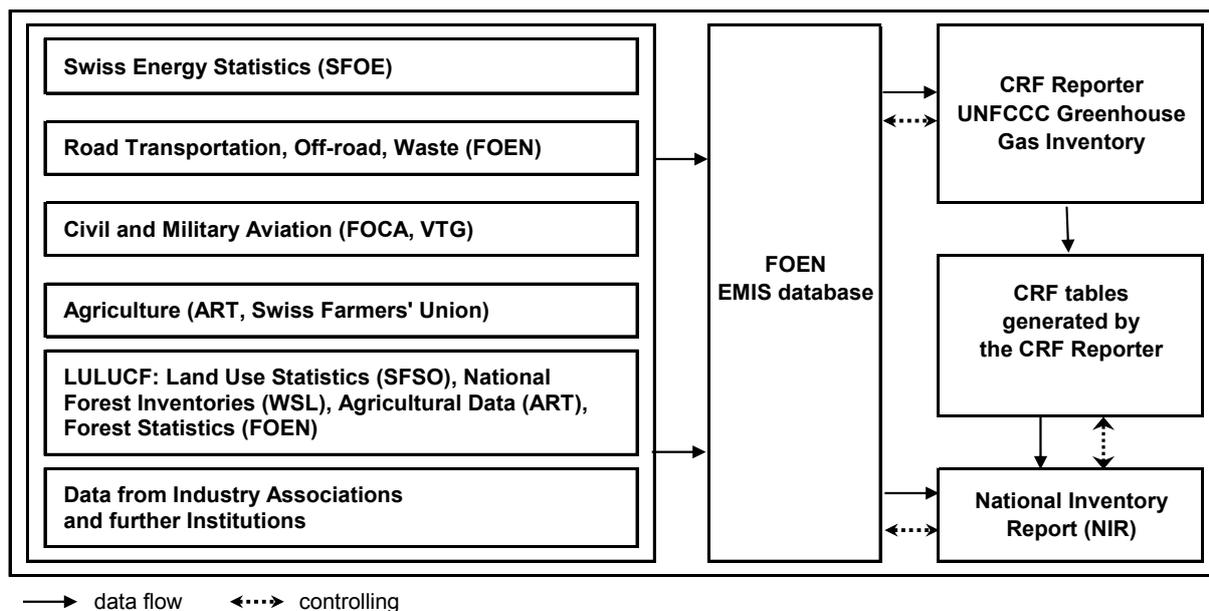


Figure 1-2 Schematic overview: Data collection for EMIS database, CRF Reporter and National Inventory Report (NIR).

## 1.4. Methodologies

### 1.4.1. General Description

Emissions are calculated on the basis of the standard methods and procedures published in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c), in IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000), and in IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003). Under the UNFCCC, these GL and GPG have been adopted for mandatory use in reporting on GHG inventories. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006), adopted in April 2006 by the IPCC, but not yet under the UNFCCC, have been consulted in a few cases.

One part of the emissions has been calculated by multiplying emission factors and activity rates in the "FOEN EMIS database". Another part of the emissions has been calculated by the data suppliers listed in Table 1-1 (transport, synthetic gases, agriculture). In the latter cases, the resulting emission data have been directly inserted into FOEN EMIS database. For further details, see Chapter 1.4.3 below.

The National Approach for sector 1 Energy is based on import and fuel consumption statistics (fuel sales in the transport sector) in Switzerland (see Chapter 1.4.2). The other sectors rely on national statistics and data surveys. For the various sectors, Tier 1, Tier 2 and Tier 3 methodologies according to IPCC Guidelines (IPCC 1997b) and Good Practice Guidance (IPCC 2000) are used. GHG emissions by sources and removals by sinks due to land use, land-use change and forestry (LULUCF sector) are calculated according to IPCC 2003. The following list (Table 1-2) indicates the approaches adopted.

Table 1-2 Summary table for emission factors and methods used (from CRF tables Summary3).

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO <sub>2</sub>		CH <sub>4</sub>		N <sub>2</sub> O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
<b>1. Energy</b>	<b>CS,T1,T2,T3</b>	<b>CS</b>	<b>CS,T1,T2,T3</b>	<b>CR,CS</b>	<b>CS,D,T1,T2,T3</b>	<b>CS,D</b>
A. Fuel Combustion	CS,T1,T2,T3	CS	CS,T1,T2,T3	CR,CS	CS,D,T1,T2,T3	CS,D
1. Energy Industries	CS,T2	CS	CS,T2	CS	CS,D	CS,D
2. Manufacturing Industries and Construction	CS,T2	CS	CS,T2,T3	CS	D	D
3. Transport	T1,T2,T3	CS	T1,T2,T3	CR,CS	T1,T2,T3	CS,D
4. Other Sectors	CS,T2	CS	CS,T2	CS	D	D
5. Other	T2	CS	T2	CS	T2	CS
B. Fugitive Emissions from Fuels	CS	CS	CS	CS	CS	CS
1. Solid Fuels	NA	NA	NA	NA	NA	NA
2. Oil and Natural Gas	CS	CS	CS	CS	CS	CS
<b>2. Industrial Processes</b>	<b>CS,D,T2</b>	<b>CS,D</b>	<b>CS</b>	<b>CS</b>	<b>D</b>	<b>CS</b>
A. Mineral Products	CS,D,T2	CS,D	CS	CS	NA	NA
B. Chemical Industry	CS	CS	CS	CS	D	CS
C. Metal Production	CS	CS	NA	NA	NA	NA
D. Other Production	NA	NA				
E. Production of Halocarbons and SF6						
F. Consumption of Halocarbons and SF6						
G. Other	CS	CS	NA	NA	NA	NA
<b>3. Solvent and Other Product Use</b>	<b>CS</b>	<b>CS</b>			<b>CS</b>	<b>CS</b>
<b>4. Agriculture</b>			<b>D,T2</b>	<b>CR,CS,D</b>	<b>CS,D,T1b</b>	<b>CR,D</b>
A. Enteric Fermentation			T2	CS		
B. Manure Management			T2	CS,D	CS	D
C. Rice Cultivation			NA	NA		
D. Agricultural Soils			NA	NA	CS,T1b	D
E. Prescribed Burning of Savannas			NA	NA	NA	NA
F. Field Burning of Agricultural Residues			D	CR	D	CR
G. Other			NA	NA	NA	NA
<b>5. Land Use, Land-Use Change and Forestry</b>	<b>T2</b>	<b>CS</b>	<b>T1</b>	<b>CS</b>	<b>T1</b>	<b>D</b>
A. Forest Land	T2	CS	T1	CS	T1	D
B. Cropland	T2	CS	NA	NA	T1	D
C. Grassland	T2	CS	NA	NA	NA	NA
D. Wetlands	T2	CS	NA	NA	NA	NA
E. Settlements	T2	CS	NA	NA	NA	NA
F. Other Land	T2	CS	NA	NA	NA	NA
G. Other	NA	NA	NA	NA	NA	NA
<b>6. Waste</b>	<b>CS</b>	<b>CS</b>	<b>CS,D</b>	<b>CS,D</b>	<b>CS</b>	<b>CS</b>
A. Solid Waste Disposal on Land	CS	CS	CS,D	CS,D		
B. Waste-water Handling			D	CS,D	D	CS
C. Waste Incineration	CS	CS	CS	CS	CS	CS
D. Other	NA	NA	CS	CS	CS	CS

<b>2. Industrial Processes</b>	<b>HFCs</b>		<b>PFCs</b>		<b>SF<sub>6</sub></b>	
C. Metal Production	NA	NA	NA	NA	T2	D
E. Production of Halocarbons and SF6	NA	NA	NA	NA	NA	NA
F. Consumption of Halocarbons and SF6	T1, T2	CS, D	T1,T2	CS,D	T2	CS,D,M

### 1.4.2. National and Reference Approach for Sector 1 Energy

The Reference Approach is used as a check for (i) overall energy consumption and (ii) the resulting CO<sub>2</sub> emissions reported in source category 1 Energy. In Switzerland, it is applied on the basis of customs statistics for imported oil and oil products, and data published in the annual report of the Swiss Petroleum Association (Erdöl-Vereinigung/Union pétrolière; EV 2008). The results of the Reference Approach are compared with the results of the National Approach for sector 1 Energy in order to test the quality and completeness of the inventory. For the present inventory, the two approaches show very good correspondence, with CO<sub>2</sub> emissions differing by only 1.58% in 2007 (see Chapter 3.6).

### 1.4.3. National Air Pollution Database EMIS

A large body of emission data is adopted from Switzerland's national air pollution database EMIS, which is operated by FOEN (FOEN 2006c). EMIS was established at SAEFL (former name of FOEN) in the late 1980s. Its initial purpose was to record and monitor emissions of air pollutants. It has since been extended to cover greenhouse gases, too. Its structure corresponds to the EMEP/CORINAIR system for classifying emission-generating activities. EMEP/CORINAIR uses the Nomenclature for Reporting ("NFR code", UNECE 2003). The Revised 1996 IPCC Guidelines provide a correspondence key between IPCC and EMEP/CORINAIR source categories (IPCC 1997a: Annex 2). EMIS thus contains cross-references to IPCC/UNFCCC coding formats.

EMIS calculates emissions for various pollutants using emission factors and activity data according to the EMEP/CORINAIR methodology. Pollutants in EMIS include sulphur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), nitrous oxide (N<sub>2</sub>O), ammonia (NH<sub>3</sub>), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), hydrochloric acid (HCl), particulate matter, heavy metals (lead, zinc, cadmium, mercury), polychlorinated dibenzodioxins and -furanes (PCDD/PCDF), hydrogen fluoride (HF), hydrofluorocarbons (HFC), perfluorinated carbon compounds (PFC), sulphur hexafluoride (SF<sub>6</sub>), methane (CH<sub>4</sub>), carbon dioxide CO<sub>2</sub> (fossil/geological origin) and CO<sub>2</sub> (biogen). The input data originate from a variety of sources, such as production data and emission factors from industry, industry associations and research institutions, as well as population, employment, waste and agriculture statistics. EMIS is documented in an internal FOEN manual for the database (FOEN 2006c).

The original EMIS database underwent a full redesign in 2005/2006. It was extended to incorporate more data sources, updated, and migrated to a new software platform. At the same time, activity data and emission factors were being checked and updated. Emission data from EMIS that are relevant for the GHG inventory are exported to the CRF Reporter.

Input data for the EMIS database comprise the SFOE Swiss overall energy statistics, FOEN statistics and models for emissions from road transportation, statistics and models of off-road activities, import statistics for synthetic gases, waste and agricultural statistics, the National Forest Inventory and the National Forest Statistics (see Figure 1-2).

## 1.5. Key Categories

### 1.5.1. Methodology

The key category analyses are performed according to the IPCC Good Practice Guidance (IPCC 2000, chapter 7). A Tier 1 level and trend assessment is applied with the proposed threshold of 95%. A Tier 2 key category analyses has also been carried out for this submission with the proposed threshold of 90% of the sum of all level assessments weighted with their uncertainty.

Similarly detailed disaggregation as in FOEN (2008), the previous submission, has been used to identify important sub-sources. A more detailed description of the key category analysis and the level of disaggregation is provided in Annex A1. The categories 2C Metal Production, 2F Consumption of Halocarbons and SF<sub>6</sub> and 4D Agricultural Soils have been separated into the following sub-categories:

- 2C3 Metal Production; Aluminium Production CO<sub>2</sub> (no key category, therefore not contained in Table 1-3)
- 2C3 Metal Production; Aluminium Production PFC (no key category, therefore not contained in Table 1-3)
- 2C\_o Metal Production; without Aluminium Production CO<sub>2</sub> (No. 26 in Table 1-3)

- 2F, sum of PFC (No. 27 in Table 1-3)
- 2F\_o, sum of HFC without HFC from 2F1 (no key category, therefore not contained in Table 1-3)
- 2F1, HFC from 2F1 Refrigeration and Air Conditioning Equipment (No. 28 in Table 1-3)
- 2F\_o, sum of SF<sub>6</sub> without SF<sub>6</sub> from 2F8 (no key category, therefore not contained in Table 1-3)
- 4D1, N<sub>2</sub>O from Agricultural Soils, Direct Soil Emissions (No. 35 in Table 1-3)
- 4D3, N<sub>2</sub>O from Agricultural Soils, Indirect Emissions (No. 36 in Table 1-3)
- 4D\_o, N<sub>2</sub>O from Agricultural Soils without 4D1-N<sub>2</sub>O and without 4D3-N<sub>2</sub>O (No. 34 in Table 1-3),
- 4D\_o, CH<sub>4</sub> from Agricultural Soils without 4D1-N<sub>2</sub>O and without 4D3-N<sub>2</sub>O (not occurring, no key category in 2007, therefore not contained in Table 1-3)

According to good practice guidance (IPCC 2003), the result of Tier 2 key category analysis should be used when results between Tier 1 and Tier 2 differ. However, it would also be possible to keep Tier 1 key categories as key categories based on qualitative criteria. It is planned that this topic will be examined for future submissions. The GHG Inventory Core Group has agreed to keep Tier 1 key categories in this submission as key categories, even if they are not key in Tier 2. This procedure would also be compatible with the 2006 IPCC Guidelines (IPCC 2006), which recommend exactly such a procedure of combining results from Tier 1 and Tier 2 categories if results from the two approaches differ. When combining Tier 1 and Tier 2 key category analysis results, we consider a category to be key because of trend, if the category is key due to trend according to Tier 1 or Tier 2, and a category is considered to be key because of level, if the category is key due to level according to Tier 1 or Tier 2.

### 1.5.2. KCA without LULUCF categories

#### Tier 1

For 2007, among a total of 134 categories, 36 have been identified as key categories with an aggregated contribution of 97.9% to total national emissions. 25 categories are key due to the level assessment, 30 due to the trend assessment.

Of the 36 key categories, 21 are in sector 1 Energy, accounting for 80.7% of total CO<sub>2</sub> equivalent emissions in 2007. The other key categories are from sectors 2 Industrial Processes (5.4%), 3 Solvent and Other Product Use (0.3%), 4 Agriculture (10.4%), and 6 Waste (1.1%). There are two major key sources:

- 1A3b Energy, Fuel Combustion, Road Transportation, gasoline, CO<sub>2</sub>, level contribution 20.7%,
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, liquid fuels, CO<sub>2</sub>, level contribution 15.5%.

Compared to the key category analysis in the previous inventory report (FOEN 2008), N<sub>2</sub>O emissions from 2B Chemical Industry (KC Trend), PFC emissions from 2F Consumption of Halocarbons and SF<sub>6</sub>(KC Trend) and N<sub>2</sub>O emissions from 4D\_o Agricultural Soils without 4D1- N<sub>2</sub>O & 4D3- N<sub>2</sub>O are new key categories. CO<sub>2</sub> and PFC emissions from 2C3 Aluminium Production, and HFC emissions from 2F\_o Consumption of Halocarbons and SF<sub>6</sub> without 2F1-HFC (all previously KC Trend) are no longer key categories.

The following table shows the contributions of the individual key categories. The complete results of the key category analysis for 2007 are given in Annex A1.2.

Table 1-3 List of Switzerland's Tier 1 key categories 2007 without LULUCF categories, sorted by category code.

No.	A		B	C		D	E-L	E-T	F-T	M	N
	IPCC Source Categories and fuels if applicable (without LULUCF categories)			Direct GHG	Base Year 1990 Estimate						
11A1	1. Energy	A. Fuel Combustion	1. Energy Industries	CO2	234.93	261.60	0.61%	0.00066	0.2%	KC level	-
21A1	1. Energy	A. Fuel Combustion	1. Energy Industries	CO2	691.23	758.97	1.48%	0.00174	0.8%	KC level	KC trend
31A1	1. Energy	A. Fuel Combustion	1. Energy Industries	CO2	1519.73	2162.03	4.22%	0.01371	4.8%	KC level	KC trend
41A1	1. Energy	A. Fuel Combustion	1. Energy Industries	N2O	48.42	112.44	0.23%	0.00131	0.5%	-	-
51A1	1. Energy	A. Fuel Combustion	1. Energy Industries	CO2	46.90	161.21	0.31%	0.00232	0.8%	-	-
61A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	CO2	1066.65	2161.70	4.22%	0.02254	7.7%	KC level	KC trend
71A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	CO2	3339.26	2572.26	5.02%	0.01356	4.7%	KC level	KC trend
81A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	CO2	156.87	295.17	0.58%	0.00286	1.0%	KC level	KC trend
91A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	CO2	1387.85	774.46	1.51%	0.01154	4.0%	KC level	KC trend
101A3a	1. Energy	A. Fuel Combustion	3. Transport: Civil Aviation	CO2	262.55	138.39	0.27%	0.00215	0.7%	-	-
111A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	CO2	2647.42	5188.33	10.12%	0.05240	18.2%	KC level	KC trend
121A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	N2O			This source is not key category in Tier 1, only key category in Tier 2				
131A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	CO2	11335.25	10614.99	20.70%	0.00824	2.9%	KC level	KC trend
141A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	CH4	91.32	17.86	0.03%	0.00142	0.5%	-	-
151A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	N2O			This source is not key category in Tier 1, only key category in Tier 2				
161A3e	1. Energy	A. Fuel Combustion	3. Transport: Other Transportation (military aviation)	CO2	200.04	115.09	0.23%	0.00159	0.6%	-	-
171A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	CO2	938.95	1350.12	2.63%	0.00876	3.0%	KC level	KC trend
181A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	CO2	4444.11	3310.50	6.46%	0.02030	7.0%	KC level	KC trend
191A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	CO2	1406.59	2141.71	4.18%	0.01551	5.4%	KC level	KC trend
201A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	CO2	10215.56	7922.91	15.45%	0.04038	14.0%	KC level	KC trend
211A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	CO2	547.47	529.32	1.03%	0.00006	0.0%	KC level	-
221A5	1. Energy	A. Fuel Combustion	5. Other	CO2	443.97	568.91	1.15%	0.00315	1.1%	KC level	KC trend
231B2	1. Energy	B. Fugitive Emissions from 2. Oil and Natural Gas		CH4	380.46	173.28	0.34%	0.00395	1.4%	-	-
242A1	2. Industrial Proc.	A. Mineral Products, Cement Production-CO2		CO2	2524.77	1844.15	3.60%	0.01227	4.3%	KC level	KC trend
252B	2. Industrial Proc.	B. Chemical Industry		N2O	173.76	83.15	0.16%	0.00172	0.6%	-	-
262C	2. Industrial Proc.	C. Metal Production without Aluminium Production		CO2	112.45	179.13	0.35%	0.00140	0.5%	-	-
272F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		PFC	0.04	77.08	0.15%	0.00154	0.5%	-	-
282F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.02	568.66	1.11%	0.01140	4.0%	KC level	KC trend
293	3. Solvent and Other Product Use			CO2	357.79	177.11	0.35%	0.00343	1.2%	-	-
303	3. Solvent and Other Product Use			N2O			This source is not key category in Tier 1, only key category in Tier 2				
314A	4. Agriculture	A. Enteric Fermentation		CH4	2474.84	2318.64	4.52%	0.00178	0.6%	KC level	KC trend
324B	4. Agriculture	B. Manure Management		CH4	557.43	500.85	0.98%	0.00083	0.3%	KC level	-
334B	4. Agriculture	B. Manure Management		N2O	448.20	408.39	0.80%	0.00055	0.2%	KC level	-
344D	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		N2O	200.19	180.11	0.35%	0.00029	0.1%	KC level	-
354D1	4. Agriculture	D. Agricultural Soils, Direct Soil Emissions		N2O	1389.94	1231.47	2.40%	0.00242	0.8%	KC level	KC trend
364D3	4. Agriculture	D. Agricultural Soils, Indirect Emissions		N2O	818.89	692.36	1.35%	0.00209	0.7%	KC level	KC trend
376A	6. Waste	A. Solid Waste Disposal on Land		CH4	683.04	279.30	0.54%	0.00792	2.7%	KC level	KC trend
386B	6. Waste	B. Wastewater Handling		N2O	179.35	201.02	0.39%	0.00053	0.2%	KC level	-
396D	6. Waste	D. Other		CH4	30.34	99.94	0.19%	0.00141	0.5%	-	-

Table 1-4 List of Switzerland's Tier 1 key categories for the base year 1990 without LULUCF categories, sorted by category code.

No.	Key category analysis for the base year 1990 IPCC Source Categories and fuels if applicable (without LULUCF categories)	Direct GHG	Base Year 1990 Estimate	Level/Assessm.	Result level assessm.
1	1. Energy		[Gg CO2eq]		
2	1A1 1. Energy	A. Fuel Combustion			
1	1A1 1. Energy	A. Fuel Combustion	234.93	0.45%	KC level
3	1A1 1. Energy	A. Fuel Combustion	691.23	1.31%	KC level
4	1A2 1. Energy	A. Fuel Combustion	1'519.73	2.88%	KC level
5	1A2 1. Energy	A. Fuel Combustion	1'066.65	2.02%	KC level
6	1A2 1. Energy	A. Fuel Combustion	3'339.62	6.34%	KC level
7	1A2 1. Energy	A. Fuel Combustion	not key category in Tier 1, only key category in Tier 2		
8	1A3a 1. Energy	A. Fuel Combustion	1'387.85	2.63%	KC level
9	1A3b 1. Energy	A. Fuel Combustion	252.55	0.48%	KC level
10	1A3b 1. Energy	A. Fuel Combustion	2'647.42	5.02%	KC level
11	1A3b 1. Energy	A. Fuel Combustion	11'335.25	21.50%	KC level
12	1A4a 1. Energy	A. Fuel Combustion	not key category in Tier 1, only key category in Tier 2		
13	1A4a 1. Energy	A. Fuel Combustion	938.95	1.78%	KC level
14	1A4b 1. Energy	A. Fuel Combustion	4'444.11	8.43%	KC level
15	1A4b 1. Energy	A. Fuel Combustion	1'406.59	2.67%	KC level
16	1A4c 1. Energy	A. Fuel Combustion	10'215.56	19.38%	KC level
17	1A5 1. Energy	A. Fuel Combustion	547.47	1.04%	KC level
18	1B2 1. Energy	B. Fugitive Emissions from Fuels	443.97	0.84%	KC level
19	2A1 2. Industrial Proc.	A. Mineral Products; Cement Production-CO2	380.46	0.72%	KC level
20	3 3. Solvent and Other Product Use	A. Mineral Products; Cement Production-CO2	2'524.77	4.79%	KC level
21	4A 4. Agriculture	A. Enteric Fermentation	357.79	0.68%	KC level
22	4B 4. Agriculture	B. Manure Management	2'474.84	4.70%	KC level
23	4B 4. Agriculture	B. Manure Management	557.43	1.06%	KC level
24	4D_o 4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O	448.20	0.85%	KC level
25	4D1 4. Agriculture	D. Agricultural Soils; Direct Soil Emissions	not key category in Tier 1, only key category in Tier 2		
26	4D3 4. Agriculture	D. Agricultural Soils; Indirect Emissions	1'389.94	2.64%	KC level
27	6A 6. Waste	A. Solid Waste Disposal on Land	818.89	1.55%	KC level
28	6B 6. Waste	B. Wastewater Handling	693.04	1.31%	KC level
			not key category in Tier 1, only key category in Tier 2		

There are 24 level key categories in the base year 1990 (see Table 1-4). All of them are also key categories in 2007. Compared to the key category analysis in the previous inventory report, N<sub>2</sub>O emissions from 4D\_o Agricultural Soils without 4D1-N<sub>2</sub>O & 4D3-N<sub>2</sub>O are no longer a key category because recalculations led to a decrease of total emissions in the base year, and therefore the source 4D\_o is no longer needed to reach the 95% threshold.

## Tier 2

For 2007, among a total of 134 categories, 32 have been identified as key categories with an aggregated contribution of 93.4% to total national emissions and 95.25% of the sum of all level assessments weighted with their uncertainty in 2007. 24 categories are key due to the level assessment, 26 due to the trend assessment.

Of the 32 key categories, 17 are in sector 1 Energy, accounting for 45.7% of the sum of all level assessments weighted with their uncertainty in 2007 (15.70%, see Table A - 6). Sector 4 Agriculture accounts for 38.9% of that sum. Tier 2 key category analysis shows that these two sectors have the highest impact on inventory uncertainty. The other key categories are from sectors 2 Industrial Processes (3.7%), 3 Solvent and Other Product Use (1.6%), and 6 Waste (5.2%). There are three major key sources:

- 1A1 Energy, Fuel Combustion, Energy Industries, Other Fuels, CO<sub>2</sub>, contribution of 8.9% to the sum of all level assessments weighted with their uncertainty.
- 4D1, Agricultural Soils; Direct Soil Emissions, N<sub>2</sub>O, contribution of 11.7% to the sum of all level assessments weighted with their uncertainty.
- 4D3, Agricultural Soils; Indirect Emissions, N<sub>2</sub>O, contribution of 13.7% to the sum of all level assessments weighted with their uncertainty.

Table 1-5 shows the contributions of the individual key categories. The complete results of the key category analysis for 2007 are given in Annex A1.4.

Table 1-5 List of Switzerland's Tier 2 key categories 2007 without LULUCF categories, sorted by category code.

No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)		Direct GHG	Base Year 1990 Estimate [Gg CO <sub>2</sub> eq]	Year 2007 Estimate [Gg CO <sub>2</sub> eq]	Level Assessment, with Uncertainty	Trend Assessment, with Uncertainty	% Contribution in Trend	Result level assessment	Result trend assessment
11A1	1. Energy	A. Fuel Combustion	CO2							
21A1	1. Energy	A. Fuel Combustion	CO2							
31A1	1. Energy	A. Fuel Combustion	CO2	1519.73	2'162.03	1.40%	0.00455	9.1%	KC level	KC trend
41A1	1. Energy	A. Fuel Combustion	N2O	48.42	112.44	0.18%	0.00106	2.1%	KC level	KC trend
51A1	1. Energy	A. Fuel Combustion	CO2	48.90	161.21	0.08%	0.00060	1.2%	KC level	KC trend
61A2	1. Energy	A. Fuel Combustion	CO2	1'066.65	2'161.70	0.57%	0.00303	6.1%	KC level	KC trend
71A2	1. Energy	A. Fuel Combustion	CO2	3'339.62	2'572.26	0.25%	0.00068	1.4%	KC level	KC trend
81A2	1. Energy	A. Fuel Combustion	CO2	156.87	295.17	0.41%	0.00201	4.0%	KC level	KC trend
91A2	1. Energy	A. Fuel Combustion	CO2	1'387.85	774.46	0.48%	0.00370	7.4%	KC level	KC trend
101A3a	1. Energy	A. Fuel Combustion	CO2							
111A3b	1. Energy	A. Fuel Combustion	CO2	2'647.42	5'188.33	0.42%	0.00219	4.4%	KC level	KC trend
121A3b	1. Energy	A. Fuel Combustion	N2O	8.41	31.93	0.09%	0.00071	1.4%	KC level	KC trend
131A3b	1. Energy	A. Fuel Combustion	CH4	91.32	17.86	0.02%	0.00085	1.7%	KC level	KC trend
141A3b	1. Energy	A. Fuel Combustion	CO2	1'1335.25	10'614.99	0.86%	0.00034	0.7%	KC level	KC trend
151A3b	1. Energy	A. Fuel Combustion	N2O	87.79	81.62	0.24%	0.00011	0.2%	KC level	KC trend
161A3e	1. Energy	A. Fuel Combustion	CO2							
171A4a	1. Energy	A. Fuel Combustion	CO2	938.95	1'350.12	0.35%	0.00118	2.4%	KC level	KC trend
181A4a	1. Energy	A. Fuel Combustion	CO2	4'444.11	3'310.50	0.32%	0.00102	2.0%	KC level	KC trend
191A4b	1. Energy	A. Fuel Combustion	CO2	1'406.59	2'141.71	0.56%	0.00208	4.2%	KC level	KC trend
201A4b	1. Energy	A. Fuel Combustion	CO2	10'215.56	7'922.91	0.77%	0.00202	4.0%	KC level	KC trend
211A4c	1. Energy	A. Fuel Combustion	CO2							
221A4c	1. Energy	A. Fuel Combustion	CO2							
231B2	1. Energy	B. Fugitive Emissions froj2. Oil and Natural Gas	CH4	380.46	173.28	0.17%	0.00197	4.0%	KC level	KC trend
242A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2	CO2	2'524.77	1'844.15	0.23%	0.00078	1.6%	KC level	KC trend
252B	2. Industrial Proc.	B. Chemical Industry	N2O	173.76	83.15	0.07%	0.00071	1.4%	KC level	KC trend
262C o	2. Industrial Proc.	C. Metal Production without Aluminium Production	CO2	112.45	179.13	0.14%	0.00056	1.1%	KC level	KC trend
272F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6	PFC							
282F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & A/C Eq.	HFC	0.02	568.66	0.15%	0.00158	3.2%	KC level	KC trend
293	3. Solvent and Other Product Use		CO2	357.79	177.11	0.17%	0.00171	3.4%	KC level	KC trend
303	3. Solvent and Other Product Use		N2O	110.14	53.72	0.08%	0.00086	1.7%	KC level	KC trend
314A	4. Agriculture	A. Enteric Fermentation	CH4	2'474.84	2'318.64	0.83%	0.00033	0.7%	KC level	-
324B	4. Agriculture	B. Manure Management	CH4	557.43	500.85	0.53%	0.00045	0.9%	KC level	-
334B	4. Agriculture	B. Manure Management	N2O	448.20	408.39	0.50%	0.00035	0.7%	KC level	-
344D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O	N2O	200.19	180.11	0.26%	0.00022	0.4%	KC level	-
354D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions	N2O	1'389.94	1'231.47	1.84%	0.00185	3.7%	KC level	KC trend
364D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions	N2O	818.89	692.36	2.15%	0.00332	6.7%	KC level	KC trend
376A	6. Waste	A. Solid Waste Disposal on Land	CH4	693.04	279.30	0.33%	0.00475	9.5%	KC level	KC trend
386B	6. Waste	B. Wastewater Handling	N2O	179.35	201.02	0.39%	0.00053	1.1%	KC level	KC trend
396D	6. Waste	D. Other	CH4	30.34	99.94	0.10%	0.00071	1.4%	KC level	KC trend

Table 1-6 List of Switzerland's Tier 2 key categories for the base year 1990 without LULUCF categories, sorted by category code.

No.	Key category analysis for the base year 1990 IPCC Source Categories and fuels if applicable (without LULUCF categories)		Direct GHG	Base Year 1990 Estimate [Gg CO <sub>2</sub> eq]	Level Assessment, with Uncertainty	Result level assessm.
1	1A1	1. Energy	1. Energy Industries	Gaseous Fuels	not key category in Tier 2, only key category in Tier 1	
2	1A1	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	not key category in Tier 2, only key category in Tier 1	
3	1A1	A. Fuel Combustion	1. Energy Industries	Other Fuels	1'519.73	0.96% KC level
4	1A2	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	1'066.65	0.27% KC level
5	1A2	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	3'339.62	0.32% KC level
6	1A2	1. Energy	2. Manufacturing Industries and Construction	Other Fuels	156.87	0.21% KC level
7	1A2	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	1'387.85	0.84% KC level
8	1A3a	1. Energy	3. Transport: Civil Aviation		not key category in Tier 2, only key category in Tier 1	
9	1A3b	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	2'647.42	0.21% KC level
10	1A3b	1. Energy	3. Transport: Road Transportation	Gasoline	1'335.25	0.90% KC level
11	1A3b	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	87.79	0.25% KC level
12	1A4a	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	938.95	0.24% KC level
13	1A4a	1. Energy	4. Other Sectors: Commercial/Institutional	Liquid Fuels	4'444.11	0.42% KC level
14	1A4b	A. Fuel Combustion	4. Other Sectors: Residential	Gaseous Fuels	1'406.59	0.36% KC level
15	1A4b	1. Energy	4. Other Sectors: Residential	Liquid Fuels	10'215.56	0.97% KC level
16	1A4c	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	not key category in Tier 2, only key category in Tier 1	
17	1A5	1. Energy	5. Other	Liquid and Gaseous Fuels	not key category in Tier 2, only key category in Tier 1	
18	1B2	1. Energy	2. Oil and Natural Gas		380.46	0.36% KC level
19	2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO <sub>2</sub>		2'524.77	0.30% KC level
20	3	Solvent and Other Product Use			357.79	0.34% KC level
21	4A	4. Agriculture	A. Enteric Fermentation		2'474.84	0.86% KC level
22	4B	4. Agriculture	B. Manure Management		557.43	0.56% KC level
23	4B	4. Agriculture	B. Manure Management		448.20	0.54% KC level
24	4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N <sub>2</sub> O & 4D3-N <sub>2</sub> O		200.19	0.28% KC level
25	4D1	4. Agriculture	D. Agricultural Soils: Direct Soil Emissions		1'389.94	2.02% KC level
26	4D3	4. Agriculture	D. Agricultural Soils: Indirect Emissions		818.89	2.47% KC level
27	6A	6. Waste	A. Solid Waste Disposal on Land		693.04	0.79% KC level
28	6B	6. Waste	B. Wastewater Handling		179.35	0.34% KC level

There are 23 level Tier 2 key categories in the base year 1990 (see Table 1-6). All of them are also key categories in 2007.

### 1.5.3. Combined KCA without and with LULUCF categories

The key category analysis including LULUCF categories has also been carried out for 2007 and 1990. The complete results of the key category analysis for 2007 are shown in Annex A1. According to IPCC Good Practice Guidance for LULUCF (IPCC 2003, Section 5.4.2), the set of key categories consists of all non-LULUCF key categories that result from the KCA without LULUCF combined with all LULUCF key categories that result from the KCA including LULUCF.

#### Tier 1

In the Tier 1 KCA for the year 2007 including LULUCF categories there are four additional categories out of the LULUCF sector:

- 5A1 Forest Land remaining Forest Land (level and trend key category)
- 5A2 Land converted to Forest Land (trend key category)
- 5B1 Cropland remaining Cropland (level key category)
- 5E2 Land converted to Settlements (level and trend key category)

Source category 5A1 Forest Land remaining Forest Land is a large category, contributing 3.2% to the level assessment. Source categories 5A2, 5B1 and 5E2 contribute less to the level assessment with 0.05%, 1.0% and 0.6%, respectively. For the combined KCA without and with LULUCF categories these categories are added to the other 36 key categories from the KCA without LULUCF as shown in Table 1-3.

In the KCA for the year 1990, three of these four LULUCF categories are also key categories. Source category 5A2 is not a key category for the year 1990.

The results of the combined Tier 1 KCA are summarised in Table 1-7 (year 2007) and Table 1-8 (year 1990).

The three LULUCF key categories 5A1, 5B1, 5E2 were also key in the analysis for 2006 as contained in the previous inventory report (FOEN 2008). In contrast, source category 5A2 was not a key category.

#### Tier 2

In the Tier 2 KCA for 2007 including LULUCF categories the same four additional categories out of the LULUCF sector are key as in Tier 1.

Source category 5A1 Forest Land remaining Forest Land is a large category, contributing 7.5% to the sum of all level assessments weighted with their uncertainty. Source categories 5A2, 5B1 and 5E2 contribute less, with 0.1%, 2.4% and 1.8%, respectively. For the combined KCA without and with LULUCF categories these categories are added to the other 32 key categories from the KCA without LULUCF.

In the KCA for the year 1990, three of these four LULUCF categories are also key categories. Source category 5A2 is not a key category for the year 1990.

The results of the combined Tier 2 KCA are summarised in Table 1-9 (year 2007) and Table 1-10 (year 1990).

In the previous submission (FOEN 2008) no Tier 2 KCA has been performed.

Table 1-7 List of Switzerland's Tier 1 key categories, combined KCA without and with LULUCF (*in italic*) categories 2007, sorted by category code.

No.	A		B	C		D	E-L	E-T	F-T	M	N	
	IPCC Source Categories and fuels if applicable (combined key category analysis without and with LULUCF categories)	Direct GHG		Base Year 1990 Estimate	Year 2007 Estimate							Level Assesment
11A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	261.50	0.51%	0.00661	0.2%	KC level	-
21A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	758.97	1.48%	0.00137	0.8%	KC level	KC trend
31A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2'162.03	4.22%	0.01370	4.8%	KC level	KC trend
41A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	112.44	0.23%	0.001310	0.5%	-	KC trend
51A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.90	161.21	0.31%	0.002318	0.8%	-	KC trend
61A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'066.65	2'161.70	4.22%	0.022541	7.8%	KC level	KC trend
71A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'339.62	2'572.26	5.08%	0.013558	4.7%	KC level	KC trend
81A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	156.87	295.17	0.58%	0.002859	1.0%	KC level	KC trend
91A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'387.85	774.46	1.51%	0.011539	4.0%	KC level	KC trend
101A3a	1. Energy	A. Fuel Combustion	3. Transport: Civil Aviation	CO2	CO2	252.55	138.39	0.27%	0.002151	0.7%	-	KC trend
111A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	CO2	264.742	5'188.33	10.12%	0.052397	18.2%	KC level	KC trend
121A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	CO2	11'335.25	10'614.99	20.70%	0.008238	2.8%	KC level	KC trend
131A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	CH4	91.32	17.86	0.03%	0.001423	0.5%	-	KC trend
141A3e	1. Energy	A. Fuel Combustion	3. Transport: Other Transportation (military aviation)	CO2	CO2	200.04	115.09	0.22%	0.001594	0.5%	-	KC trend
151A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	CO2	938.95	1'350.12	2.63%	0.008758	3.0%	KC level	KC trend
161A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Liquid Fuels	CO2	4'444.11	3'310.50	6.48%	0.020298	7.0%	KC level	KC trend
171A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Gaseous Fuels	CO2	1'406.59	2'141.71	4.18%	0.015510	5.4%	KC level	KC trend
181A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Liquid Fuels	CO2	10'215.56	7'922.91	15.45%	0.040379	14.0%	KC level	KC trend
191A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	CO2	547.47	529.32	1.03%	0.000064	0.0%	KC level	-
201A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseol	CO2	443.97	588.91	1.15%	0.003149	1.1%	KC level	KC trend
211B2	1. Energy	B. Fugitive Emissions fro/2, Oil and Natural Gas		CH4	CH4	380.46	173.28	0.34%	0.003946	1.4%	-	KC trend
222A1	2. Industrial Proc.	A. Mineral Products: Cement Production-CO2		CO2	CO2	2'524.77	1'844.15	3.60%	0.012265	4.3%	KC level	KC trend
232B	2. Industrial Proc.	B. Chemical Industry		N2O	N2O	173.76	83.15	0.16%	0.001722	0.6%	-	KC trend
242C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CO2	CO2	112.45	179.13	0.35%	0.001399	0.5%	-	KC trend
252F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		PFC	PFC	0.04	77.08	0.15%	0.001545	0.5%	-	KC trend
262F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	HFC	0.02	568.66	1.11%	0.011402	4.0%	KC level	KC trend
273	3. Solvent and Other Product Use			CO2	CO2	357.79	177.11	0.35%	0.003427	1.2%	-	KC trend
284A	4. Agriculture	A. Enteric Fermentation		CH4	CH4	2'474.64	2'318.64	4.52%	0.001771	0.6%	KC level	KC trend
294B	4. Agriculture	B. Manure Management		CH4	CH4	557.43	500.85	0.98%	0.000829	0.3%	KC level	-
304B	4. Agriculture	B. Manure Management		N2O	N2O	448.20	408.39	0.80%	0.000553	0.2%	KC level	-
314D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		N2O	N2O	200.19	180.11	0.35%	0.000293	0.1%	KC level	-
324D1	4. Agriculture	D. Agricultural Soils: Direct Soil Emissions		N2O	N2O	1'389.94	1'231.47	2.40%	0.002417	0.8%	KC level	KC trend
334D3	4. Agriculture	D. Agricultural Soils: Indirect Emissions		N2O	N2O	818.89	692.36	1.35%	0.002089	0.7%	KC level	KC trend
345A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	CO2	CO2	3'362.03	1'722.75	3.18%	0.028348	9.5%	KC level	KC trend
355A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land	CO2	CO2	126.38	28.85	0.05%	0.001769	0.6%	-	KC trend
365B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland	CO2	CO2	570.89	559.03	1.03%	0.000409	0.1%	KC level	-
375E2	5. LULUCF	E. Settlements	2. Land converted to Settlements	CO2	CO2	398.89	307.58	0.56%	0.001459	0.5%	KC level	KC trend
386A	6. Waste	A. Solid Waste Disposal on Land		CH4	CH4	693.04	279.30	0.54%	0.007917	2.7%	KC level	KC trend
396B	6. Waste	B. Wastewater Handling		N2O	N2O	179.35	201.02	0.39%	0.000533	0.2%	KC level	-
406D	6. Waste	D. Other		CH4	CH4	30.34	99.94	0.19%	0.001412	0.5%	-	KC trend

Table 1-8 List of Switzerland's Tier 1 key categories for the base year 1990, combined KCA without and with LULUCF (*in italic*) categories, sorted by category code.

No.	IPCC Source Categories and fuels if applicable (combined key category analysis without and with LULUCF categories)	Direct GHG	Base Year 1990 Estimate	Level Assessment	Result level assessm.
1	1A1 1. Energy				
2	1A1 A. Fuel Combustion				
3	1A1 1. Energy	1. Energy Industries	Gaseous Fuels	0.44%	KC level
4	1A1 A. Fuel Combustion	1. Energy Industries	Liquid Fuels	1.31%	KC level
5	1A2 1. Energy	1. Energy Industries	Other Fuels	2.88%	KC level
6	1A2 A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	2.01%	KC level
7	1A2 1. Energy	2. Manufacturing Industries and Construction	Liquid Fuels	6.42%	KC level
8	1A2 A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	2.63%	KC level
9	1A3a 1. Energy	3. Transport: Civil Aviation		0.48%	KC level
10	1A3a A. Fuel Combustion	3. Transport: Civil Aviation		0.48%	KC level
11	1A3b 1. Energy	3. Transport: Road Transportation	Diesel	4.97%	KC level
12	1A3b A. Fuel Combustion	3. Transport: Road Transportation		4.97%	KC level
13	1A4a 1. Energy	3. Transport: Road Transportation	Gasoline	2.152%	KC level
14	1A4a A. Fuel Combustion	3. Transport: Road Transportation		2.152%	KC level
15	1A4b 1. Energy	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	1.78%	KC level
16	1A4b A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Liquid Fuels	8.32%	KC level
17	1A4c 1. Energy	4. Other Sectors: Residential	Gaseous Fuels	2.66%	KC level
18	1A4c A. Fuel Combustion	4. Other Sectors: Residential	Liquid Fuels	19.35%	KC level
19	1A5 1. Energy	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	1.05%	KC level
20	1A5 A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid and Gaseous Fuels	0.87%	KC level
21	1B2 1. Energy	5. Other		0.72%	KC level
22	1B2 A. Mineral Products; Cement Production-CO2	2. Oil and Natural Gas		0.72%	KC level
23	1B2 A. Mineral Products; Cement Production-CO2	2. Oil and Natural Gas		0.72%	KC level
24	3. Solvent and Other Product Use				
25	4A Agriculture	A. Enteric Fermentation			
26	4A Agriculture	B. Manure Management			
27	4B Agriculture	B. Manure Management			
28	4D Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			
29	4D Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			
30	4D3 Agriculture	D. Agricultural Soils; Direct Soil Emissions			
31	4D3 Agriculture	D. Agricultural Soils; Indirect Emissions			
32	5A1 LULUCF	1. Forest Land remaining Forest Land		6.38%	KC level
33	5A1 LULUCF	1. Forest Land remaining Forest Land		6.38%	KC level
34	5B1 LULUCF	1. Cropland remaining Cropland		1.07%	KC level
35	5B1 LULUCF	1. Cropland remaining Cropland		1.07%	KC level
36	5E2 LULUCF	2. Land converted to Settlements		0.70%	KC level
37	5E2 LULUCF	2. Land converted to Settlements		0.70%	KC level
38	6A Waste	A. Solid Waste Disposal on Land		1.31%	KC level
39	6A Waste	A. Solid Waste Disposal on Land		1.31%	KC level

Table 1-9 List of Switzerland's Tier 2 key categories, combined KCA without and with LULUCF (*in italic*) categories 2007, sorted by category code.

Combined key category analysis 2007 without and with LULUCF categories										
No.	IPCC Source Categories and fuels if applicable (combined key category analysis without and with LULUCF categories)	Direct GHG	Base Year 1990 Estimate (Gg CO <sub>2</sub> eq)	Year 2007 Estimate (Gg CO <sub>2</sub> eq)	Level Assessment, with Uncertainty	Trend Assessment, with Uncertainty	% Contrib. in Trend	Result level assessment.	Result trend assessment.	
11A1	1. Energy	A. Fuel Combustion	151973	216203	1.40%	0.004549	9.1%	KC level	KC trend	
21A1	1. Energy	1. Energy Industries	4842	11244	0.18%	0.001056	2.1%	KC level	KC trend	
31A1	1. Energy	1. Energy Industries	4690	16121	0.08%	0.000603	1.2%	-	-	
41A2	1. Energy	A. Fuel Combustion	106665	216170	0.57%	0.003025	6.1%	KC level	KC trend	
51A2	1. Energy	A. Fuel Combustion	333962	257226	0.25%	0.000678	1.4%	KC level	KC trend	
61A2	1. Energy	2. Manufacturing Industries and Construction	15687	29517	0.41%	0.002013	4.0%	KC level	KC trend	
71A2	1. Energy	2. Manufacturing Industries and Construction	138785	77446	0.42%	0.003702	7.4%	KC level	KC trend	
81A3b	1. Energy	A. Fuel Combustion	264742	518833	0.42%	0.002156	4.4%	KC level	KC trend	
91A3b	1. Energy	A. Fuel Combustion	841	3193	0.09%	0.000714	1.4%	-	-	
101A3b	1. Energy	A. Fuel Combustion	9132	1786	0.02%	0.000654	1.7%	-	-	
111A3b	1. Energy	A. Fuel Combustion	1133525	1061499	0.86%	0.000344	0.7%	KC level	-	
121A3b	1. Energy	A. Fuel Combustion	8779	8162	0.24%	0.000113	0.2%	KC level	-	
131A4a	1. Energy	A. Fuel Combustion	93895	135012	0.35%	0.001176	2.4%	KC level	KC trend	
141A4a	1. Energy	A. Fuel Combustion	4144411	331050	0.32%	0.001016	2.0%	KC level	KC trend	
151A4b	1. Energy	A. Fuel Combustion	140659	214171	0.56%	0.002082	4.2%	KC level	KC trend	
161A4b	1. Energy	A. Fuel Combustion	1021556	792291	0.77%	0.002021	4.0%	KC level	KC trend	
171B2	1. Energy	B. Fugitive Emissions fl <sub>2</sub> , Oil and Natural Gas	38046	17328	0.17%	0.001973	4.0%	KC level	KC trend	
182A1	2. Industrial Proc.	A. Mineral Products: Cement Production-CO <sub>2</sub>	252477	184415	0.23%	0.000776	1.6%	KC level	KC trend	
192B	2. Industrial Proc.	B. Chemical Industry	17376	8315	0.07%	0.000710	1.4%	-	-	
202C_0	2. Industrial Proc.	C. Metal Production without Aluminium Production	112445	17913	0.14%	0.000560	1.1%	-	-	
212F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> , Refrig. & AC Eq.	002	56866	0.15%	0.001576	3.2%	-	-	
223	3. Solvent and Other Product Use	A. Fuel Combustion	35779	17711	0.17%	0.001714	3.4%	KC level	KC trend	
233	3. Solvent and Other Product Use	A. Fuel Combustion	11014	5372	0.06%	0.000657	1.7%	-	-	
244A	4. Agriculture	A. Enteric Fermentation	247484	231864	0.83%	0.000326	0.7%	KC level	-	
254B	4. Agriculture	B. Manure Management	55743	50085	0.53%	0.000452	0.9%	KC level	-	
264B	4. Agriculture	B. Manure Management	44820	40839	0.50%	0.000349	0.7%	KC level	-	
274D_0	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O	20019	18011	0.26%	0.000220	0.4%	KC level	-	
284D1	4. Agriculture	D. Agricultural Soils: Direct Soil Emissions	138994	123147	1.84%	0.001849	3.7%	KC level	KC trend	
294D3	4. Agriculture	D. Agricultural Soils: Indirect Emissions	81889	69236	2.15%	0.003324	6.7%	KC level	KC trend	
305A1	5. LULUCF	A. Forest Land	336203	172275	1.28%	0.011427	18.8%	KC level	KC trend	
315A2	5. LULUCF	A. Forest Land	12638	2885	0.02%	0.000791	1.3%	-	-	
325B1	5. LULUCF	B. Cropland	57089	55903	0.40%	0.000160	0.3%	KC level	-	
335E2	5. LULUCF	E. Settlements	38889	30158	0.30%	0.00286	1.3%	KC level	KC trend	
346A	6. Waste	A. Solid Waste Disposal on Land	69304	27930	0.33%	0.004750	9.5%	KC level	KC trend	
356B	6. Waste	B. Wastewater Handling	17935	20102	0.39%	0.000533	1.1%	KC level	KC trend	
366D	6. Waste	D. Other	3034	9994	0.10%	0.000706	1.4%	-	-	

Table 1-10 List of Switzerland's Tier 2 key categories for the base year 1990, combined KCA without and with LULUCF (*in italic*) categories, sorted by category code.

A		B			C	E-L	M	
Combined key category analysis 1990 without and with LULUCF categories								
No. IPCC Source Categories and fuels if applicable (combined key category analysis without and with LULUCF categories)								
		Direct GHG			Base Year 1990 Estimate	Level Assessment, with Uncertainty	Result level assessment	
					[Gg CO <sub>2</sub> eq]			
1	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	1519.73	0.96%	KC level
2	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	1066.65	0.27%	KC level
3	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	3339.62	0.32%	KC level
4	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	156.87	0.21%	KC level
5	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	1387.85	0.84%	KC level
6	1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	2647.42	0.21%	KC level
7	1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	11335.25	0.90%	KC level
8	1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	87.79	0.25%	KC level
9	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	938.95	0.24%	KC level
10	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Liquid Fuels	4144.11	0.42%	KC level
11	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Gaseous Fuels	1406.59	0.36%	KC level
12	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Liquid Fuels	10215.56	0.97%	KC level
13	1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas	CH <sub>4</sub>	380.46	0.36%	KC level
14	2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO <sub>2</sub>		CO <sub>2</sub>	2524.77	0.30%	KC level
15	3	Solvent and Other Product Use			CO <sub>2</sub>	357.79	0.34%	KC level
16	4A	4. Agriculture	A. Enteric Fermentation		CH <sub>4</sub>	2474.84	0.86%	KC level
17	4B	4. Agriculture	B. Manure Management		CH <sub>4</sub>	557.43	0.58%	KC level
18	4B	4. Agriculture	B. Manure Management		N <sub>2</sub> O	448.20	0.54%	KC level
19	4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N <sub>2</sub> O & 4D3-N <sub>2</sub> O		N <sub>2</sub> O	200.19	0.28%	KC level
20	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N <sub>2</sub> O	1389.94	2.02%	KC level
21	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N <sub>2</sub> O	818.89	2.47%	KC level
22	5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	CO <sub>2</sub>	3362.03	2.36%	KC level
23	5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland	CO <sub>2</sub>	570.89	0.39%	KC level
24	5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements	CO <sub>2</sub>	398.89	0.37%	KC level
25	6A	6. Waste	A. Solid Waste Disposal on Land		CH <sub>4</sub>	693.04	0.79%	KC level
26	6B	6. Waste	B. Wastewater Handling		N <sub>2</sub> O	179.35	0.34%	KC level

## **1.6. Quality Assurance and Quality Control (QA/QC)**

### **1.6.1. The Quality Management System**

In 2002, a total quality management (TQM) system was introduced within the FOEN. The GHG inventory compilation was registered as a process to be managed in line with the principles of the TQM system. In 2004, the process was subjected to an audit. Subsequently, the establishment of a quality management system (QMS) was initiated. The QMS is designed to comply with the quality objectives of Good Practice Guidance of IPCC (2000), i.e. to ensure and continuously improve transparency, consistency, comparability, completeness, accuracy, and confidence in national GHG emission and removal estimates. Based on these quality criteria, the objective of Switzerland's inventory system is to annually produce a high quality inventory that ensures full compliance with the reporting requirements of the UNFCCC and the Kyoto Protocol.

The NIS quality management system is designed according to a Plan-Do-Check-Act cycle. It complies with the ISO 9001:2000 standard and has been certified by the Swiss Association for Quality and Management Systems in December 2007 (SQS 2008).

The major QMS elements are summarized below. The detailed state of its implementation is documented in the Description of the Quality Management System (FOEN 2009a), annexed to this report.

#### **a) Inventory agency responsible for coordinating QA/QC activities**

The FOEN has the lead within the federal administration regarding climate policy and its implementation. With the establishment of Switzerland's Initial Report under Article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006h) and its formal approval by the Federal Council, the Swiss NIS became operative. By providing for structures and in defining tasks and responsibilities of institutions, organisations and consultants involved, the NIS itself is a key tool in improving the quality and the process management of inventory preparation. Within the NIS, the FOEN-based QA/QC officer is responsible for enforcement of the defined quality objectives.

#### **b) Quality manual**

The quality manual constitutes the heart of the quality management system. It is designed as an interlinked compilation of all documents relevant to quality issues and runs on the FOEN Internal Document Management System (IDM).

The quality manual contains basics on the QMS, requirements, core processes, and results of the GHG inventory project, current QA/QC activities and planned improvements (Inventory Development Plan), supporting processes as well as links to supporting documents (see Annex B in FOEN 2009a). Specific monitoring protocols for core and sub processes have been added to ensure agreed standards and transparency. These flow charts specify the methodologies to be used, institutional tasks and responsibilities, the data sources and collection processes, relevant reference material and guidelines, and finally provide direct access to archived documents.

Since autumn 2007, the most important contributors to the GHG inventory are authorised to work online on IDM-based inventory master files by means of a SSL connection to a web platform (GHG Inv; cf. Figure 3 in FOEN 2009a). Overall inventory work thus benefits from the quality manual and its services.

Table 1-11 illustrates the annual cycle of inventory planning, preparation, and management with a focus on the timelines for the performance of QA/QC activities as specified in the quality manual.

Table 1-11 Annual cycle of inventory planning, preparation, and management.

	Year n												Year n+1	
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
Meeting of NIS Supervisory Board														
Meeting of GHG Inventory Core Group														
Annual Meeting of GHG Working Group														
Evaluation of UNFCCC Synthesis & Assessment Report														
Data Collection														
Quality Check of Energy Data														
Quality Check of Non-Energy Data														
Calculation of Emissions/Removals														
Compilation/Editing of NIR														
Generation of NIR Tables (EMIS)														
Generation of CRF Tables (EMIS)														
Completion of Checklists and other QC Activities														
Expert Peer Review														
Evaluation of UNFCCC Individual Review														
Uncertainty Analysis														
Key Category Analysis														
Internal Review														
Official Consideration and Approval														
Submission														
(Online) Publication and Archiving														
Check Internal Audit Plan														
Milestones regarding Inventory Development Plan														

Note: Red signatures in the line "Milestones regarding Inventory Development Plan" refer to meetings of the NIS Supervisory Board and the GHG Inventory Core Group, blue signatures refer to the evaluation of external or internal reviews, and the green one refers to the official consideration by the NIS Supervisory Board.

### c) QC procedures

All contributors to the inventory complete checklists that have been designed following the requirements of Table 8.1 of the Good Practice Guidance (Tier 1; IPCC 2000) and that have been subsequently modified to meet the specific needs of the experts.

During the period of data collection, the data suppliers fill in the checklists. Once completed the checklists are returned to FOEN. Simultaneously to GHG inventory preparation, the suppliers of emission data, the National Inventory Compiler, the NIR Lead Authors and the Project Management complete the respective checklists as well. The QA/QC officer reviews the checklists and contacts the suppliers if concerns about data integrity and/or the performance of quality control procedures arise.

In addition to general QC, the Inventory Project Management ensures the performance of Tier 2 QC procedures both by providing for a FOEN (co-)funding of selected research projects and by initiating internal studies, where appropriate. Significant outcomes are to be recorded in the Inventory Development Plan (IDP; FOEN 2009a, Chapter 3).

### d) QA review procedures

QA procedures include an internal review of NIR, GHG Inventory CRF tables, Kyoto Protocol LULUCF CRF tables, and the QA/QC supplement prior to each submission to the UNFCCC and the Kyoto Protocol. It is performed by members of the GHG Inventory Core Group as well as by the staff of the consultants involved in inventory compilation. Periodically, external experts are mandated to review selected key categories after submission (expert peer review, domestic review). Additionally, the outcomes of the UNFCCC inventory review reports are evaluated by the Project Management together with the QA/QC Officer, put up for discussion in the GHG Inventory Core Group, and subsequently used to update the IDP.

FOEN operates a homepage ([www.climatereporting.ch](http://www.climatereporting.ch)) where the Swiss GHG inventories (NIR, CRF tables, QA/QC supplement, UNFCCC review reports), the Swiss National Communications and other reports submitted to the UNFCCC and the Kyoto Protocol may be downloaded. On this web site most papers, internal reports, domestic reviews, Excel calculation sheets, and other difficult-to-access materials ('grey literature') quoted in the Swiss GHG inventory are provided online. The Climatereporting homepage thus provides the option for public review.

## **e) Reporting, documentation, and archiving procedures**

Inventory data as well as background information on activity data and emission factors are archived by the National Inventory Compiler in the EMIS data base. EMIS allows to file background information (e.g. interim worksheets; references; rationale for choice of methods) for any subset of inventory-related data (EMIS 2009/(NFR-Code); FOEN 2006c).

Information on the QMS, all QA/QC activities performed, decisions reached by the experts (minutes), results of key category analyses and uncertainty analyses as well as inventory development (IDP) is documented and archived in the FOEN IDM system and accessible to authorised collaborators via the GHG Inv web platform. All inventory information, as far as needed to reconstruct and interpret inventory data and to describe the inventory system and its functions, is accessible at a single location at the FOEN in Ittigen near Bern.

Data backup is managed by the Federal Office of Information Technology, Systems and Telecommunication (FOITT) using a Storage Area Network. FOITT runs backup facilities at two distinct locations on a nocturnal as well as on a weekly basis.

### **1.6.2. Treatment of Confidential Data**

Nearly all of the data necessary to compile the Swiss GHG inventory are publicly available. There are, however, a few exceptions:

- (i) Emission data that refer to a single enterprise are in general confidential.
- (ii) The reporting of disaggregated emissions from synthetic gases is confidential (not confidential as aggregated data).
- (iii) In the civil aviation sub-sector one data source (FOCA 1991), containing a few activity data, has been marked confidential by the Federal Office of Civil Aviation (FOCA).
- (iv) Unpublished AREA land use statistics raw data have been temporarily classified confidential by the Swiss Federal Statistical Office (SFSO).

The FOEN collects the data needed for calculating emissions of HFCs, PFCs and SF<sub>6</sub> from private companies or industry associations. In the National Inventory Report, the activity data underlying emission estimates of HFCs, PFCs and SF<sub>6</sub> are only partly presented at the most disaggregated level for reasons of confidentiality. However, complete emissions are reported in aggregated tables.

Confidential data will be made available by the FOEN in line with the procedures agreed under the UNFCCC for the technical review of GHG inventories (UNFCCC 2003).

## **1.7. Uncertainty Evaluation**

### **1.7.1. Tier 1 and Tier 2 analysis**

The uncertainty analysis Tier 1 of the April 2008 submission (FOEN 2008) has been updated for the present submission, whereas the Tier 2 analysis (Monte Carlo simulation) has not been updated. Nevertheless, the results of the Monte Carlo simulation carried out for the inventory 2006 and published in FOEN (2008) are repeated in this chapter.

Thus, the current NIR presents both of these quantitative uncertainty evaluations (see Annex 7). Uncertainties are assessed in accordance with the IPCC Good Practice Guidance

- Tier 1 methodology (IPCC 2000: p. 6.13ff.)

- Tier 2 methodology, Monte Carlo simulation (IPCC 2000: p. 6.18ff.).

In Tier 1 analysis all categories (without LULUCF) are included partly on an aggregated level. In Tier 2 analysis all sources are included on a disaggregated level. For the uncertainty analyses, non-key categories have been attributed with a non-individual but adequate uncertainty (see tables in Annex A7.2). Since information about the uncertainty is not available for every single category, a semi-quantitative assessment has been carried out. Based on results of the 2<sup>nd</sup> International Workshop on Uncertainty in Greenhouse Gas Inventories (Vienna 27-28 September 2007) a list of overall uncertainties has been defined (see Table 1-12).

In the sectoral chapters (energy, industrial processes, etc.), specific information is provided on the uncertainty estimation for activity data, emission factors or emissions for key category sources and in some cases for non-key sources (e.g. LULUCF), too.

All uncertainties are given as half of the 95% confidence interval divided by the mean and expressed as a percentage (approximately two standard deviations) as suggested by the IPCC Guidelines (IPCC 1997a).

### 1.7.2. Data Used

For many key data sources, no explicit information on uncertainties is available – e.g., the Swiss overall energy statistics (SFOE 2008) do not provide estimates of uncertainties. For these cases, authors of the NIR chapters, FOEN experts involved and several data suppliers derived estimates of uncertainties based on the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC 2000) default values and on information concerning the process of data collection for activity data and emission factors (import or sales statistics, surveys or modelling). Several experts from data suppliers were contacted for further information on some of the uncertainties. Some industry associations/sources also provided published or unpublished uncertainty estimates for their data. The data sources can be found in the relevant sub-sections on “Uncertainties and Time-Series Consistency” in each of the sectoral chapters (3–8) below.

Distributions are assumed to be symmetric in the Tier 1 method. For the Monte Carlo simulation, asymmetric distributions (lognormal, triangle) were also adopted.

Uncertainties in the GWP values were not taken into account.

Despite the investigation carried out for the current uncertainty analyses it will be necessary to further motivate institutions to supply not only average data but also estimates of associated uncertainties.

### 1.7.3. Uncertainty Estimates

For key categories individual uncertainties are used. For non-key categories the NIR provides qualitative estimates of uncertainties. The terms high, medium and low data quality are used. In order to extend the quantitative uncertainty analysis to every non-key category the default values as presented in Table 1-12 are used. They are motivated by the comparison of uncertainty analyses of several countries carried out by de Keizer et al. (2007), as presented at the 2<sup>nd</sup> Internat. Workshop on Uncertainty in Greenhouse Gas Inventories (Vienna 27-28 September 2007), and by Table A1-1 of IPCC Guidelines, Vol. 1, Annex 1, Managing uncertainties (IPCC 1997a).

Table 1-12 Semi-quantitative uncertainties ( $2\sigma$ ) for non-key categories.

Gas	Uncertainty category	Relative uncertainty
CO <sub>2</sub>	low	2%
	medium	10%
	high	40%
CH <sub>4</sub>	low	15%
	medium	30%
	high	60%
N <sub>2</sub> O	low	40%
	medium	80%
	high	150%
HFC	medium	20%
PFC	medium	20%
SF <sub>6</sub>	medium	20%

#### 1.7.4. Results of Tier 1 Uncertainty Evaluation

With this submission, results of a new uncertainty evaluation are presented. Apart from a calculation of the uncertainty excluding the LULUCF sector as in the last submission, this submission also contains an uncertainty evaluation including LULUCF. As described in IPCC (2000) and IPCC (2003), the uncertainty estimates of the LULUCF sector were combined with the uncertainty estimates of the non-LULUCF sector to obtain the total inventory uncertainty. The results of the Tier 1 uncertainty analysis for GHG emissions 2007 are summarised in Table 1-13 and Table 1-14. Details of the uncertainty estimates for specific sources are provided in the sub-sections on "Uncertainties and Time-Series Consistency" in each of the chapters on source categories below.

The resulting Tier 1 uncertainty in the national total annual CO<sub>2</sub> equivalent emissions **without LULUCF** is estimated to be 3.83% (level uncertainty). Trend uncertainty is 3.64% meaning that the change of the base year (1990) to 2007, reported as -2.74%, lies with a probability of 95% between -6.38% and +0.90%.

The resulting Tier 1 uncertainty in the national total annual CO<sub>2</sub> equivalent emissions of the **LULUCF sector** is estimated to be 116% (level uncertainty). Trend uncertainty of LULUCF sector is 19%.

The resulting Tier 1 **total inventory uncertainty** in the national total annual CO<sub>2</sub> equivalent emissions **including LULUCF** sector is estimated to be 4.15% (level uncertainty). Trend uncertainty is 5.01%.

It should be noted that the present results of the Tier 1 uncertainty analysis for GHG emissions from key sources in Switzerland do not, or not fully, take into account the following factors that may further increase uncertainties:

- correlations existing between source categories that have not been considered by the Tier 1 approach (e.g. production data used for industry emissions in both categories 1A2 Manufacturing Industries and 2 Industrial Processes, or cattle numbers used for emissions related to enteric fermentation and animal manure production);
- errors due to the assumption of constant parameters, e.g. constant net calorific values for fuels for the entire period since 1990;
- errors due to non-normal, asymmetric distribution of the uncertainties;
- errors due to methodological shortcomings;

- errors due to sources not reported (these are assumed to be very small).

On the other hand, the Tier 2 uncertainty evaluation described below explicitly takes into account correlations between sources and asymmetric distributions.

Table 1-13 Tier 1 uncertainty results for sources in Switzerland 2007 (IPCC 2000, Table 6.1, IPCC 2003). Note that the total of emissions shown in this table (52'272 Gg CO<sub>2</sub> eq) is slightly higher than the total in the CRF and the rest of this report (51'265 Gg CO<sub>2</sub> eq), because the uncertainty analysis was carried out before an error was detected and corrected during the drafting of the report.

IPCC GPG Table 6.1 Tier 1 Uncertainty Calculation and Reporting												
A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Year 2007 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by national activity data uncertainty	Uncertainty in trend in national emissions introduced by national activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO <sub>2</sub> eq	Gg CO <sub>2</sub> eq	%	%	%	%	%	%	%	%	%
<b>1. CO<sub>2</sub> emissions from Fuel Combustion</b>												
1A	1. Energy	3'696.03	5'952.67	5.0	4.60	6.8	0.789	0.047	0.1129	0.21	0.80	0.82
	A. Fuel Combustion											
1A	1. Energy	34'249.14	31'874.30	2.1	0.55	2.1	1.333	-0.0271	0.6047	-0.01	1.77	1.77
	A. Fuel Combustion											
1A	1. Energy	1'491.85	970.81	18.0	5.00	18.7	0.354	-0.0091	0.0184	-0.05	0.47	0.47
	A. Fuel Combustion											
1A	1. Energy	1'876.60	2'457.20	10.0	30.0	31.6	1.516	0.0157	0.0466	0.47	0.66	0.81
	A. Fuel Combustion											
	Other fuels											
	CO <sub>2</sub>	41'113.63	41'254.98									
	Total CO <sub>2</sub> Emissions Fuel Combustion											
<b>2. Emissions which are not CO<sub>2</sub> emissions from Fuel Combustion</b>												
A	B	C	D	E	F	G	H	I	J	K	L	M
		Gg CO <sub>2</sub> eq	Gg CO <sub>2</sub> eq	%	%	%	%	%	%	%	%	%
<b>Key Sources</b>												
1A1	1. Energy	48.42	112.44	10.0	80.0	80.6	0.177	0.0012	0.0021	0.10	0.03	0.10
	A. Fuel Combustion											
1A3b	1. Energy	91.32	17.86	10.0	59.2	60.0	0.021	-0.0013	0.0003	-0.08	0.00	0.08
	A. Fuel Combustion											
1B2	1. Energy	380.46	173.28	35.4	35.4	50.0	0.169	-0.0037	0.0033	-0.13	0.16	0.21
	B. Fugitive Emissions											
2A1	2. Industrial Proc.	2'524.77	1844.17	2.0	6.0	6.3	0.227	-0.0116	0.0350	-0.07	0.10	0.12
	A. Mineral Products; Cement Production-CO <sub>2</sub>											
2B	2. Industrial Proc.	173.76	83.15	10.0	40.0	41.2	0.067	-0.0016	0.0016	-0.07	0.02	0.07
	B. Chemical Industry											
2C_o	2. Industrial Proc.	112.45	179.13	2.0	40.0	40.0	0.140	0.0013	0.0034	0.05	0.01	0.05
	C. Metal Production without Aluminium Production											
2F	2. Industrial Proc.	0.04	77.08	14.1	14.1	20.0	0.030	0.0015	0.0015	0.02	0.03	0.04
	F. Consumption of Halocarbons and SF <sub>6</sub>											
2F1	2. Industrial Proc.	0.02	568.66	9.8	9.8	13.8	0.153	0.0108	0.0108	0.11	0.15	0.18
	F. Consumption of Halocarbons and SF <sub>6</sub> ; Refrig. & AC Eq.											
3	3. Solvent and Other Product Use	357.79	177.11	35.4	35.4	50.0	0.173	-0.0032	0.0034	-0.11	0.17	0.20
	A. Enteric Fermentation											
4A	4. Agriculture	2'474.84	2'318.64	6.4	17.2	18.3	0.829	-0.0017	0.0440	-0.03	0.40	0.40
	A. Agriculture											
4B	4. Agriculture	557.43	500.85	6.4	54.1	54.5	0.532	-0.0008	0.0095	-0.04	0.09	0.10
	B. Manure Management											
4B	4. Agriculture	448.20	408.39	44.6	44.6	63.1	0.503	-0.0005	0.0077	-0.02	0.49	0.49
	B. Manure Management											
4D_o	4. Agriculture	200.1936	180.1128	53.0	53.0	75.0	0.263	-0.0003	0.0034	-0.01	0.26	0.26
	D. Agricultural Soils without 4D1-N <sub>2</sub> O & 4D3-N <sub>2</sub> O											
4D1	4. Agriculture	1'389.94	1'231.47	54.1	54.1	76.5	1.837	-0.0023	0.0234	-0.12	1.79	1.79
	D. Agricultural Soils; Direct Soil Emissions											
4D3	4. Agriculture	818.89	692.36	112.5	112.5	159.1	2.148	-0.0020	0.0131	-0.22	2.09	2.10
	D. Agricultural Soils; Indirect Emissions											
6A	6. Waste	693.04	279.30	20.0	56.6	60.0	0.327	-0.0075	0.0053	-0.42	0.15	0.45
	A. Solid Waste Disposal on Land											
6B	6. Waste	179.35	201.02	0.0	100.0	100.0	0.392	0.0005	0.0038	0.05	0.00	0.05
	B. Wastewater Handling											
6D	6. Waste	30.34	99.94	10.0	49.0	50.0	0.097	0.0013	0.0019	0.07	0.03	0.07
	D. Other											
	Non Key Sources											
	Rest of sources	1116.19	872.41	12.0	12.0	17.0	0.289	-0.0040	0.0166	-0.05	0.28	0.29
	Total emissions which are not CO <sub>2</sub> emissions from Fuel Combustion	11'597.45	10'017.35									
<b>3. Total without LULUCF (combined uncertainty of 1. and 2.)</b>												
A	B	C	D	E	F	G	H	I	J	K	L	M
		Gg CO <sub>2</sub> eq	Gg CO <sub>2</sub> eq	%	%	%	%	%	%	%	%	%
	all gases	52'711.08	51'272.33	2.7	2.7	3.8	3.877	-0.0336	1.0179	-0.09	3.90	3.90
	Total Emissions											
	Total Uncertainties											
	Overall uncertainty in the year (%)											
	Trend uncertainty (%)											

Tier 1 Uncertainty calculation and reporting for sources in Switzerland 2007 (continued).

Table 6.1 (CONTINUED)  
Tier 1 Uncertainty Calculation and Reporting

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Year 2007 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by national activity data uncertainty	Uncertainty in trend in national emissions introduced by national activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Gg CO2 eq	Gg CO2 eq	%	%	%	%	%	%	%	%	%
<b>4. LULUCF</b>												
<b>Key Sources</b>												
5A1 5. LULUCF	1. Forest Land remaining Forest Land	-3'362.03	-1'722.75	5.0	40.0	40.3	-107.296	0.3340	-0.7362	13.36	-5.21	14.34
5A2 5. LULUCF	2. Land converted to Forest Land	-126.38	-28.85	20	40	44.7	-1.993	-0.0026	-0.0123	-0.10	-0.35	0.36
5B1 5. LULUCF	1. Cropland remaining Cropland	570.89	559.03	30.0	25.0	39.1	33.729	-0.1718	0.2389	-4.30	10.14	11.01
5E2 5. LULUCF	2. Land converted to Settlements	395.89	301.56	20.0	50.0	53.9	25.092	-0.0819	0.1289	-4.09	3.65	5.48
<b>Non Key Sources</b>												
5A1 5. LULUCF	1. Forest Land remaining Forest Land	8.19	1.74	10.0	50.0	51.0	0.137	0.0002	0.0007	0.01	0.01	0.02
5A1 5. LULUCF	1. Forest Land remaining Forest Land	4.22	0.90	10.0	50.0	51.0	0.071	0.0001	0.0004	0.01	0.01	0.01
5B2 5. LULUCF	2. Land converted to Cropland	36.76	17.16	20.0	40.0	44.7	1.166	-0.0030	0.0073	-0.12	0.21	0.24
5B2 5. LULUCF	2. Land converted to Cropland	7.12	4.69	20.0	50.0	53.9	0.391	-0.0012	0.0020	-0.06	0.06	0.08
5C1 5. LULUCF	1. Grassland remaining Grassland	-22.13	0.08	20.0	90.0	92.2	0.011	-0.0026	0.0000	-0.24	0.00	0.24
5C2 5. LULUCF	2. Land converted to Grassland	39.63	93.55	5.0	50.0	50.2	7.263	-0.0353	0.0400	-1.76	-0.04	1.79
5D1 5. LULUCF	1. Wetlands remaining Wetlands	-15.81	-3.09	20.0	50.0	53.9	-0.257	-0.0005	-0.0013	-0.03	-0.04	0.05
5D2 5. LULUCF	2. Land converted to Wetlands	6.85	17.59	25.0	50.0	50.1	1.519	-0.0067	0.0075	-0.34	0.27	0.43
5E1 5. LULUCF	1. Settlements remaining Settlements	3.48	29.21	25.0	50.0	55.9	2.523	-0.0121	0.0125	-0.60	0.44	0.75
5F2 5. LULUCF	2. Land converted to Other Land	110.35	81.92	20.0	50.0	53.9	6.816	-0.0220	0.0350	-1.10	0.99	1.48
Total LULUCF emissions		-2'339.97	-647.24									
<b>5. Total LULUCF</b>												
Total Emissions		Gg CO2 eq	Gg CO2 eq									
Total Uncertainties	all gases	-2'339.97	-647.24	81.8	81.8	115.7	-1.480	0.0339	-0.0128	2.77	-1.49	3.14
				Overall uncertainty in the year (%)			115.73	Trend uncertainty (%)			19.06	
<b>6. Total with LULUCF (combined uncertainty of 3. and 5.)</b>												
Total Emissions		Gg CO2 eq	Gg CO2 eq									
Total Uncertainties	all gases	50'371.10	50'625.09									
				Overall uncertainty in the year (%)			4.15	Trend uncertainty (%)			5.01	

## Tier 1 Uncertainty calculation and reporting for sources in Switzerland 2007 (continued).

A (continued)				B	N	O	P	Q
IPCC Source category				Gas	Emission factor quality indicator	Activity data quality indicator	Expert judgement reference numbers	Reference to section in NIR
					IPCC Default, Measurement based, national Referenced data	IPCC Default, Measurement based, national Referenced data		
1A	1. Energy	A. Fuel Combustion	Gaseous fuels	CO2	M	D		Section 3.2.3
1A	1. Energy	A. Fuel Combustion	Liquid fuels	CO2	M	R		Section 3.2.3
1A	1. Energy	A. Fuel Combustion	Solid fuels	CO2	D	D, R		Section 3.2.3
1A	1. Energy	A. Fuel Combustion	Other fuels	CO2	R	R		Section 3.2.3
1A1	1. Energy	A. Fuel Combustion	1. Energy Ind. Other Fuels	N2O	R	R		Section 3.2.3
1A3b	1. Energy	A. Fuel Combustion	3b. Road Transp. Gasoline	CH4	R	R		Section 3.2.3
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CH4	D	D		Section 3.3.3
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2		CO2	D	D		Section 4.2.3
2B	2. Industrial Proc.	B. Chemical Industry		N2O	R	R		Section 4.3.3
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CO2	R	R		Section 4.4.3
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		PFC	R	R		Section 4.7.3
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	R	R		Section 4.7.3
3	3. Solvent and Other Product Use			CO2	R	R		Section 5.2.3
4A	4. Agriculture	A. Enteric Fermentation		CH4	R	R		Section 6.2.3
4B	4. Agriculture	B. Manure Management		CH4	R	R		Section 6.3.3
4B	4. Agriculture	B. Manure Management		N2O	D	R		Section 6.3.3
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		N2O	D	R		Section 6.5.3
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N2O	D	R		Section 6.5.3
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	D	D		Section 6.5.3
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	CO2	R	R		Section 7.3.2
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land	CO2	R	R		Section 7.3.2
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland	CO2	M	R		Section 7.4.2
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements	CO2	R	R		Section 7.7.2
6A	6. Waste	A. Solid Waste Disposal on Land		CH4	R	R		Section 8.2.3
6B	6. Waste	B. Wastewater Handling		N2O	R	R		Section 8.3.3
6D	6. Waste	D. Other		CH4	R	R		Section 8.5.3
Rest of sources				CO2	R	R		Exp. est.

Table 1-14 Ranked combined level uncertainties for sources in Switzerland.

A		B	C	D	E	F	G	H	
IPCC Source category		Gas	Base year emissions 1990	Year 2007 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emission in year 2007	
			Gg CO2 eq	Gg CO2 eq	%	%	%	%	
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions	N2O	818.89	692.36	112.5	112.5	159.1	2.148
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions	N2O	1'389.94	1'231.47	54.1	54.1	76.5	1.837
1A	1. Energy	A. Fuel Combustion	Other fuels	CO2	1'676.60	2'457.20	10.0	30.0	1.516
1A	1. Energy	A. Fuel Combustion	Liquid fuels	CO2	34'249.14	31'874.30	2.1	0.5	1.333
1A	1. Energy	A. Fuel Combustion	Gaseous fuels	CO2	3'696.03	5'952.67	5.0	4.6	0.789
4B	4. Agriculture	B. Manure Management		CH4	557.43	500.85	6.4	54.1	0.532
4B	4. Agriculture	B. Manure Management		N2O	448.20	408.39	44.6	63.1	0.503
6B	6. Waste	B. Wastewater Handling		N2O	179.35	201.02	0.0	100.0	0.392
1A	1. Energy	A. Fuel Combustion	Solid fuels	CO2	1'491.85	970.81	18.0	5.0	18.7
6A	6. Waste	A. Solid Waste Disposal on Land		CH4	693.04	279.30	20.0	56.6	0.327
Rest of sources									
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O	N2O	200.19	180.11	53.0	53.0	75.0	0.263
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2	CO2	2'524.77	1'844.15	2.0	6.0	6.3	0.227
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries Other Fuels	N2O	48.42	112.44	10.0	80.0	0.177
3	3. Solvent and Other Product Use		CO2	357.79	177.11	35.4	35.4	50.0	0.173
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CH4	380.46	173.28	35.4	35.4	0.169
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.02	568.66	9.8	9.8	0.153
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CO2	112.45	179.13	2.0	40.0	0.140
6D	6. Waste	D. Other		CH4	30.34	99.94	10.0	49.0	0.097
2B	2. Industrial Proc.	B. Chemical Industry		N2O	173.76	83.15	10.0	40.0	0.067
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		PFC	0.04	77.08	14.1	14.1	0.030
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Tr Gasoline	CH4	91.32	17.86	10.0	59.2	0.021

Ranked by their contribution to uncertainty in the total national emissions level without LULUCF (cf. Column H, Table 1-14), indirect and direct emissions of N<sub>2</sub>O from Agricultural Soils, CO<sub>2</sub> from 1A Fuel Combustion Activities (Other fuels and Liquid fuels) are the top four contributors. Their combined uncertainty amounts to 3.47% of total national emissions in 2007. The table permits the identification of future areas of improvement in the context of the Inventory Development Plan (IDP).

Compared to the results of the previous inventory 2006 (level 3.50%, trend 1.73%; FOEN 2008), the level and the trend uncertainties for 2007 for the non-LULUCF sector are higher.

This reflects the fact that an extraordinary reduction of the gas oil stocks happened in 2007. Since the uncertainty of stock changes have a much higher uncertainty than the import numbers, the uncertainty of the activity data of gas oil has doubled (for details see Chapter 3.2.3). In addition to that, trend uncertainty is influenced by the following change carried out for this submission: For sources, where an uncertainty estimate was made only for the emissions, and not for activity data and emission factor separately, the uncertainty is now split equally on emission factor and activity. In the previous submission, uncertainty was completely allocated to the emission factor for the calculation of the trend uncertainty. This change now results in a higher trend uncertainty.

### **1.7.5. Results of Tier 2 Uncertainty Evaluation (Monte Carlo)**

The principle of Monte Carlo analysis is to select random values for emission factor and activity data from within their individual probability distributions, and to calculate the corresponding emission values. This procedure is repeated until an adequately stable result has been found. The results of all iterations yield the overall emission probability distribution.

In the analysis shown here and **valid for the Swiss GHG inventory 2006 as submitted in April 2008** (FOEN 2008), Monte Carlo simulations were performed to estimate uncertainties both in emissions and in emission trends, at the source category level as well as for the inventory as a whole (excluding LULUCF). The simulations were run with the commercial software package Crystal Ball (® Decisioneering). This tool generates random numbers within user-defined probability ranges and probability distributions. As a result, selected statistics are produced for the forecast variables.

#### **a) Uncertainty in emissions**

As a first step, the shape and extent of the probability distributions were derived for the activity data and emission factors, based on measured data, literature or expert judgement. The mean value of the probability distributions was set equal to the value of the GHG inventory. In most cases, normal distributions were assumed. However, for data with a high level of uncertainty, normal distribution would allow negative emissions. For these cases, log-normal distributions were used (cf. Annex A7.2). The log-normal distribution is positively skewed and produces only positive values, while the upper bound of emissions may be poorly known. For special cases in the agricultural sector, also triangle distributions have been applied.

As a second step, emissions were calculated as emission factor multiplied by the corresponding activity data. For those cases where the activity data or emission factor for a specific source category were not available, emissions were modelled directly, with the mean value set equal to the value of the GHG inventory and an adequate probability distribution of the emissions.

The Monte Carlo simulation then provided information on the simulated distribution, on the 2.5 and 97.5 percentiles of emissions, on the uncertainty of the national total emission in 2006 and in the base year 1990 as well as on the trend uncertainty 1990–2006 (please note: not 1990-2007!).

#### **b) Dependent Uncertainties**

Correlations may have a significant effect on the overall inventory uncertainty. Special care was taken when deriving the correlations of the source categories of 1A Energy – fuel combustion. Here, the uncertainty of the total source category per fuel type is well known, whereas the uncertainty of the sub-categories is derived by applying the rules of error propagation – i.e., the uncertainty of each sub-category is larger (on the relative level) than the uncertainty of the total source category. A detailed description of this analysis and the respective correlation coefficients can be found in Annex A7.2. Note that the setting of

correlation coefficients may lead to inconsistencies in the Monte Carlo simulation. In those cases, Crystal Ball software automatically adjusts the corresponding correlation coefficients and sends a message to the user. For the simulation of the inventory 2006, the adjustments indicated were 0.1 (average).

### **c) Uncertainty in Emission Trends**

The trend is defined as the difference between the base year and the year of interest (year t, 2006). Hence for estimation of the uncertainty in the emission trends, the Monte Carlo simulation was run for the year 2006 and for the base year 1990. The trend was then derived for the source categories as well as for the total emissions. It was assumed that the activity data of 1990 are positively correlated with the activity data of 2006 (correlation coefficients are set to 0.8). Furthermore, the emission factors of the two years are assumed to be positively correlated (correlation coefficient set to 1). The probability distributions of the 1990 data are assumed to be of equal shape as the distributions derived for 2006.

### **d) Results**

#### **Uncertainties of national total 2006 (as submitted in FOEN 2008) and of trend 1990–2006**

The Monte Carlo simulations reveal that the uncertainty distribution of the total emissions for 2006 (year t) is slightly narrower than the distribution for the base year 1990. Due to the higher emissions in 2006, it is shifted towards higher mean emissions (cf. Figure 1-3). The uncertainty estimates as derived from the Monte Carlo simulations are shown in Table 1-15.

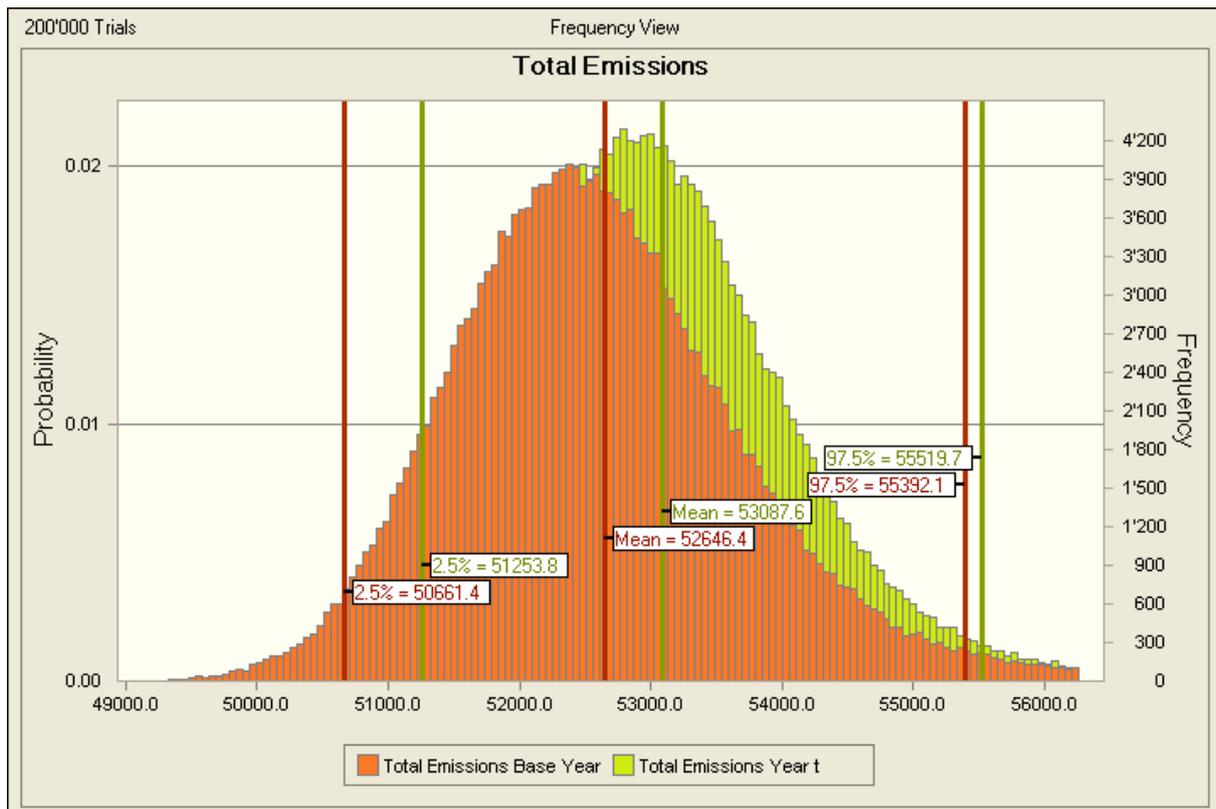


Figure 1-3 Probability distributions of total emissions for the base year (1990) and for year t (2006) based on the submission of April 2008 (FOEN 2008). On the x-axis, the total emissions reported in the Swiss inventory (excluding LULUCF) are given in Gg CO<sub>2</sub> equivalent. Number of Monte Carlo runs: 200'000. The vertical lines show simulated mean values (*Mean*) and the 2.5 (*P2.5*) and 97.5 (*P97.5*) percentile values.

Note that mean and percentile values correspond to the simulated values and differ slightly from the reported inventory values. For the transformation, see Table A - 45 in Annex A7.2.

## Main results of the Monte Carlo simulation

### Level uncertainty of national total emissions in 2006

The total uncertainty of the 2006 Swiss emissions is **4.02%** (2'139 Gg CO<sub>2</sub> equivalent) of the total GHG emissions (53'209 Gg CO<sub>2</sub> equivalent excluding LULUCF).

The 95% confidence interval is slightly asymmetric and lies between **96.5% and 104.6%** of the Swiss total GHG emissions. The end points are: 51'371 Gg (=53'209 Gg-1'838 Gg) and 55'647 Gg (=53'209 Gg+2'438 Gg).

### Trend uncertainty of national total emissions 1990–2006

The change in total emissions between 1990 and 2006 is +0.77%. With a probability of 95%, the change lies within the range of **-2.1% to +3.5%**. The average of lower and upper bound is **2.8%**.

In FOEN (2006a), it has been shown that the introduction of correlations between activity data or between emission factors leads to an increase of the overall level uncertainty of the GHG emissions, which also holds for the uncertainty analysis with 2006 data.

Table 1-15 Tier 2 uncertainty results for sources in Switzerland 2006 (IPCC 2000, Table 6.2). In this table, uncertainties of the key categories are reported. For the non-key categories, see Table A - 47 in Annex A7.2

A IPCC Source Category	B Gas	C Base year (1990) emissions (Gg CO2 equivalent)	D Year t (2006) emissions (Gg CO2 equivalent)	E Uncertainty in year t emissions as % of emissions in the category		F Year t emissions in the category (% above (97.5 percentile) % below (2.5 percentile))	G Uncertainty introduced on national total in year t (%)	H % change in emissions between year t and base year (%)	I Range of likely % change between year t and base year (2.5 percentile) (97.5 percentile)		J % above (97.5 percentile) % below (2.5 percentile)
				% below (2.5 percentile)	% above (97.5 percentile)				% below (2.5 percentile)	% above (97.5 percentile)	
<b>1A. Fuel Combustion</b>											
1A1 1. Energy Industries	Gaseous Fuels	235	321	93	107	0.04	36.8	33	41		
1A1 1. Energy Industries	Liquid Fuels	691	912	99	101	0.02	32.0	31	33		
1A1 1. Energy Industries	Other Fuels	1520	2181	72	134	1.27	43.5	30	61		
1A1 1. Energy Industries	Solid Fuels	47	188	93	108	0.03	299.8	277	324		
1A1 1. Energy Industries	Other Fuels	48	121	21	180	0.18	150.9	32	273		
1A2 2. Manufacturing Industries and Construction	Gaseous Fuels	1063	2095	90	110	0.39	97.0	85	109		
1A2 2. Manufacturing Industries and Construction	Liquid Fuels	3387	2864	98	102	0.09	-15.4	-14			
1A2 2. Manufacturing Industries and Construction	Other Fuels	157	307	53	158	0.31	95.5	42	160		
1A2 2. Manufacturing Industries and Construction	Solid Fuels	1388	708	92	109	0.11	-49.0	-45			
1A3a 3. Transport: Civil Aviation	CO2	253	121	99	101	0.00	-52.0	-53	-51		
1A3b 3. Transport: Road Transportation	Diesel	2624	4741	99	101	0.13	80.7	79	83		
1A3b 3. Transport: Road Transportation	Gasoline	11363	10687	98	102	0.31	-59	-7	-5		
1A3b 3. Transport: Road Transportation	Gasoline	92	19	44	156	0.02	-79.2	-135	-24		
1A3e 3. Transport: Other Transportation (military aviation)	CO2	200	122	99	101	0.00	-38.8	-40	-38		
1A4a 4. Other Sectors: Commercial/Institutional	Gaseous Fuels	942	1429	90	110	0.27	51.7	43	60		
1A4a 4. Other Sectors: Commercial/Institutional	Liquid Fuels	4392	3741	98	102	0.12	-14.8	-16	-14		
1A4b 4. Other Sectors: Residential	Gaseous Fuels	1407	2236	95	105	0.20	58.9	56	62		
1A4b 4. Other Sectors: Residential	Liquid Fuels	10216	9145	98	102	0.30	-10.5	-12	-9		
1A4c 4. Other Sectors: Agriculture/Forestry	CO2	553	528	98	102	0.02	-4.5	-6	-3		
1A5 5. Other	Liquid Fuels	449	586	99	101	0.02	30.3	29	32		
1A5 5. Other	Gaseous Fuels	9	18	90	110	0.00	103.2	91	116		
<b>1B. Fugitive Emissions from Fuels</b>											
1B2 2. Oil and Natural Gas	CH4	380	174	51	149	0.16	-54.1	-84	-24		
<b>2. Industrial Processes</b>											
2A1 A. Mineral Products: Cement Production-CO2	CO2	2525	1813	94	106	0.21	-28.2	-30	-26		
2C o C. Metal Production without Aluminium Production	CO2	112	177	61	139	0.13	57.7	27	89		
2C3 C. Metal Production: Aluminium Production-CO2	CO2	139	19	70	130	0.01	-86.2	-112	-61		
2C3 C. Metal Production: Aluminium Production-PFC	PFC	100	3	56	144	0.00	-97.2	-140	-54		
2F o F. Consumption of Halocarbons and SF6 without 2F1-HFC	HFC	0	69	63	137	0.05	*	*	*		
2F1 F. Consumption of Halocarbons and SF6: Refrig. & AC Eq.	HFC	0	549	82	118	0.19	*	*	*		
<b>3. Solvent and Other Product Use</b>											
CO2	CO2	357	186	51	149	0.17	-48.0	-76	-20		
<b>4. Agriculture</b>											
4A A. Enteric Fermentation	CH4	2475	2303	82	118	0.80	-6.9	-20	6		
4B B. Manure Management	CH4	557	502	45	155	0.51	-10.0	-49	29		
4B B. Manure Management	liquid	42	37	15	112	0.03	-13.8	-28	6		
4B B. Manure Management	solid	406	367	38	150	0.39	-9.6	-33	12		
4D1 D. Agricultural Soils: Direct Soil Emissions	N2O	1324	1139	21	181	1.71	-13.9	-55	27		
4D1 D. Agricultural Soils: Direct Soil Emissions	organic soil	66	66	24	193	0.11	0.0	-66	67		
4D3 D. Agricultural Soils: Indirect Emissions	N2O	272	235	18	209	0.42	-13.7	-103	56		
4D3 D. Agricultural Soils: Indirect Emissions	leaching and runoff	546	448	8	482	2.00	-18.1	-182	85		
<b>6. Waste</b>											
6A A. Solid Waste Disposal on Land	CH4	693	291	41	159	0.32	-58.1	-96	-20		
6B B. Wastewater Handling	N2O	191	212	2	198	0.39	11.2	-34	57		
6D D. Other	CH4	30	97	51	149	0.09	220.0	105	334		
Other		1547	1453	**	**	**	**	**	**		
Total		52800	53209	96.5	104.6	4.02	0.9	-2.1	3.5		

\* Trend not calculated when base year emission = 0

\*\* For the uncertainties of the non Key Categories, see Annex

## Uncertainties by gas

For the uncertainties by gas, the Monte Carlo simulation provides results shown in Table 1-16. The relative uncertainty of CO<sub>2</sub> is very low in accordance with the high precision of fuel statistics and carbon contents of fuels. CH<sub>4</sub> and synthetic gases have medium uncertainties. N<sub>2</sub>O has the highest uncertainty in relative and absolute terms.

Table 1-16 Uncertainties by gas using Monte Carlo simulation for the emissions in 2006.

Gas	Emission 2006 (excl. LULUCF) Gg CO <sub>2</sub> eq	Lower bound 2.5 percentile Gg CO <sub>2</sub> eq	Upper bound 97.5 percentile Gg CO <sub>2</sub> eq	Mean absolute uncertainty Gg CO <sub>2</sub> eq	Mean relative uncertainty %
CO <sub>2</sub>	45561	44770	46454	842	1.8%
CH <sub>4</sub>	3538	2893	4184	645	18.2%
N <sub>2</sub> O	3274	1829	5541	1856	56.7%
HFC	617	529	706	88	14.3%
PFC	56	48	64	8	14.3%
SF <sub>6</sub>	162	146	179	17	10.2%
Total	53209	51'371	55'647	2113	4.02%

### 1.7.6. Comparison of Tier 1 and Tier 2 Results

In the GHG inventory, some of the uncertainties may become large and their statistical distribution may clearly deviate from normal distributions. Tier 1 uncertainty analysis is based on simple error propagation, which assumes only small and normally distributed uncertainties. The application of the Tier 1 method is therefore not the optimal instrument for determining the uncertainties of a GHG inventory. The more appropriate choice is the Monte Carlo simulation, which is designed for uncertainties of any shape, for any size of uncertainties, any correlated figures and which is recommended by the IPCC Good Practice Guidance (IPCC 2000) as the Tier 2 method. The results of the Monte Carlo simulation are therefore considered to provide a more realistic picture of the uncertainties than the results of the Tier 1 method.

Tier 2 uncertainty analysis produces an overall level uncertainty of 4.02% for 2006 emissions as published in FOEN (2008). This value is somewhat larger than the result of Tier 1 uncertainty analysis 3.50% (2006; FOEN 2008) and 3.83% (2007; this submission). The trend uncertainty of Tier 2, 2.8%, is larger than that of Tier 1 analysis, 1.7% (2006; FOEN 2008), but smaller than the 3.6% of the 2007 analysis (this submission). These differences are due to the following reasons:

- The Monte Carlo simulation produces different results as it treats large uncertainties correctly and takes log-normal and triangle distributions into account. Furthermore, the correlations existing between activity data and between emission factors are considered, which is not the case in the Tier 1 analysis. As shown above, the correlations lead to an expansion of the uncertainty. Without any correlations, the Tier 2 uncertainty would be somewhat lower than the Tier 1 uncertainty.
- For the Monte Carlo simulation, the category 1A Fuel Combustion Activities (CO<sub>2</sub>) was split into sub-categories. This was not done for the Tier 1 analysis. (Splitting introduces a more differentiated structure into the uncertainties of the activity data. The differentiation is derived and quantified in Annex A7.2.). This splitting results in a slight reduction of the overall uncertainty. A simple error propagation (in analogy to Tier 1) in the uncertainty analysis of FOEN (2006a) showed that the overall uncertainty decreased from 4.0% to 3.2% due to the splitting.

## **1.8. *Completeness Assessment***

For all known sources complete estimates are accomplished for all gases. Based on current knowledge, the Swiss inventory is complete.



## 2. Trends in Greenhouse Gas Emissions and Removals

This chapter gives an overview of Switzerland's GHG emissions/removals and trends for the period 1990–2007.

### 2.1. Aggregated Greenhouse Gas Emissions 2007

In 2007, Switzerland emitted 51'265 Gg CO<sub>2</sub> equivalent (excluding LULUCF) to the atmosphere, or 6.73 tonnes CO<sub>2</sub> equivalent per capita (inhabitants 2007: 7.617 million, SFOE 2008). The largest contributor gas was CO<sub>2</sub>, 43'636 Gg (5.73 tonnes per capita), and the most important source was sector 1 Energy, 41'966 Gg CO<sub>2</sub> equivalent. Table 2-1 shows emissions by gas and sector in Switzerland for the year 2007. A breakdown of Switzerland's total emissions by gas (excluding LULUCF) is given in Figure 2-1. Figure 2-2 charts the relative contributions of the individual sectors (excluding LULUCF) to the emission of each GHG.

Table 2-1 Switzerland's GHG emissions in CO<sub>2</sub> equivalent (Gg) by gas and sector, 2007.

Emissions 2007	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	HFCs	PFCs	SF <sub>6</sub>	Total	Share
	CO <sub>2</sub> equivalent (Gg)							
1 All Energy	41'358	279	330				41'966	81.9%
2 Industrial Processes	2'086	7	83	630	77	175	3'058	6.0%
3 Solvent Use	177	0	54				231	0.5%
4 Agriculture (1 year average)	0	2'829	2'516				5'346	10.4%
6 Waste	15	396	252				663	1.3%
<b>Total (excluding LULUCF)</b>	<b>43'636</b>	<b>3'511</b>	<b>3'235</b>	<b>630</b>	<b>77</b>	<b>175</b>	<b>51'265</b>	<b>100.0%</b>
5 LULUCF	-655	2	6				-647	-1.3%
<b>Total (including LULUCF)</b>	<b>42'982</b>	<b>3'513</b>	<b>3'241</b>	<b>630</b>	<b>77</b>	<b>175</b>	<b>50'617</b>	<b>98.7%</b>
<i>International Bunkers</i>	3'919	1	38				3'959	

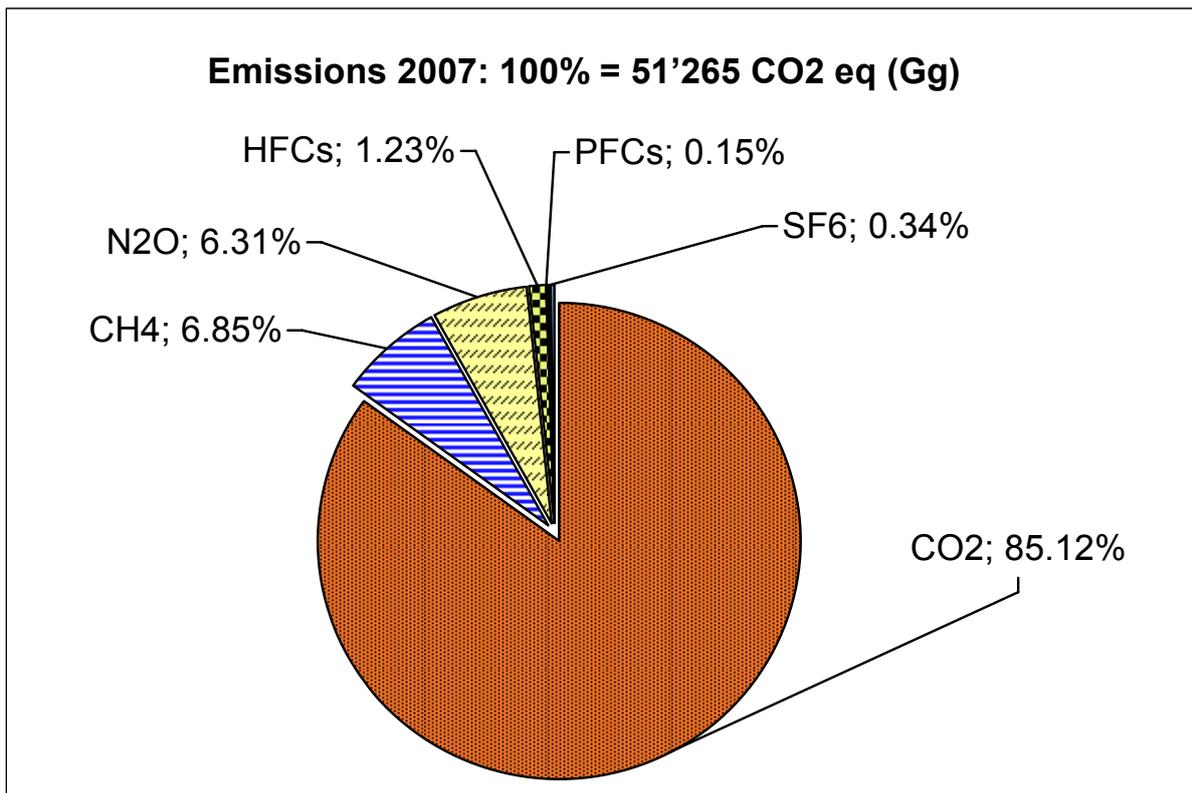


Figure 2-1 Contribution of individual gases to Switzerland's GHG emissions (excluding LULUCF) in 2007. 100% = 51'265 CO<sub>2</sub> eq (Gg).

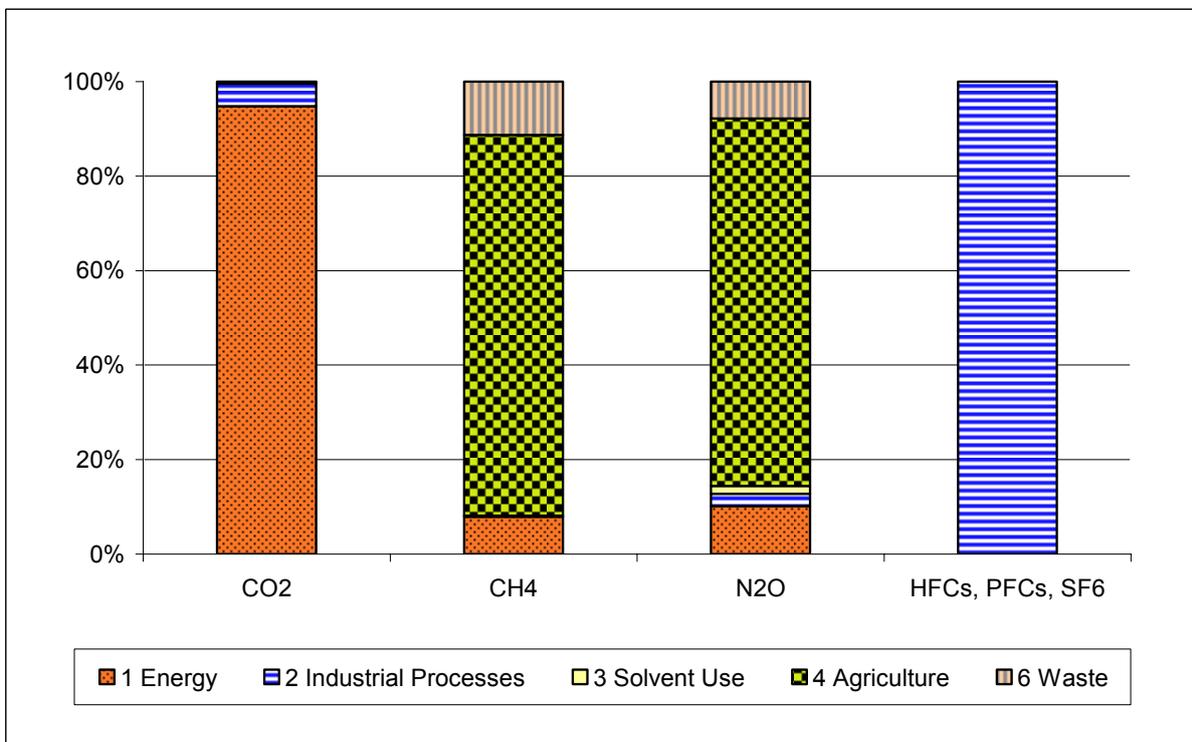


Figure 2-2 Relative contributions of the individual sectors (excluding LULUCF) to GHG emissions in 2007.

Fuel combustion within the energy sector was by far the largest source of emissions of CO<sub>2</sub> in 2007. Emissions of CH<sub>4</sub> and N<sub>2</sub>O originated mainly from agriculture, and the synthetic gas emissions stemmed by definition from industrial processes.

## 2.2. Emission Trends by Gas

Emission trends by gas for the period 1990–2007 are summarized in Table 2-2.

Table 2-2 Switzerland's GHG emissions in CO<sub>2</sub> equivalent (Gg) by gas, 1990–2007 (corresponds to CRF table 10s5/10s5.2, upper half). The column below on the far right (digits in italics) indicates the percentage change in emissions in 2007 as compared to the base year 1990.

Greenhouse Gas Emissions	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO <sub>2</sub> equivalent (Gg)									
CO <sub>2</sub> emissions including net CO <sub>2</sub> from LULUCF	42'144	44'466	45'004	40'357	37'308	38'016	39'472	40'809	42'873	43'423
CO <sub>2</sub> emissions excluding net CO <sub>2</sub> from LULUCF	44'504	46'142	46'161	43'578	42'826	43'322	44'002	43'324	44'560	44'802
CH <sub>4</sub> emissions including CH <sub>4</sub> from LULUCF	4'356	4'325	4'212	4'072	3'980	3'963	3'906	3'837	3'772	3'720
CH <sub>4</sub> emissions excluding CH <sub>4</sub> from LULUCF	4'348	4'324	4'212	4'072	3'978	3'960	3'904	3'826	3'770	3'719
N <sub>2</sub> O emissions including N <sub>2</sub> O from LULUCF	3'624	3'640	3'614	3'567	3'563	3'491	3'538	3'366	3'367	3'349
N <sub>2</sub> O emissions excluding N <sub>2</sub> O from LULUCF	3'613	3'632	3'606	3'560	3'555	3'483	3'530	3'354	3'360	3'343
HFCs	0	0	6	13	29	169	209	270	315	362
PFCs	100	85	69	30	18	15	17	24	28	40
SF <sub>6</sub>	144	146	148	126	112	95	92	130	159	146
<b>Total (including LULUCF)</b>	<b>50'369</b>	<b>52'662</b>	<b>53'053</b>	<b>48'165</b>	<b>45'010</b>	<b>45'749</b>	<b>47'234</b>	<b>48'436</b>	<b>50'514</b>	<b>51'039</b>
<b>Total (excluding LULUCF)</b>	<b>52'709</b>	<b>54'330</b>	<b>54'202</b>	<b>51'379</b>	<b>50'517</b>	<b>51'043</b>	<b>51'754</b>	<b>50'928</b>	<b>52'192</b>	<b>52'412</b>

Greenhouse Gas Emissions	2000	2001	2002	2003	2004	2005	2006	2007	Change base year to 2007 (%)
	CO <sub>2</sub> equivalent (Gg)								
CO <sub>2</sub> emissions including net CO <sub>2</sub> from LULUCF	44'645	44'894	44'147	43'293	45'642	46'897	46'646	42'982	2.0%
CO <sub>2</sub> emissions excluding net CO <sub>2</sub> from LULUCF	43'900	44'682	43'771	44'877	45'347	46'038	45'575	43'636	-1.9%
CH <sub>4</sub> emissions including CH <sub>4</sub> from LULUCF	3'669	3'681	3'621	3'518	3'498	3'516	3'506	3'513	-19.4%
CH <sub>4</sub> emissions excluding CH <sub>4</sub> from LULUCF	3'669	3'680	3'618	3'514	3'498	3'516	3'505	3'511	-19.2%
N <sub>2</sub> O emissions including N <sub>2</sub> O from LULUCF	3'366	3'343	3'328	3'254	3'254	3'225	3'233	3'241	-10.6%
N <sub>2</sub> O emissions excluding N <sub>2</sub> O from LULUCF	3'360	3'337	3'321	3'246	3'248	3'220	3'228	3'235	-10.5%
HFCs	422	496	521	574	640	629	609	630	
PFCs	93	53	51	88	75	57	74	77	-23.1%
SF <sub>6</sub>	203	235	211	195	182	205	181	175	22.1%
<b>Total (including LULUCF)</b>	<b>52'399</b>	<b>52'701</b>	<b>51'878</b>	<b>50'922</b>	<b>53'291</b>	<b>54'530</b>	<b>54'250</b>	<b>50'617</b>	<b>0.49%</b>
<b>Total (excluding LULUCF)</b>	<b>51'648</b>	<b>52'483</b>	<b>51'493</b>	<b>52'494</b>	<b>52'990</b>	<b>53'665</b>	<b>53'173</b>	<b>51'265</b>	<b>-2.74%</b>

The emission trends for individual gases are as follows (see Table 2-2 above, Table 2-3 and Figure 2-3 below):

- Total emissions (excluding LULUCF) show a minimum of 95.8% in 1994 and a maximum of 103.1% in 1991 (100%: value of base year 1990). The 2007 total emissions decreased by -2.7% as compared to the emissions recorded in the base year 1990. CO<sub>2</sub> contributed the largest share of emissions, accounting for 85.1% of the total in 2007.
- Total emissions (including LULUCF) in 2007 show an increase of 0.5% compared to the emissions recorded in the base year 1990. Heavy storms in 1990 and, in particular, at the end of 1999 ("Lothar") led to significant reductions in net removals within the LULUCF sector (visible over several years due to 3-year averaging of the storm effects). Due to the accounting of the climatic parameters, the net CO<sub>2</sub> emissions from LULUCF show considerable variability from year to year.

- A comparison of CO<sub>2</sub> emissions with the number of heating degree days (definition is shown in footnote 2, page 62) in the period 1990–2007 (see Figure 2-7 below) indicates a strong correlation between CO<sub>2</sub> emissions and winter climatic conditions.
- Between 1990 and 2007, CH<sub>4</sub> decreased by -19%, which was mainly attributable to a reduction of productive livestock, accompanied by a reduction of emissions from enteric fermentation. Moreover, from 2000, a change in waste legislation, banning the disposal of municipal solid waste in landfills, contributed to this trend. The CH<sub>4</sub> share of total GHG emissions decreased from 8.2% in 1990 to 6.8% in 2007.
- In parallel to the reduction of CH<sub>4</sub> due to decreases in livestock populations, N<sub>2</sub>O emissions from manure management and agricultural soils declined by -10.5% between 1990 and 2007.
- HFC emissions increased significantly due to their application as substitutes for CFCs, while PFC emissions declined by -23.1%. SF<sub>6</sub> emissions have shown relatively large fluctuations between 92 and 235 Gg CO<sub>2</sub> equivalent since 1990. In 2007, SF<sub>6</sub> emissions increased by 22.1% compared to 1990. The share of all synthetic gases combined rose from 0.5% in 1990 to 1.7% in 2007.

Table 2-3 Switzerland's total GHG emissions (excluding LULUCF) in CO<sub>2</sub> equivalent (Gg), selected years.

Greenhouse Gas Emissions (excluding LULUCF)	1990		1995		2000		2005		2006		2007	
	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%
CO <sub>2</sub>	44'504	84.4%	43'322	84.9%	43'900	85.0%	46'038	85.8%	45'575	85.7%	43'636	85.1%
CH <sub>4</sub>	4'348	8.2%	3'960	7.8%	3'669	7.1%	3'516	6.6%	3'505	6.6%	3'511	6.8%
N <sub>2</sub> O	3'613	6.9%	3'483	6.8%	3'360	6.5%	3'220	6.0%	3'228	6.1%	3'235	6.3%
HFCs	0	0.0%	169	0.3%	422	0.8%	629	1.2%	609	1.1%	630	1.2%
PFCs	100	0.2%	15	0.0%	93	0.2%	57	0.1%	74	0.1%	77	0.2%
SF <sub>6</sub>	144	0.3%	95	0.2%	203	0.4%	205	0.4%	181	0.3%	175	0.3%
<b>Total (excluding LULUCF)</b>	<b>52'709</b>	<b>100%</b>	<b>51'043</b>	<b>100%</b>	<b>51'648</b>	<b>100%</b>	<b>53'665</b>	<b>100%</b>	<b>53'173</b>	<b>100%</b>	<b>51'265</b>	<b>100%</b>

Figure 2-3 below shows Switzerland's relative GHG emission trends by gas. The base year 1990 is set to 100%.

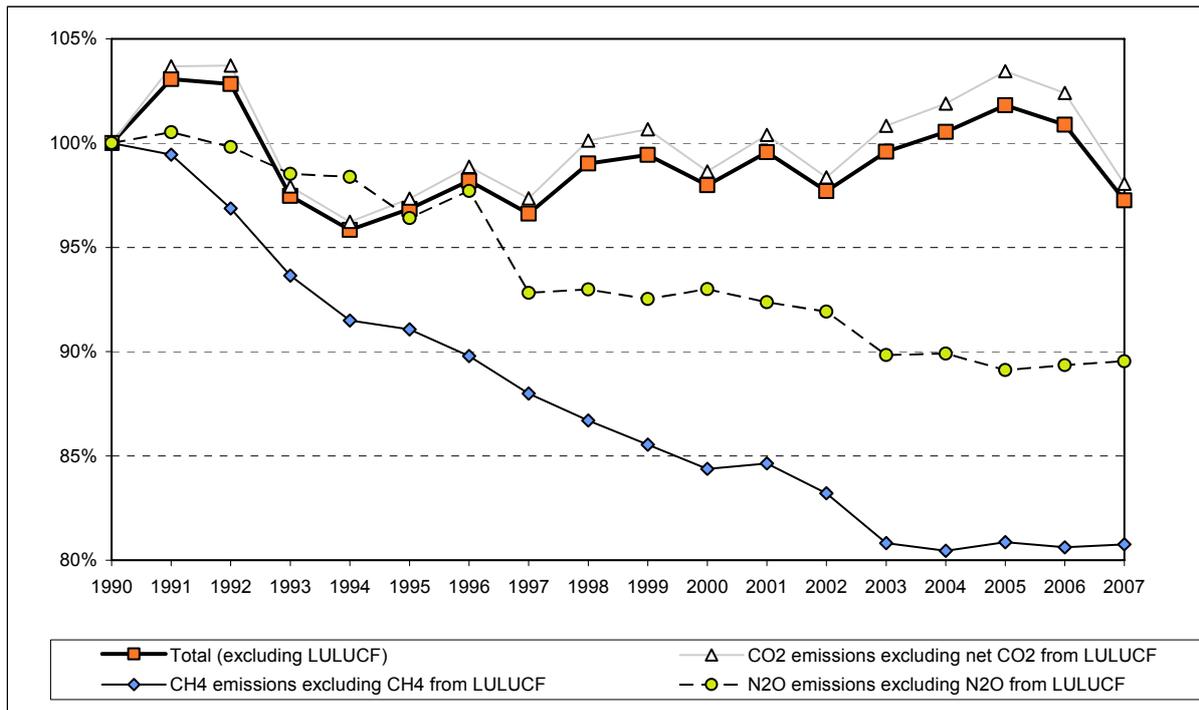


Figure 2-3 Relative trend of Switzerland's GHG emissions excluding LULUCF by gas, 1990–2007 (base year 1990 = 100%). The increase of the synthetic gases is not shown (362% in 2007, compared to 1990).

### 2.3. Emission Trends by Sources and Sinks

Table 2-4 shows the emission trends for all major source and sink categories. As the largest share of emissions originated from the energy sector, the table also includes the contributions of the energy sub-sectors.

Table 2-4 Switzerland's GHG emissions in CO<sub>2</sub> equivalent (Gg) by sources and sinks, 1990–2007. The column below on the far right (digits in italics) indicates the percentage change in emissions in 2007 as compared to the base year 1990.

Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO <sub>2</sub> equivalent (Gg)									
<b>1. Energy</b>	<b>42'086</b>	<b>44'081</b>	<b>44'235</b>	<b>41'880</b>	<b>40'974</b>	<b>41'651</b>	<b>42'530</b>	<b>42'030</b>	<b>43'270</b>	<b>43'486</b>
1A1 Energy Industries	744	1'107	1'188	887	900	890	1'005	903	1'142	913
1A2 Manufacturing Industries and Construction	6'013	5'886	5'719	5'512	5'591	5'438	5'272	5'431	5'584	5'620
1A3 Transport	14'772	15'255	15'576	14'508	14'703	14'376	14'421	14'988	15'193	15'788
1A4 Other Sectors	17'786	19'149	19'085	18'367	17'161	18'296	19'087	17'906	18'460	18'182
1A5 Other (Offroad)	450	466	482	498	514	531	542	553	564	575
1B Fugitive emissions from oil and natural gas	520	497	462	432	416	392	379	361	353	355
<b>2. Industrial Processes</b>	<b>3'258</b>	<b>2'912</b>	<b>2'745</b>	<b>2'438</b>	<b>2'617</b>	<b>2'554</b>	<b>2'410</b>	<b>2'268</b>	<b>2'380</b>	<b>2'470</b>
<b>3. Solvent and Other Product Use</b>	<b>468</b>	<b>448</b>	<b>429</b>	<b>406</b>	<b>390</b>	<b>371</b>	<b>348</b>	<b>324</b>	<b>299</b>	<b>294</b>
<b>4. Agriculture</b>	<b>5'903</b>	<b>5'907</b>	<b>5'833</b>	<b>5'755</b>	<b>5'706</b>	<b>5'638</b>	<b>5'655</b>	<b>5'499</b>	<b>5'468</b>	<b>5'410</b>
<b>6. Waste</b>	<b>994</b>	<b>982</b>	<b>961</b>	<b>901</b>	<b>830</b>	<b>824</b>	<b>811</b>	<b>807</b>	<b>776</b>	<b>753</b>
<b>Total (excluding LULUCF)</b>	<b>52'709</b>	<b>54'330</b>	<b>54'202</b>	<b>51'379</b>	<b>50'517</b>	<b>51'039</b>	<b>51'754</b>	<b>50'928</b>	<b>52'192</b>	<b>52'412</b>
5. Land Use, Land-Use Change and Forestry	-2'340	-1'668	-1'149	-3'214	-5'508	-5'294	-4'521	-2'492	-1'678	-1'373
<b>Total (including LULUCF)</b>	<b>50'369</b>	<b>52'662</b>	<b>53'053</b>	<b>48'165</b>	<b>45'010</b>	<b>45'745</b>	<b>47'234</b>	<b>48'436</b>	<b>50'514</b>	<b>51'039</b>

Source and Sink Categories	2000	2001	2002	2003	2004	2005	2006	2007	2007/1990
	CO <sub>2</sub> equivalent (Gg)								%
<b>1. Energy</b>	<b>42'433</b>	<b>43'197</b>	<b>42'309</b>	<b>43'430</b>	<b>43'788</b>	<b>44'390</b>	<b>43'953</b>	<b>41'966</b>	<b>-0.3%</b>
1A1 Energy Industries	775	835	864	830	974	948	1'041	877	17.9%
1A2 Manufacturing Industries and Construction	5'797	5'820	5'737	5'714	5'756	5'861	5'916	5'857	-2.6%
1A3 Transport	16'021	15'713	15'592	15'759	15'864	15'940	16'026	16'347	10.7%
1A4 Other Sectors	16'810	17'715	16'994	18'016	17'908	18'182	17'363	15'428	-13.3%
1A5 Other (Offroad)	586	588	590	593	595	597	597	597	32.5%
1B Fugitive emissions from oil and natural gas	334	342	313	282	285	282	285	276	-46.9%
<b>2. Industrial Processes</b>	<b>2'789</b>	<b>2'897</b>	<b>2'840</b>	<b>2'876</b>	<b>3'034</b>	<b>3'081</b>	<b>3'041</b>	<b>3'058</b>	<b>-6.1%</b>
<b>3. Solvent and Other Product Use</b>	<b>282</b>	<b>265</b>	<b>253</b>	<b>244</b>	<b>230</b>	<b>230</b>	<b>229</b>	<b>231</b>	<b>-50.7%</b>
<b>4. Agriculture</b>	<b>5'411</b>	<b>5'416</b>	<b>5'391</b>	<b>5'285</b>	<b>5'259</b>	<b>5'282</b>	<b>5'287</b>	<b>5'346</b>	<b>-9.4%</b>
<b>6. Waste</b>	<b>733</b>	<b>708</b>	<b>700</b>	<b>659</b>	<b>679</b>	<b>682</b>	<b>663</b>	<b>663</b>	<b>-33.3%</b>
<b>Total (excluding LULUCF)</b>	<b>51'648</b>	<b>52'483</b>	<b>51'493</b>	<b>52'494</b>	<b>52'990</b>	<b>53'665</b>	<b>53'173</b>	<b>51'265</b>	<b>-2.7%</b>
5. Land Use, Land-Use Change and Forestry	751	218	385	-1'572	300	865	1'076	-647	-72.3%
<b>Total (including LULUCF)</b>	<b>52'399</b>	<b>52'701</b>	<b>51'878</b>	<b>50'922</b>	<b>53'291</b>	<b>54'530</b>	<b>54'250</b>	<b>50'617</b>	<b>0.5%</b>

The percentage shares of source categories are shown for selected years in Table 2-5. Figure 2-4 through Figure 2-6 are graphical representations of Table 2-4 data. For the time series of the sub-sectors of 1 Energy see Chapter 3.

Table 2-5 Switzerland's total gross GHG emissions (excluding LULUCF) in CO<sub>2</sub> equivalent (Gg) and the contribution of individual source categories, selected years.

Source and Sink Categories	1990		1995		2000		2005		2006		2007	
	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%	Gg CO <sub>2</sub> eq	%
<b>1. Energy</b>	<b>42'086</b>	<b>79.8%</b>	<b>41'651</b>	<b>81.6%</b>	<b>42'433</b>	<b>82.2%</b>	<b>44'390</b>	<b>82.7%</b>	<b>43'953</b>	<b>82.7%</b>	<b>41'966</b>	<b>81.9%</b>
1A1 Energy Industries	744	1.4%	890	1.7%	775	1.5%	948	1.8%	1'041	2.0%	877	1.7%
1A2 Manufacturing Industries and Construction	6'013	11.4%	5'438	10.7%	5'797	11.2%	5'861	10.9%	5'916	11.1%	5'857	11.4%
1A3 Transport	14'772	28.0%	14'376	28.2%	16'021	31.0%	15'940	29.7%	16'026	30.1%	16'347	31.9%
1A4 Other Sectors	17'786	33.7%	18'296	35.8%	16'810	32.5%	18'182	33.9%	17'363	32.7%	15'428	30.1%
1A5 Other (Offroad)	450	0.9%	531	1.0%	586	1.1%	597	1.1%	597	1.1%	597	1.2%
1B Fugitive emissions from oil and natural gas	520	1.0%	392	0.8%	334	0.6%	282	0.5%	285	0.5%	276	0.5%
<b>2. Industrial Processes</b>	<b>3'258</b>	<b>6.2%</b>	<b>2'554</b>	<b>5.0%</b>	<b>2'789</b>	<b>5.4%</b>	<b>3'081</b>	<b>5.7%</b>	<b>3'041</b>	<b>5.7%</b>	<b>3'058</b>	<b>6.0%</b>
<b>3. Solvent and Other Product Use</b>	<b>468</b>	<b>0.9%</b>	<b>371</b>	<b>0.7%</b>	<b>282</b>	<b>0.5%</b>	<b>230</b>	<b>0.4%</b>	<b>229</b>	<b>0.4%</b>	<b>231</b>	<b>0.5%</b>
<b>4. Agriculture</b>	<b>5'903</b>	<b>11.2%</b>	<b>5'638</b>	<b>11.0%</b>	<b>5'411</b>	<b>10.5%</b>	<b>5'282</b>	<b>9.8%</b>	<b>5'287</b>	<b>9.9%</b>	<b>5'346</b>	<b>10.4%</b>
<b>6. Waste</b>	<b>994</b>	<b>1.9%</b>	<b>824</b>	<b>1.6%</b>	<b>733</b>	<b>1.4%</b>	<b>682</b>	<b>1.3%</b>	<b>663</b>	<b>1.2%</b>	<b>663</b>	<b>1.3%</b>
<b>Total (excluding LULUCF)</b>	<b>52'709</b>	<b>100.0%</b>	<b>51'039</b>	<b>100.0%</b>	<b>51'648</b>	<b>100.0%</b>	<b>53'665</b>	<b>100.0%</b>	<b>53'173</b>	<b>100.0%</b>	<b>51'265</b>	<b>100.0%</b>

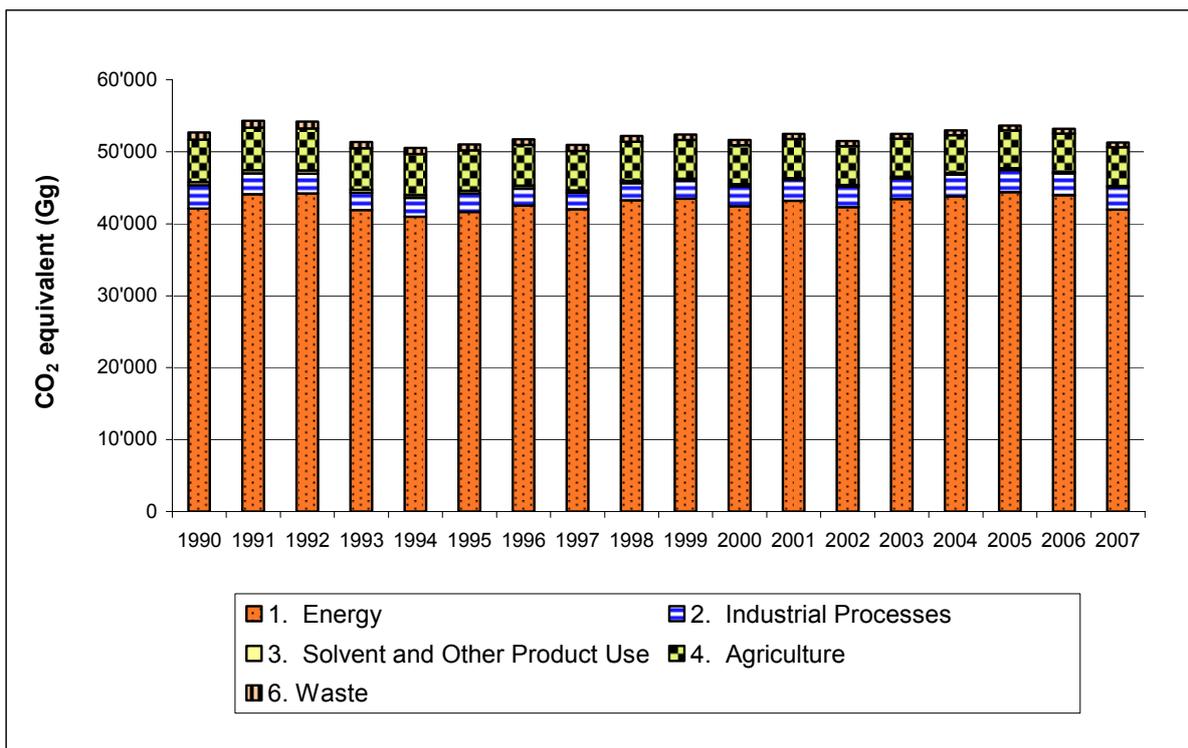


Figure 2-4 Switzerland's GHG emissions in CO<sub>2</sub> equivalent (Gg) by sectors, 1990–2007 (excluding LULUCF).

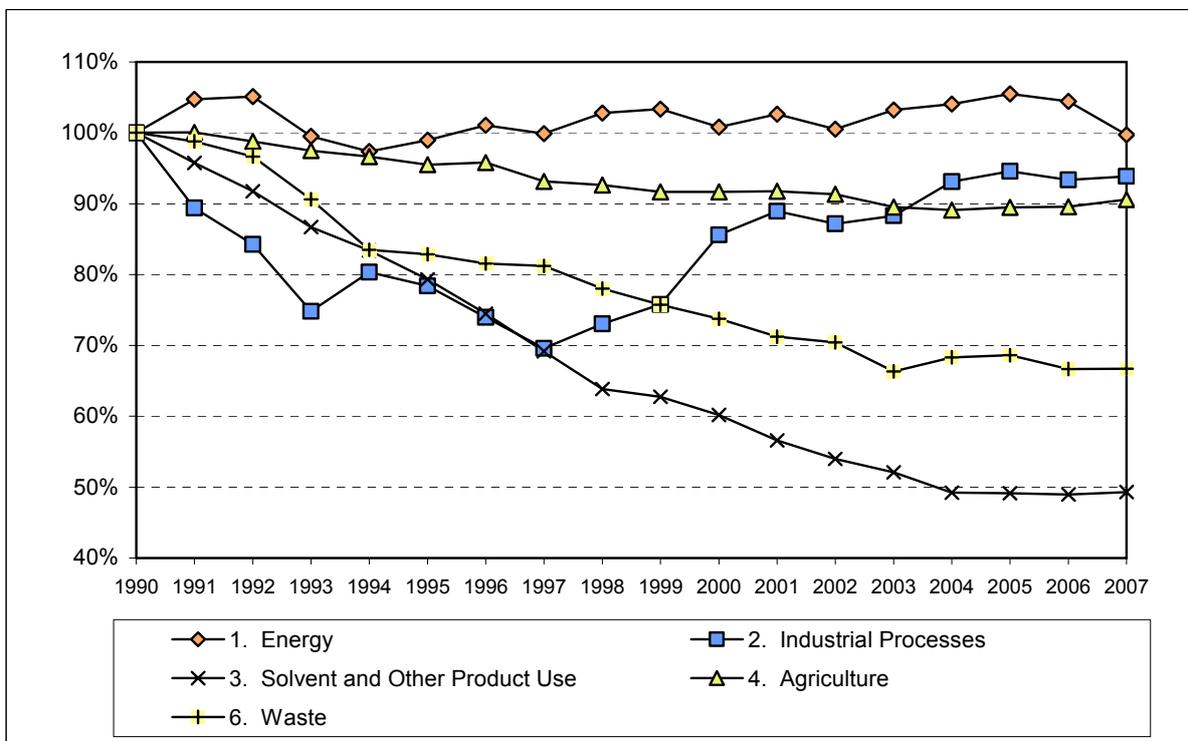


Figure 2-5 Relative emission trends by main source categories (base year 1990 = 100%).

Emission trends for the various sectors are as follows:

- 1 Energy: The variations can only be understood if the trends within the source sub-categories are considered separately (see Figure 2-6 and comments below).
- 2 Industrial Processes: In line with economic development, overall emissions in the Industry sector showed a decreasing trend at the beginning and a rebound between 1998 and 2005.
- 3 Solvent and Other Product Use: NMVOC emissions, the main source of indirect CO<sub>2</sub> of the sector, have diminished between 1990 and 2004 due to their limitation brought by the Ordinance on Air Pollution Control (Swiss Confederation 1985) and due to the introduction of the VOC-tax in 2000 (Swiss Confederation 1997).
- 4 Agriculture: Declining populations of cattle and swine and reduced fertilizer use have led to a decrease in CO<sub>2</sub> equivalent emissions until 2004. Since then CH<sub>4</sub> emissions slightly increased again due to higher livestock numbers (mainly cattle).
- 6 Waste: Total emissions from the source category Waste decreased steadily throughout the period 1990-2003. Since 2000, emissions have been reduced further by a change in legislation: disposal of burnable municipal solid wastes on landfills has been banned, leading to an increasing amount of municipal solid waste being incinerated, with emissions reported under source 1A1 Energy Industries rather than sector 6 Waste. Altogether, “waste-related” emissions incl. emissions from waste management activities reported in sources 1A, 4D and 6 have *increased* since 1990 by 19.2 % (see Figure 8-3 in Chapter 8).

The main sub-categories within the Energy sector – representing the major sources of Switzerland’s GHG emissions – are shown in Figure 2-6.

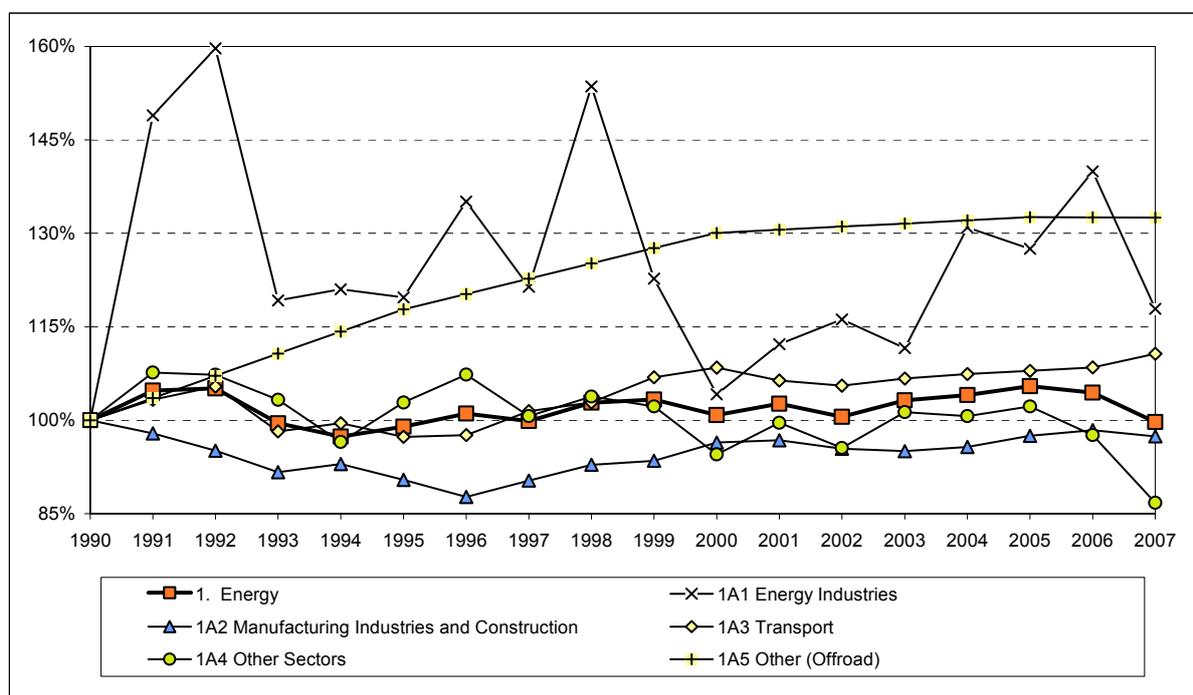


Figure 2-6 Emission trends for the sub-categories in the sector 1 Energy/1A Fuel Combustion. The trend for the sector as a whole (“1 Energy”) is shown in bold. Not included in the figure is the trend for 1B Fugitive Emissions which drops down steadily from 100% (1990) to 53% (2007).

It is noteworthy that, due to Switzerland’s electricity production structure (about 95.2% generated by hydroelectric and nuclear power plants in 2007; see SFOE 2008: Table 24), the sector 1A1 Energy Industries plays only a minor role – representing not classical thermal

power stations but waste incineration plants in the Swiss GHG inventory. The following emission trends are observed within the Energy sector:

- Despite of differing trends for the sub-sectors, the overall emissions resulted in a relatively constant level for the energy sector (bold line in Figure 2-6).
- The trend for sub-sector 1A1 Energy Industry is mainly caused by annual fluctuation in waste incineration and in combustion activities in the petroleum refinery industry. Note that less than 10% of sector 1Energy emissions stem from 1A1.
- The trend for sub-sector 1A3 Transport shows a slight increase over the period 1990–2007, but with fluctuations indicating a fairly strong correlation between this sector and economic development – periods of stagnation 1993–1996 and 2001–2003, and growth (gross value-added) 1997–2000 and 2004–2007 (SFSO 2007).
- The trend for sub-sector 1A4 Other Sectors reflects the impact of climatic variations on demand for heating. The strong correlation with the number of “heating degree days”<sup>2</sup> – used as an index of cold weather conditions – is apparent from Figure 2-7, which shows CO<sub>2</sub> emissions from fuel combustion (i.e. from 1A without on-/off-road sources 1A3/1A5 or mobile sources in 1A4c) and the number of heating degree days. An extraordinary decrease from 2006 to 2007 reflects the high prices for heating oil (gas oil) in 2007, which is also expressed in an exceeding reduction of gas oil stocks. As well, the number of heating degree days was lower in 2007 compared to 2006 and was 7% lower than the average of the period 1990–2007. In the period 1990–2007, the number of buildings and apartments increased, as well as the average floor space per person and workplace. Both phenomena resulted in an increase in the total area heated. Over the same period, however, higher standards were specified for insulation and for combustion equipment efficiency for both new and renovated buildings, compensating for the emissions from the additional area heated.

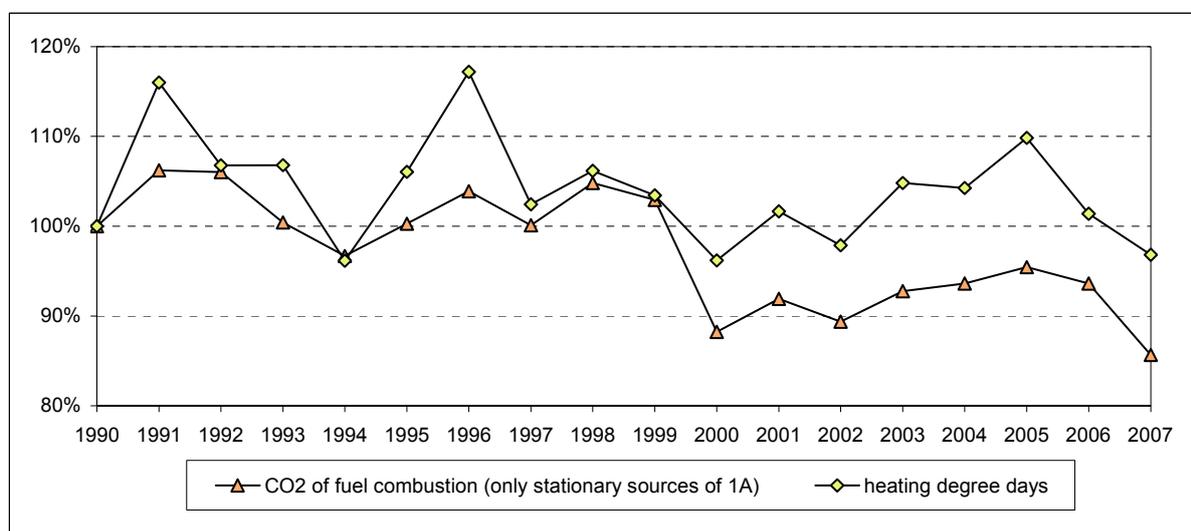


Figure 2-7 Relative trend for CO<sub>2</sub> emissions from 1A Fuel Combustion (excluding transport and off-road activities) compared with the number of heating degree days.

<sup>2</sup> Heating degree days: Number of degrees per day calculated as the difference between 20°C (room temperature) and the daily average outdoor temperature for such days where the daily average temperature is below 12°C (e.g. daily outdoor average equals 7°C, then for that day 20 – 7 = 13). The number of degrees per day are summed up for a year t to yield the heating degree days of year t.

Figure 2-8 shows the net emissions/removals from the LULUCF sector in Switzerland, which is dominated by biomass dynamics in forests. Before the year 2000 removals were higher than emissions. As the forestal carbon sink seems to diminish since the mid-nineties, emissions and removals are almost equal after 2000. However, a strong year to year variation is evident during the whole period.

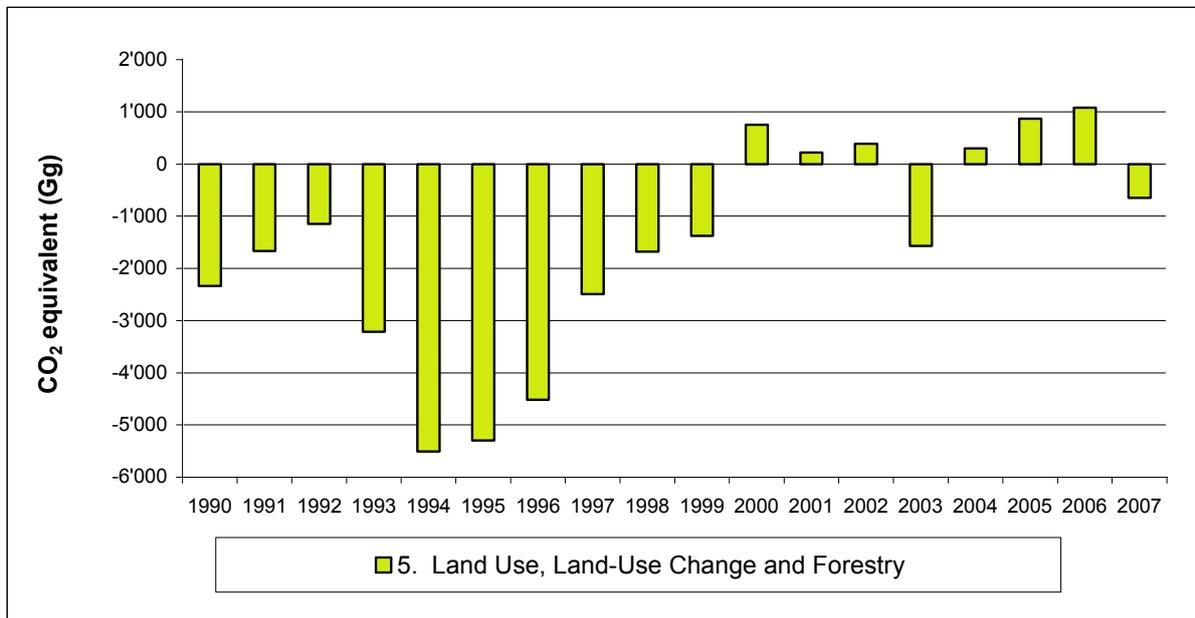


Figure 2-8 Switzerland's net CO<sub>2</sub> equivalent balance of sector Land Use, Land-Use Change and Forestry (LULUCF) 1990–2007 in Gg. Positive values refer to emissions, negative values refer to removals. Note that the annual contributions of CH<sub>4</sub> and N<sub>2</sub>O emissions from LULUCF in this period are very small compared to the net CO<sub>2</sub> emissions and removals (8 Gg CO<sub>2</sub> equivalent on an average).

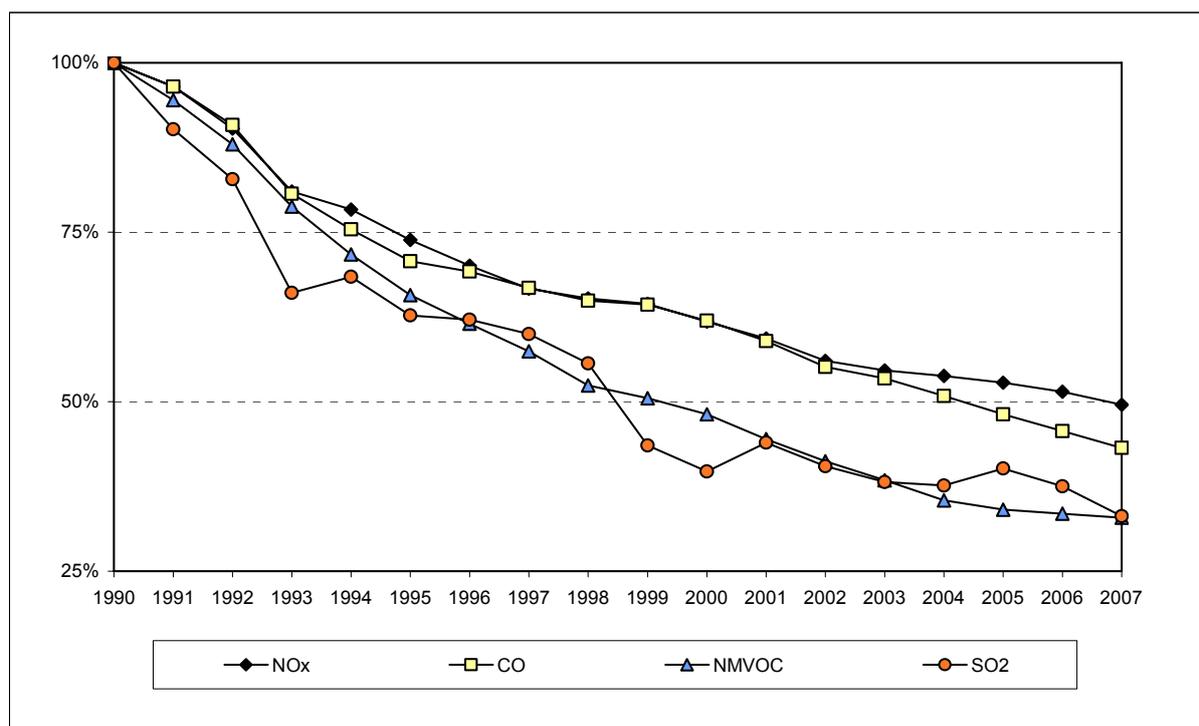
## 2.4. Emission Trends for Indirect Greenhouse Gases and SO<sub>2</sub>

Emission trends for indirect greenhouse gases show a very pronounced decline (see Table 2-6 and Figure 2-9). From 1990 to 2007, a strict air pollution control policy and the implementation of a large number of emission reduction measures led to a decrease of -50% to -70% in the period 1990-2007 in emissions of air pollutants. The main reduction measures were abatement of exhaust emissions from road vehicles and stationary combustion equipment, taxation of solvents and sulphured fuels, and voluntary agreements with industry sectors (SAEFL 2004, Swiss Confederation 1985, 1997).

Table 2-6 Switzerland's indirect GHG and SO<sub>2</sub> emissions (Gg), 1990–2007 (without NMVOC from LULUCF).

Indirect Greenhouse Gases and SO <sub>2</sub>	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Gg									
NO <sub>x</sub>	159	153	144	129	125	117	111	106	104	102
CO	725	700	659	585	547	513	502	484	471	466
NMVOC	293	276	257	231	210	192	180	168	153	148
SO <sub>2</sub>	41	37	34	27	28	26	25	25	23	18

Indirect Greenhouse Gases and SO <sub>2</sub>	2000	2001	2002	2003	2004	2005	2006	2007
	Gg							
NO <sub>x</sub>	98	94	89	87	86	84	82	79
CO	449	427	400	387	369	349	331	313
NMVOC	141	130	121	112	104	100	98	96
SO <sub>2</sub>	16.3	18.0	16.6	15.6	15.4	16.4	15.4	13.6

Figure 2-9 Relative trends for indirect GHG and SO<sub>2</sub> emissions (without NMVOC from LULUCF), 1990–2007 (base year 1990 = 100%).

The energy sector was by far the largest source of indirect greenhouse gas emissions (see Table 2-7), with the only exception being NMVOC, where sector 3 Solvent and Other Product Use accounted for 24.3% of the total. The total shown in Table 2-7 includes NMVOC emissions from LULUCF, which amounted to 95.5 Gg in 2007.

Table 2-7 Indirect GHG and SO<sub>2</sub> emissions (Gg) by source, 2007. The total NMVOC emissions include NMVOC from LULUCF.

Sources	NO <sub>x</sub>	CO	NMVOC	SO <sub>2</sub>
	Emissions 2007 (Gg)			
1 Energy	74.7	297.2	32.0	11.4
2 Industrial Processes	0.4	6.8	11.0	2.0
3 Solvent and Other Product Use	0.0	0.0	46.6	0.0
4 Agriculture	4.6	7.3	4.6	0.0
5 LULUCF	IE, NE	IE, NE	95.5	NE
6 Waste	0.4	1.9	2.1	0.1
<b>Total</b>	<b>80.1</b>	<b>313.2</b>	<b>191.8</b>	<b>13.6</b>

Figure 2-10 shows the relative contributions (excluding LULUCF) of the various sectors for each individual gas (data from Table 2-7). The energy sector can clearly be identified as the main source of NO<sub>x</sub>, CO and SO<sub>2</sub>.

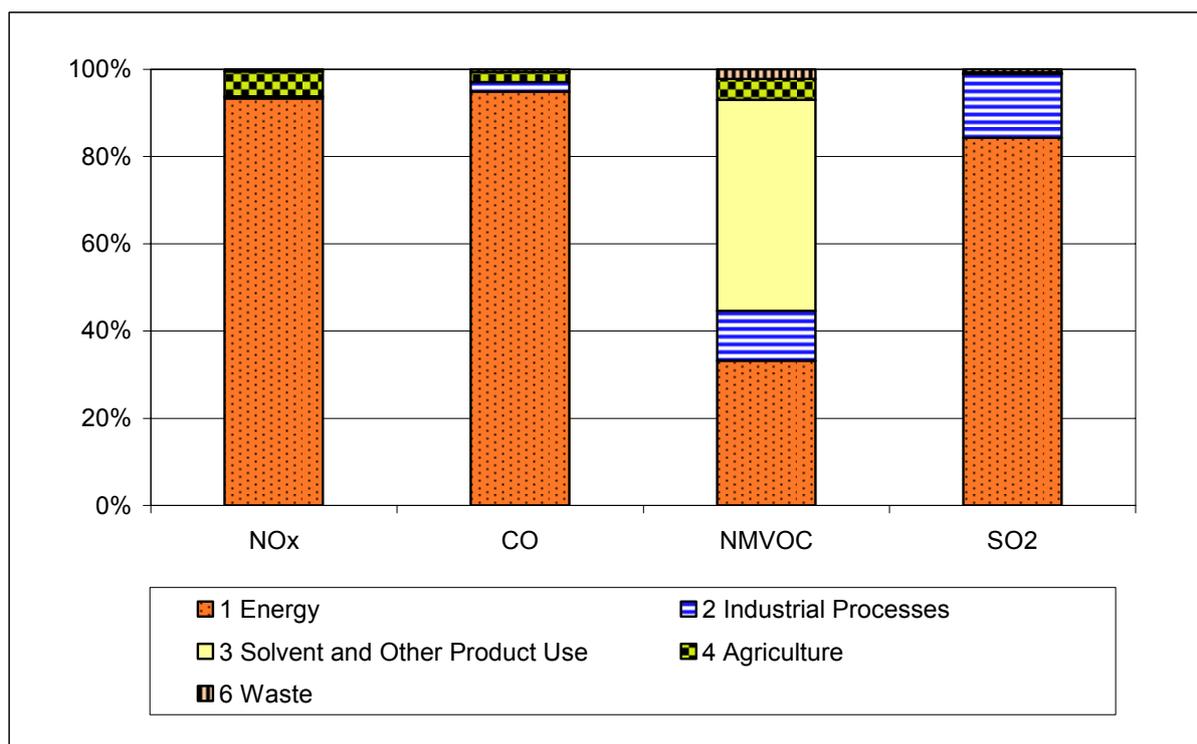


Figure 2-10 Relative contributions of individual sectors to indirect GHG and SO<sub>2</sub> emissions in 2007 (without NMVOC from LULUCF).

## 3. Energy

### 3.1. Overview

#### 3.1.1. Greenhouse Gas Emissions

This chapter provides information on the estimation of the greenhouse gas emissions from sector energy. The following source categories are reported:

- 1A. Fuel Combustion
- 1B. Fugitive Emissions from Fuels

In Switzerland, the energy sector is the most relevant greenhouse gas source. In 2007, it emitted 41'966 Gg CO<sub>2</sub> equivalent which corresponds to 81.9% of total emissions (51'265 Gg CO<sub>2</sub> equivalent, national total without LULUCF). The emissions of the period 1990–2007 are depicted in Figure 3-1.

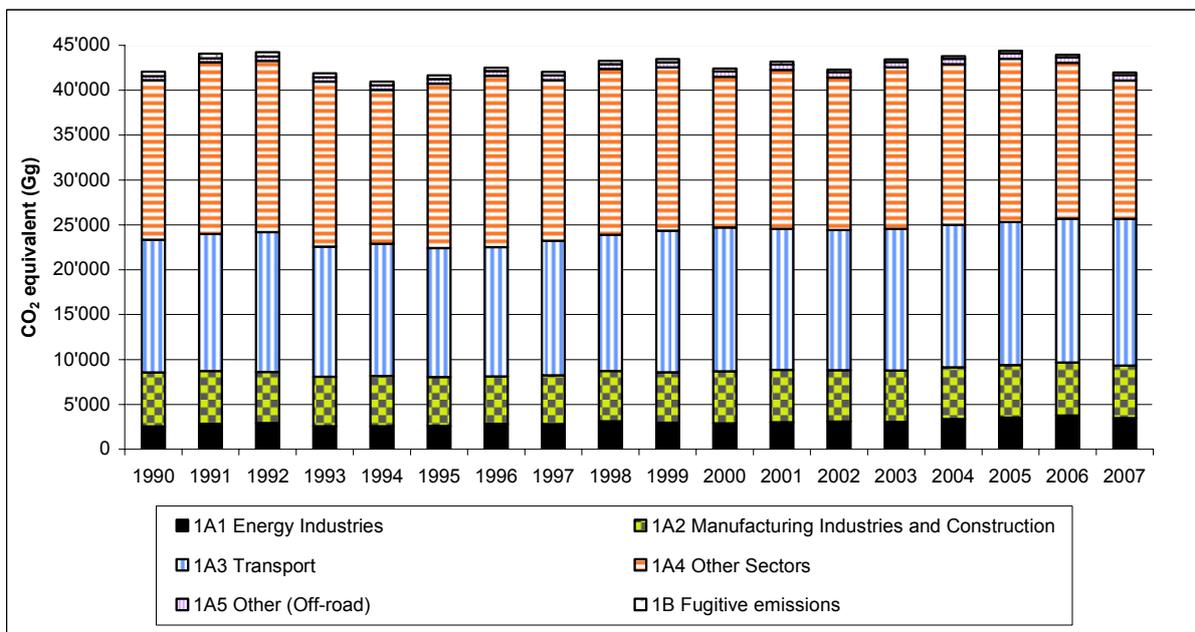


Figure 3-1 Switzerland's GHG emissions of sector 1 Energy 1990–2007 in CO<sub>2</sub> equivalent (Gg).

For the total emissions of the energy sector, there are fluctuations between 97% and 105% in the period 1994–2007 but no trends. The value 2007 is almost identical (0.3%) to the value of the base year. Three sub-categories dominate the emissions:

- 1A3 Transport and 1A4 Other Sectors are the main sources that cover 39.0% and 36.8%, respectively, of total emissions of the sector energy.
- 1A2 Manufacturing Industries and Construction are of minor importance. They contribute 14.0% to the total emissions of the sector energy.
- 1A1 Energy Industries, 1A5 Other (Off-road) and 1B Fugitive Emissions only play a minor role. In 2007, they cover 8.2%, 1.4% and 0.7%, respectively, of the total emissions of the sector energy.

The trends of the individual gases are given in the next table and figure:

- The far most important gas emitted from the sector energy is CO<sub>2</sub>. It accounts for 98.5% of the category. Its fluctuations reflect climatic variability in Switzerland (see Figure 2-7 and related comments).
- In 2007, CH<sub>4</sub> emissions contributed 0.66% to the total emissions of the sector energy. The decreasing trend since 1990 is the result of reduced emissions from gasoline passenger cars due to catalytic converters.
- N<sub>2</sub>O contributed 0.79% to the total emissions of the sector energy. The changes in N<sub>2</sub>O emissions may be explained by changes in the emission of passenger cars. The first generation of catalytic converters generated N<sub>2</sub>O as undesirable by-product in the exhaust gases, leading to an increase of N<sub>2</sub>O emissions until 2000. With new converter materials being used, the emission factors are decreasing since 2001.

Table 3-1 GHG emissions of source category 1 Energy by gas in CO<sub>2</sub> equivalent (Gg), 1990–2007.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO <sub>2</sub> equivalent (Gg)									
CO <sub>2</sub>	41'253	43'241	43'416	41'103	40'203	40'893	41'776	41'297	42'535	42'737
CH <sub>4</sub>	565	547	502	461	438	414	395	366	359	364
N <sub>2</sub> O	268	293	317	317	333	345	359	366	376	385
Sum	42'086	44'081	44'235	41'880	40'974	41'651	42'530	42'030	43'270	43'486

Gas	2000	2001	2002	2003	2004	2005	2006	2007
	CO <sub>2</sub> equivalent (Gg)							
CO <sub>2</sub>	41'708	42'467	41'618	42'759	43'131	43'740	43'312	41'358
CH <sub>4</sub>	337	343	311	295	291	292	289	279
N <sub>2</sub> O	388	388	380	376	366	357	352	330
Sum	42'433	43'197	42'309	43'430	43'788	44'390	43'953	41'966

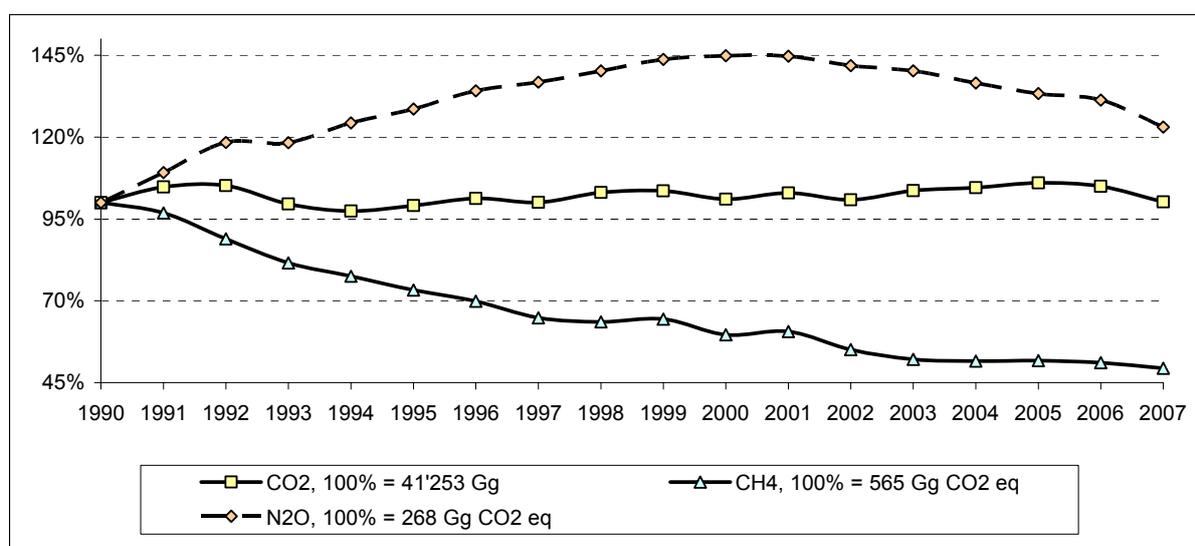


Figure 3-2 Relative trends of the greenhouse gases of source category 1 "Energy" in the period 1990–2007. The base year 1990 represents 100%.

The following table summarises the emissions of the sector energy in 2007. The table includes emissions from international bunkers (aviation) as well as from biomass burning which are both not accounted for in the Kyoto Protocol but are contained in the CRF tables.

Table 3-2 Summary of sector 1 Energy, emissions<sup>3</sup> in 2007 in Gg CO<sub>2</sub> equivalent (Total: rounded values).

Emissions 2007	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	Total
	CO <sub>2</sub> equivalent (Gg)			
<b>1 Energy</b>	<b>41'358</b>	<b>279</b>	<b>330</b>	<b>41'966</b>
<b>1A Fuel Combustion</b>	<b>41'255</b>	<b>105.8</b>	<b>329.7</b>	<b>41'690</b>
1A1 Energy Industries	3'344	1.7	116.1	<b>3'461</b>
1A2 Manufacturing Industries and Construction	5'804	11.5	42.1	<b>5'857</b>
1A3 Transport	16'209	19.8	118.0	<b>16'347</b>
1A4 Other Sectors	15'310	71.7	46.8	<b>15'428</b>
1A5 Other	589	1.1	6.7	<b>597</b>
<b>1B Fugitive Emissions from Fuels</b>	<b>103</b>	<b>173.3</b>	<b>0.0</b>	<b>276</b>
<b>International Bunkers</b>	3'919	1	38	<b>3'959</b>
<b>CO<sub>2</sub> Emissions from Biomass</b>	6'116	--	--	<b>6'116</b>

In 2007, the Swiss greenhouse gas inventory identifies in Tier 1 analysis 36 key sources in 2007 (without LULUCF), 21 of which belong to the energy sector. In Tier 2 analysis, 32 key sources are found including 17 in sector energy (without LULUCF), see Chapter 1.5. The key categories out of the energy sector are depicted in Figure 3-3. Most dominant are the CO<sub>2</sub> emissions from 1A3b Transport (gasoline, CO<sub>2</sub>) and 1A4b Other Sectors (liquid fuels, CO<sub>2</sub>).

<sup>3</sup> Biomass CO<sub>2</sub> emissions from 1 Energy in the Table and in the CRF inventory are for technical reasons incomplete. For full biomass CO<sub>2</sub> emissions see Section 3.5.

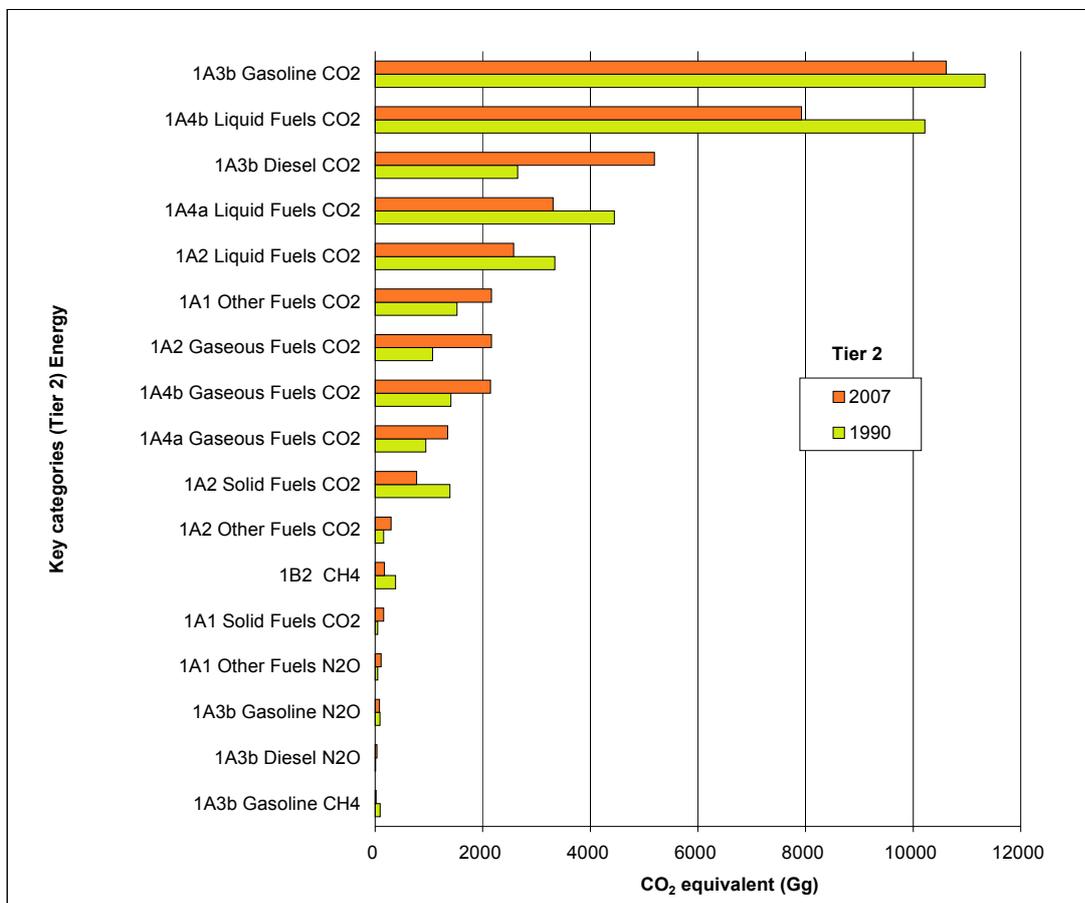
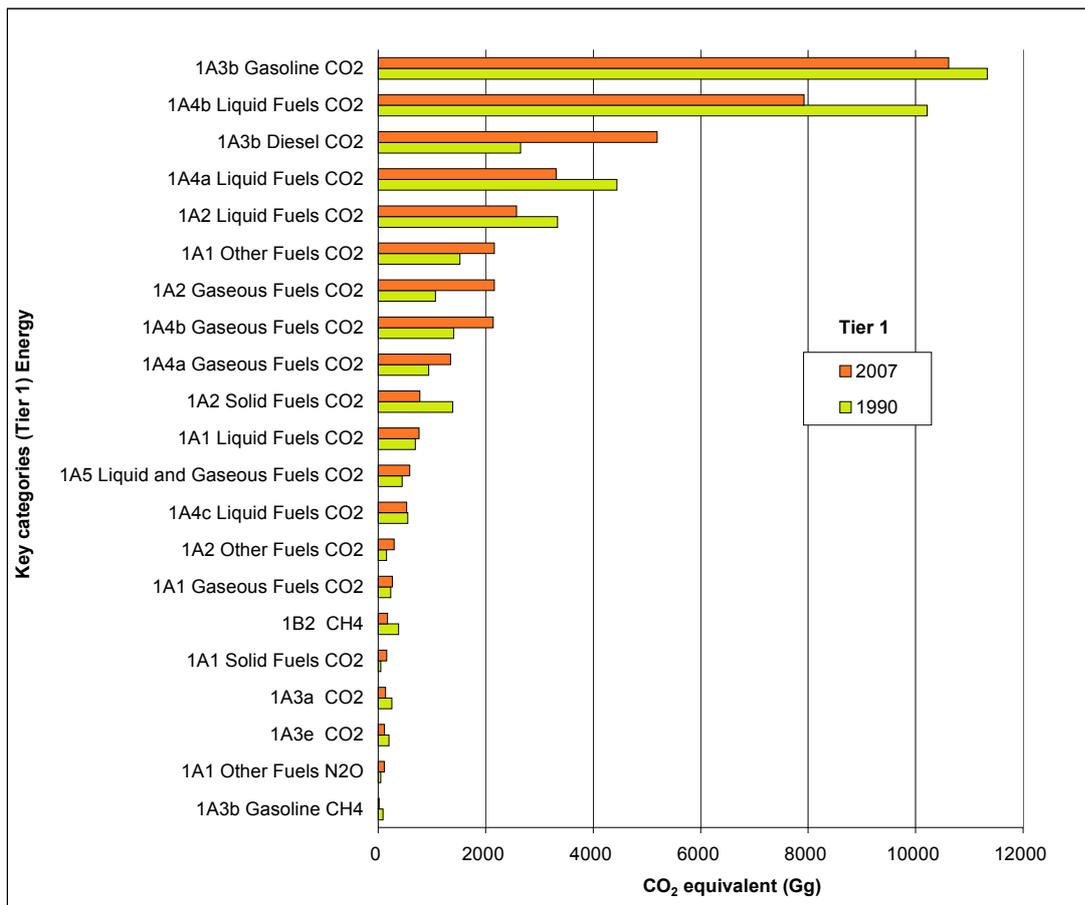


Figure 3-3 Key sources in the Swiss GHG inventory from the energy sector. Top: Tier 1, bottom Tier 2 analysis.

### 3.1.2. CO<sub>2</sub> Emission Factors

The CO<sub>2</sub> emission factors used for the calculation of the emissions of 1 Energy are shown in Table 3-3. Further details are given in Annex A2.1, Methodology for Estimating CO<sub>2</sub> Emissions. Note that the CO<sub>2</sub> emission factors are constant over the whole time period 1990-2007, which is supported by two measurement campaigns of NCV and C-content of fuels in 1999 (EMPA 1999) and in 2008 (Intertek 2008). For further details see Annex 2.1.

Table 3-3 CO<sub>2</sub> emission factors for fossil and biofuels. The values are assumed to be constant over the period 1990-2007. The value for natural gas also holds for CNG (compressed natural gas).

Fuels	CO <sub>2</sub> Emission Factors 1990-2007	
<b>Fossil fuels</b>	t CO <sub>2</sub> / TJ	data sources
Diesel Oil	73.6	SFOE (2001), Intertek (2008)
Gas Oil	73.7	SFOE (2001), Intertek (2008)
Gasoline	73.9	SFOE (2001), Intertek (2008)
Hard Coal	94.0	SFOE (2001)
Jet Kerosene	73.2	SFOE (2001), Intertek (2008)
Lignite	104.0	SFOE (2001)
Natural Gas and CNG	55.0	SFOE (2001)
Propane/Butane (LPG)	65.5	SFOE (2001)
Residual Fuel Oil	77.0	SFOE (2001), Intertek (2008)
<b>Biofuels</b>	t CO <sub>2</sub> / TJ	data sources
Biodiesel	73.6	EMIS (2009/1A3b)
Bioethanol	73.9	EMIS (2009/1A3b)
Biogas	55.0	EMIS (2009/1A3b)
Vegetable oil	73.6	EMIS (2009/1A3b)

### 3.1.3. Feedstocks

Energy data are taken from the Swiss overall energy statistics (SFOE 2008). These statistics account for production, imports, exports, transformation and stock changes. Hence all figures for energy consumption, on which the Swiss GHG inventory is based, correspond to apparent consumption figures.

In the Reference Approach of the GHG inventory, carbon stored in feedstocks has to be subtracted from fuel import to report the effective CO<sub>2</sub> emissions correctly. Bitumen as refinery product is the only feedstock reported. Other feedstocks are not reported. They are assumed to be small.

### 3.1.4. Correction of Fuel Consumption Related to Liechtenstein

The Swiss overall energy statistics (SFOE 2008) contains the fossil fuel consumption of the Principality of Liechtenstein (about 35'400 inhabitants, 32'400 employees in industrial and service sector), since the two countries form a customs and monetary union governed by a customs treaty. Thus, all imports of fossil fuel into Switzerland also contain the fuel consumed in Liechtenstein, which needs to be subtracted from the imports. In the previous and also in the present submission, the following method has been applied to get the correct Swiss fuel consumption:

Liechtenstein's energy consumption is taken from its energy statistics [see Table 18 in Liechtenstein's NIR (OEP 2009) on page 51]. In 2007 the sum of fossil fuels used in Liechtenstein was 3210 TJ that corresponds to 0.52% of the Swiss consumption. The total

consumption of every fuel (gasoline, diesel oil, gas oil etc.) is subtracted from the corresponding figures of the Swiss overall energy statistics. This procedure is carried out for every year 1990–2007. The Swiss emissions are then modelled using the correctly reduced activity data.

### 3.1.5. Disaggregation of the energy consumption

Figure 3-4 shows the disaggregation procedure of the fuel consumption. The total due to the sales principle is given in the Swiss overall energy statistics (SFOE 2008). The statistics also contains the split into energy consumption and energy transformation, further splits into residential, commercial and transportation as well as into public electricity, district heatings and refineries. Further disaggregations are carried out with the help of models run by FOEN, FOCA and the companies Cepe, Basics, INFRAS, Eicher+Pauli as well as the oil industry association (EV). The models of Cepe and Basics are described in detail in Annex A3.1.2.

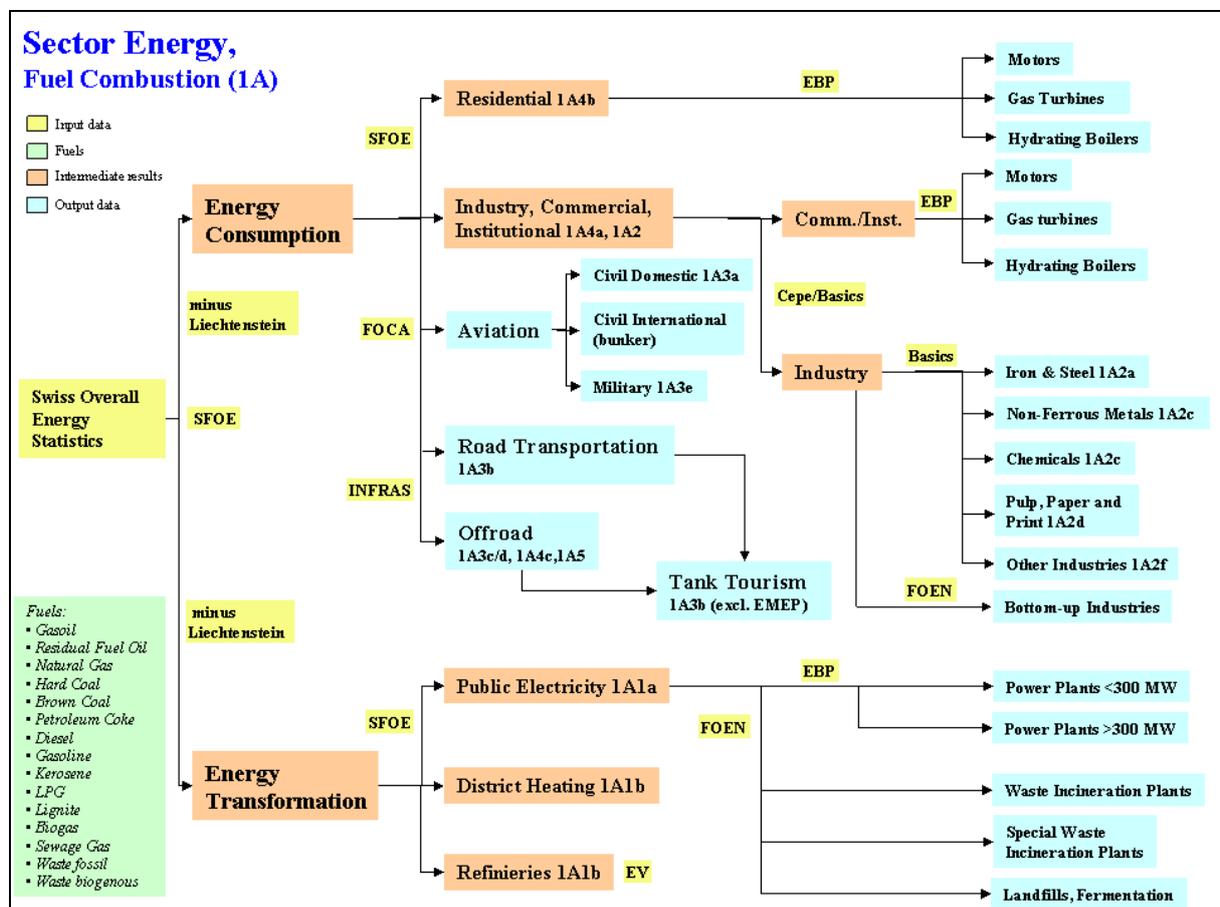


Figure 3-4 Schematic disaggregation of 1A Fuel Consumption.

## 3.2. Source Category 1A – Fuel Combustion Activities

### 3.2.1. Source Category Description

#### a) Energy Industries (1A1)

##### Key categories 1A1

CO<sub>2</sub> from the combustion of Gaseous Fuels (level)  
 CO<sub>2</sub> from the combustion of Liquid Fuels (level and trend)  
 CO<sub>2</sub> from the combustion of Solid Fuels (trend)  
 CO<sub>2</sub> from the combustion of Other Fuels (level and trend)  
 N<sub>2</sub>O from the combustion of Other Fuels (level and trend)

According to IPCC guidelines, source category 1A1 “Energy Industries” comprises emissions from fuels combusted by fuel extraction and energy producing industries.

In Switzerland, fuel extraction is not occurring and 1A1 includes only emissions from the production of heat and/or electricity for sale to the public. Producers in industry producing heat and/or electricity for their own use are included in category 1A2 “Manufacturing Industries and Construction”. Producers of heat and/or power for their own use in waste incineration plants, however, are included in 1A1.

In Switzerland, electricity production is dominated by hydroelectric power plants (55.2%) and nuclear power stations (40.0%). Other sources such as (fossil fueled) combined heat and power generation, and power generation from solar, wind and biogas account only for about 4.9% of the electricity generated in Switzerland (SFOE 2008; table 24; data for the year 2007).

Table 3-4 Specification of source category 1A1 “Energy Industries”

1A1	Source	Specification	Data Source
1A1a	Public Electricity and Heat Production	Main source are waste incineration plants with heat and power generation (Other fuels) and public district heating systems, including a small fraction of CHP. The only fossil fuelled public electricity generation unit “Vouvry” (300 MW <sub>e</sub> ; no public heat production) ceased operation in 1999.	Waste incineration: AD: FOEN 2008g; EMIS 2009/1A1a EF: CO <sub>2</sub> SAEFL 2005g; EMIS 2009/1A1a  Other sources: AD: SFOE 2008; EMIS 2009/1A1a EF: SAEFL 2000; SFOE 2001; EMIS 2009/1A1a
1A1b	Petroleum Refining	Combustion activities supporting the refining of petroleum products, excluding evaporative emissions.	AD: Annual report EV 2008, SFOE 2008; EMIS 2009/1A1b  EF: Industry data; EMIS 2009/1A1b
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Not occurring in Switzerland	-

#### b) Manufacturing Industries and Construction (1A2)

##### Key categories 1A2

CO<sub>2</sub> from the combustion of Gaseous Fuels (level and trend)  
 CO<sub>2</sub> from the combustion of Liquid Fuels (level and trend)

CO<sub>2</sub> from the combustion of Solid Fuels (level and trend)  
CO<sub>2</sub> from the combustion of Other Fuels (level and trend)

The source category 1A2 “Manufacturing Industries and Construction” comprises all emissions from the combustion of fuels in stationary boilers, gas turbines and engines within manufacturing industries and construction, including emissions from conventional and waste fuel use in cement production. Not included are combustion installations in the commercial/institutional and the residential sector as well as in agriculture/forestry. These are included in category 1A4 (“Other Sectors”).

In line with the IPCC guidelines, non-energy cement industry emissions of CO<sub>2</sub> from calcination are reported in category 2.

Table 3-5 Specification of source category 1A2 “Manufacturing Industries and Construction”

1A2	Source	Specification	Data Source
1A2a	Iron and Steel	Iron and Steel industry	AD: SFOE 2008, Basics 2007 and industry data; EMIS 2009/1A2 EF: EMIS 2009/1A2, SAEFL 2000
1A2b	Non-ferrous Metals	Non-ferrous Metals industry	Same as in 1A2a.
1A2c	Chemicals	Chemical industry	Same as in 1A2a.
1A2d	Pulp, Paper and Print	Pulp, Paper and Print industry	Same as in 1A2a.
1A2e	Food Processing, Beverages and Tobacco	Food Processing, Beverages and Tobacco industry	Same as in 1A2a.
1A2f	Other (Combustion Installations in Industries)	Category 1A2 f contains Cement, Lime, Brick and tile, Fine ceramics, Asphalt concrete plants, Container glass, Glass, Glass wool, Mineral wool, Fibreboard Production, industrial biogas boilers and engines that do not provide heat or electricity to the public.	Same as in 1A2a and EKV 1991 and Cemsuisse (2008a)

### c) Transport (1A3)

#### Key category 1A3a

CO<sub>2</sub> from the combustion of Jet Kerosene of civil aviation (trend)

#### Key categories 1A3b

CO<sub>2</sub> from the combustion of Diesel Oil (level and trend)

CO<sub>2</sub> from the combustion of Gasoline (level and trend)

CH<sub>4</sub> from the combustion of Gasoline (trend)

N<sub>2</sub>O from the combustion of Diesel (trend)

N<sub>2</sub>O from the combustion of Gasoline (level)

#### Key category 1A3e

CO<sub>2</sub> from the combustion of Jet Kerosene of military aviation (trend)

The source category includes civil and military aviation, road transportation, railways, navigation and other transportation. Further off-road transportation is included in category 1A4 Other Sectors (off-road transport in agriculture and forestry) and in 1A5 Other (off-road,

e.g. construction). For information on bunker fuel emissions from international aviation, see Chapter 3.4.

Table 3-6 Specification of Swiss source category 1A3 "Transport".

1A3	Transport	Specification	Data Source
1A3a	Civil Aviation (National)	Large (jet, turboprop) and small (piston) aircrafts, helicopters	AD: SFOE 2008, FOCA 2006, 2006a, 2007, 2008
1A3b	Road Transportation	Light and heavy motor vehicles, coaches, two-wheelers	AD: SFOE 2008, EF: SAEFL 2004, 2004a, RWTÜV 2003, Hausberger et al. 2002, Gense 2002, 2002a
1A3c	Railways	Diesel locomotives	Method, AD, EF: INFRAS 2008
1A3d	Navigation (National)	Passenger ships, motor and sailing boats on the Swiss lakes	Method, AD, EF: INFRAS 2008,
1A3e	Military Aviation		VTG 2008

#### d) Other Sectors (1A4 – Commercial/Institutional, Residential, Agriculture/Forestry)

##### Key categories 1A4a

CO<sub>2</sub> from the combustion of Gaseous Fuels in the Commercial/Institutional Sector (level and trend)

CO<sub>2</sub> from the combustion of Liquid Fuels in the Commercial/Institutional Sector (level and trend)

##### Key categories 1A4b

CO<sub>2</sub> from the combustion of Gaseous Fuels in the Residential Sector (level and trend)

CO<sub>2</sub> from the combustion of Liquid Fuels in the Residential Sector (level and trend)

##### Key category 1A4c

CO<sub>2</sub> from the combustion of Liquid Fuels in Agriculture/Forestry (level)

Source category 1A4 "Other sectors" comprises emissions from fuels combusted in commercial and institutional buildings as well as in households and emissions from fuel combustion for grass drying and off-road machinery in agriculture.

Table 3-7 Specification of source category 1A4 "Other sectors".

1A4	Source	Specification	Data Source
1A4a	Commercial/ Institutional	Emission from fuel combustion in commercial and institutional buildings	AD: SFOE 2008, CEPE 2007 EF: EMIS 2009/1A4a, SAEFL 2000; SFOE 2001, IPCC 1997c
1A4b	Residential	Emissions from fuel combustion in households	AD: SFOE 2008 EF: EMIS 2009/1A4b, SAEFL 2000; SFOE 2001, IPCC 1997c
1A4c	Agriculture/ Forestry/ Fishing	Comprises fuel combustion for grass drying and off-road machinery in agriculture	AD: EMIS 2009/1A4c and INFRAS 2008 EF: EMIS 2009/1A4c, SFOE 2001; INFRAS 2008

### e) Other / Mobile (Off-road): Construction, Garden/Hobby, Industry and Military (1A5b)

#### Key category 1A5

CO<sub>2</sub> from the combustion of Liquid and Gaseous Fuels (level and trend)

In Switzerland, the sub-sources are defined according to the next table. The IPCC category structure distinguishes stationary (1A5a) and mobile (1A5b) sources. All of the Swiss sub-categories refer to mobile sources.

Table 3-8 Specification of Swiss source category 1A5 "Other" (off-road).

1A5	Other	Specification	Data Source
1A5a	Stationary	Not occurring in Switzerland (NO)	
1A5b	Mobile (Off-road)		
	- Construction	Construction vehicles and machinery	Method, AD, EF: INFRAS 2008
	- Garden/Hobby	Household and gardening machinery and motorised equipment	
	- Industry	Industrial off-road vehicles and machinery	
	- Military (without military aviation)	Tanks and similar off-road vehicles. (emissions from military road vehicles are included in 1A3b Road Transportation)	

## 3.2.2. Methodological Issues

### General Issues

#### *Sectoral (National) and Reference Approach*

Two methods are applied for modelling CO<sub>2</sub> emissions from the energy sector, the Sectoral (or National) Approach and the Reference Approach. For the Inventory of the Framework Convention and the Kyoto Protocol the Sectoral (National) Approach is used. The Reference Approach is only used for controlling purposes (quality control activity).

The National Approach uses specific methods for the different source categories: Fossil fuel consumption statistics (top-down approach, Tier 1) and bottom-up modelling of fuel consumption (bottom-up, Tier 2 and Tier 3). In the subsequent sections, the National Approach is documented in detail for each source category within 1A Fuel Combustion.

For the Reference Approach, the fossil fuel supply statistics is used. All imports and exports of primary fuels (crude oil, natural gas, coal), secondary fuels (gasoline, diesel oil etc.) and stock changes are published in the Swiss overall energy statistics (SFOE 2008) and the yearly reports of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2008). These statistics account for production, imports, exports, transformation and stock changes. The Reference Approach corresponds to a top-down approach (Tier 1) based on net quantities of fuel imported to Switzerland.

More detailed information on the comparison of the Sectoral with the Reference Approach can be found in Chapter 3.6.

#### *Oxidation Factors*

For the calculation of CO<sub>2</sub> emissions, an oxidation factor of 100% is assumed for all fossil fuel combustion processes (including coal), because technical standards for combustion

installations in Switzerland are relatively high and because the small fraction of originally non-oxidised carbon retained in ash, particulates or soot is likely to be oxidized later naturally due to degradation processes.

As the consumption of gaseous fuels strongly increased (1990 to 2007: +61.1% to 108'230 TJ), overestimating of oxidation factors for gaseous fuels would tend to overestimate emission increase and would therefore be conservative. As the consumption of liquid fuels decreased (1990 to 2007: -6.5% to 434'573 TJ) overestimating of oxidation factors for liquid fuels would tend to overestimate emission reduction and would therefore not be conservative. Because of the reasons mentioned above for the assumption of an emission factor of 100%, the possible overestimation of emission decrease is considered to be of minor importance.

For coal, IPCC 1996 provides a global average oxidation factor of 98.0%. However, a large share of coal in Switzerland is used in cement industry. In cement production, an oxidation factor of 100% may be assumed according to EU guidelines (EC 2004)<sup>4</sup>.

The consumption of coal plays a minor role in Switzerland. It decreased over the considered period (1990 to 2007: -36.0% to 10'146 TJ). In case of a decrease, overestimating of oxidation factors may tend to overestimate emission decrease. However, the main remaining consumer of coal in Switzerland is the cement industry that accounts for 66% of total Swiss coal consumption in 2007. With a large share of coal used in cement production, and under the assumption of high efficiency coal boilers, the overestimation of emission decrease may become minor.

Therefore, for all fuel combustion activities, an oxidation factor of 100% is assumed in Switzerland.

#### a) Energy Industries (1A1)

##### Key categories 1A1

CO<sub>2</sub> from the combustion of Gaseous Fuels (level)  
 CO<sub>2</sub> from the combustion of Liquid Fuels (level and trend)  
 CO<sub>2</sub> from the combustion of Solid Fuels (trend)  
 CO<sub>2</sub> from the combustion of Other Fuels (level and trend)  
 N<sub>2</sub>O from the combustion of Other Fuels (level and trend)

In Switzerland, Energy Industries (source category 1A1) comprise

- "Public Electricity and Heat Production" including heat and power production in municipal solid waste incineration plants and special waste incineration (1A1a)
- "Petroleum Refining" (1A1b).

Manufacture of Solid Fuels and Other Energy Industries (1A1c) do not occur.

#### Public Electricity and Heat Production (1A1a)

##### Methodology

For fuel combustion in Public Electricity and Heat Production (1A1a) except waste incineration, a country specific Tier 2 method is used. A top-down method based on

<sup>4</sup> EC 2004, Annex VII, Section 2.1.1: "In cement kilns the incomplete combustion of fossil fuels is negligible, due to the very high combustion temperatures, long residence time in kilns and minimal residual carbon found in clinker. Carbon in all kiln fuels shall therefore be accounted for as fully oxidized (oxidation factor = 1.0)."

aggregated fuel consumption data from the Swiss overall energy statistics is used to calculate emissions. These sources are characterised by rather similar industrial combustion processes and the same emission factors are applied throughout these sources. Emissions of GHGs are calculated by multiplying fuel consumption (in TJ) by emission factors.

For heat and/or power generation in municipal solid waste and special waste incineration plants the GHG emissions are calculated by multiplying the waste quantity incinerated by emission factors.

For fermentation engines and co-generation on landfills the GHG emissions are calculated by multiplying quantities of combusted CH<sub>4</sub> by emission factors.

An oxidation factor of 100% is assumed for all combustion processes and fuels (see subsection on oxidation factors in the beginning of Section 3.2.2).

### *Emission Factors*

(a) Waste incineration with heat and/or power generation (reported under "Other fuels")  
Emission factors for CO<sub>2</sub>, N<sub>2</sub>O, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> emissions per ton of waste incinerated are country specific based on measurements and expert estimates, documented in the EMIS database (EMIS 2009/1A1a). Emission factors are taking into account flue gas cleaning standards in incineration plants. CH<sub>4</sub> is not occurring because of the high combustion temperatures in waste incineration plants. The share of organic matter in the municipal solid waste is estimated to be 60% (for all years considered), based on analysis of municipal solid waste by the SFOE's waste section. The burn-out efficiency in modern municipal solid and hazardous waste incineration plants is very high.

### (b) Other Public Electricity and Heat Production

The emission factors for CO<sub>2</sub> are country specific and based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (EMPA 1999; carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61. See also Annex 2.1.1).

The activity data on LFO use in the CRF includes LPG consumption. This is due to statistical reasons in the Swiss overall energy statistics (SFOE 2008). Therefore the LFO emission factor for CO<sub>2</sub> used for the CRF (see table below) is a mixed emission factor that results as a weighted average of the LFO emission factor and LPG emission factor.

Emission factors for CH<sub>4</sub>, NO<sub>x</sub>, CO and NMVOC are country specific based on comprehensive life cycle analysis of industrial boilers, documented in SAEFL 2000 (pp. 14-27). For NO<sub>x</sub> emission factors, expert judgement has been used to estimate the fraction of low-NO<sub>x</sub> burners. For the related N<sub>2</sub>O emissions the default emission factors from IPCC 1997c have been used.

Emission factors for the use of wood in district heating are based on SAEFL 2000 (pp. 26ff). Emission factors for co-generation from landfills and fermentation engines are considered to be the same as for natural gas engines in commercial and institutional buildings (EMIS 2009/1A4a).

Since the fraction of stationary engines in total fuel consumption is rather small, emission factors for industrial combustion boilers are used for all sources and fuels (except for biomass). This simplification leads to a potential underestimation of CH<sub>4</sub> emissions from stationary sources in 1A1 of less than 2 tons of CH<sub>4</sub> per year (expert estimate FOEN).

The following table presents the emission factors used in 1A1a:

Table 3-9 Emission Factors for 1A1a Public Electricity and Heat Production in Energy Industries in 2007.  
Emission factors for waste incineration are provided per ton of waste incinerated for both municipal solid waste incineration and special waste incineration.

Source/fuel	CO <sub>2</sub> t/TJ	CO <sub>2</sub> bio. t/TJ	CH <sub>4</sub> kg/TJ	N <sub>2</sub> O kg/TJ	NO <sub>x</sub> kg/TJ	CO kg/TJ	NM VOC kg/TJ	SO <sub>2</sub> kg/TJ
<b>1A1a Public Electricity/Heat</b>								
Light fuel oil	73.50		1	0.6	32	11	2	32
Natural gas	55		6	0.1	14	14	2	0.5
Biomass (wood for district heating)		92	21	1.6	160	500	7	20
Biomass (co-generation from landfills)		55	23	0.1				
Biomass (fermentation engine)		55	23	0.1				
	CO <sub>2</sub> t/t	CO <sub>2</sub> bio. t/t	CH <sub>4</sub> kg/t	N <sub>2</sub> O g/t	NO <sub>x</sub> kg/t	CO kg/t	NM VOC kg/t	SO <sub>2</sub> kg/t
Other fuels (MSW)	0.508	0.763		95.06	0.400	0.104	0.016	0.054
Other fuels (special waste)	1.450			95.06	0.400	0.104	0.016	0.054

In the table above, the CO<sub>2</sub> emission factor of light fuel oil (73.50 t/TJ) is a weighted average<sup>5</sup> emission factor including both LFO (73.7 t/TJ) and LPG (65.5 t/TJ) emissions.

The emission factor for N<sub>2</sub>O from municipal solid waste incineration has increased significantly from 60 g N<sub>2</sub>O per ton of waste in 1990 to 95.06 g/t in 2007. This is due to the increased use of DeNO<sub>x</sub>-equipment with the municipal solid waste incineration plants (EMIS 2009/1A1). It is expected that the N<sub>2</sub>O emission factor is back to 14 g/t in 2020 (EMIS 2009/1A1). This contributes to the fact that N<sub>2</sub>O emissions from 1A1 are a key category regarding trend.

### Activity Data

#### (a) Municipal solid waste incineration ("Other fuels")

Energy recovery from municipal solid waste incineration is mandatory in Switzerland and plants are equipped with energy recovery systems (Schwager 2005). The emissions from heat and/or power generation in municipal solid waste incineration plants are therefore reported under category 1A1a<sup>6</sup>. Included are also emissions from the incineration of special waste, because these plants are also equipped with energy recovery systems. Activity data for waste incineration is provided in the table below.

<sup>5</sup> Calculation: 73.50 t/TJ = (179'462 TJ \* 73.7 t/TJ + 4'543 TJ \* 65.5 t/TJ) / (184'005 TJ) for the year 2007, where 179'462 TJ refers to LFO and 4'543 TJ to LPG.

<sup>6</sup> In earlier submissions, some of the emissions from municipal solid waste incineration have been reported also under category 6C.

Table 3-10 Activity data for 1A1a "Other fuels": municipal solid waste and special waste incinerated with heat and/or power generation 1990 to 2007.

Source/fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A1a Other fuels											
Total Other fuels in 1A1a	Gg	2'603	2'477	2'467	2'441	2'411	2'433	2'471	2'535	2'655	2'824
Municipal solid waste	Gg	2'470	2'340	2'310	2'310	2'250	2'270	2'290	2'337	2'419	2'586
Special waste	Gg	133	137	157	131	161	163	181	198	237	238

Source/fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007
1A1a Other fuels									
Total Other fuels in 1A1a	Gg	3'040	3'163	3'258	3'226	3'366	3'527	3'896	3'816
Municipal solid waste	Gg	2'801	2'936	3'027	2'995	3'135	3'297	3'646	3'580
Special waste	Gg	239	227	232	231	231	230	250	236

The table above documents the increase of municipal solid waste incinerated by 45% from 1990 to 2007. This is due to the fact that since 1<sup>st</sup> of January 2000, disposal on landfill sites of waste which can be incinerated, is prohibited by law. See also Chapter 8.4 on Waste Incineration. This increase results in CO<sub>2</sub> emissions from "Other fuels" (i.e. MSW incineration) in category 1A1 being a key category regarding trend. Also, municipal solid waste is imported from neighbouring countries to optimize the load factor of MSW incineration plants.

#### (b) Other Public Electricity and Heat Production

Activity data on fuel consumption (TJ) for Public Electricity and Heat Production (1A1a) is extracted from the Swiss overall energy statistics. The activity data for 2007 correspond to the consumption of LFO, natural gas and biomass (wood) in public district heating systems (SFOE 2008; tables 21, 26, and 28). "Other fuel" is calculated from the annual amount of municipal solid waste incinerated with heat and/or electricity (see Table 3-10). Activity data for co-generation from landfills and fermentation engines is taken from the Swiss renewable energies statistics (SFOE 2008a).

Activity data for the use of wood for district heating has not yet been updated to include new data from the Swiss overall energy statistics for the years 2002-2005. It is planned to include these data in the next submission.

Table 3-11 Activity data in 1A1a Public Electricity/Heat.

Source/fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A1a Public Electricity /Heat Fuel Consumption											
Total	TJ	40047	41342	43185	38309	37751	38668	41437	42411	47698	45719
Light fuel oil	TJ	980	1790	1917	1662	810	554	810	1065	852	725
Heavy fuel oil	TJ	3195	5006	6336	1748	1541	1791	2420	1063	4093	815
Natural gas	TJ	4271	4694	4640	4603	4702	5291	6552	6916	6757	6674
Coal	TJ	499	105	105	79	79	53	0	0	0	0
Other (waste-to-energy)	TJ	30768	29369	29684	29595	29880	30264	30911	32661	35284	36784
Biomass (wood for district heating)	TJ	40	40	70	50	60	50	70	50	60	60
Biomass (co-generation from landfills)	TJ	228	265	353	484	586	563	563	535	525	530
Biomass (fermentation engine)	TJ	65	74	79	88	93	102	112	121	126	130

Source/fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007
1A1a Public Electricity /Heat Fuel Consumption									
Total	TJ	46417	48440	48713	49496	50813	53192	56905	54780
Light fuel oil	TJ	512	554	512	682	554	852	938	426
Heavy fuel oil	TJ	0	0	0	0	0	0	9	0
Natural gas	TJ	5777	6273	6031	6780	6802	6947	5845	4755
Coal	TJ	0	0	0	0	0	0	0	0
Other (waste-to-energy)	TJ	39371	40915	41472	41298	42786	44745	49405	48660
Biomass (wood for district heating)	TJ	70	70	130	160	180	190	250	480
Biomass (co-generation from landfills)	TJ	525	460	377	358	246	186	160	134
Biomass (fermentation engine)	TJ	163	167	191	218	244	271	298	325

The table above documents the increase of Gaseous Fuel consumption by 11% from 1990 to 2007. This increase is one of the reasons for category 1A1 Gaseous Fuels – CO<sub>2</sub> being a key category regarding trend. From 2005 to 2007 Gaseous Fuel consumption dropped, as gas was substituted by other fuels. "Other (waste-to-energy)" comprises municipal solid waste (MSW), which also includes biomass, and special waste. Biomass (other than MSW) comprises co-generation on landfills, fermentation engines, and use of wood for district heating.

## Petroleum Refining (1A1b)

### Methodology

For fuel combustion in Petroleum Refining (1A1b), a country specific Tier 2 bottom-up method is used. The calculations are generally based on measurements and data from individual point sources from the refining industry. The unit of emission factors refers to fuel consumption (in TJ).

### Emission Factors

Emission factors for CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CO, NMVOC and SO<sub>2</sub> are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2009/1A1b, see Section 1.4.3) and in SAEFL 2000.

The following table presents the emission factors used in 1A1b:

Table 3-12 Emission Factors for 1A1b Petroleum Refining in 2007.

Source/fuel	CO <sub>2</sub> t/TJ	CH <sub>4</sub> kg/TJ	N <sub>2</sub> O kg/TJ	NO <sub>x</sub> kg/TJ	CO kg/TJ	NM VOC kg/TJ	SO <sub>2</sub> kg/TJ
<b>1A1 b Petroleum Refining</b>							
Heavy fuel oil	77	4.0	0.8	110	15	2.5	490
Gas (refinery LPG)	59.3	1.0	0.6	55	15	2.3	25
P-Coke	94.0	10	1.6	200	100	10.0	500

### Activity Data

Activity data on fuel combustion (TJ) for Petroleum Refining (1A1b) is extracted from the Annual Reports of the Swiss Petroleum Association (EV 2008).

Table 3-13 Activity data in 1A1b Petroleum Refining.

Source/fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A1b Petroleum Refining Fuel Consumption											
Total	TJ	5'906	8'670	8'137	9'290	10'679	10'317	11'092	10'693	11'022	11'353
Heavy fuel oil	TJ	1'296	1'216	998	1'054	1'426	1'834	1'618	1'780	1'428	1'698
Gas (refinery LPG)	TJ	4'610	7'454	7'139	8'237	9'253	8'483	9'474	8'913	9'594	9'655
Petroleum coke	TJ	0	0	0	0	0	0	0	0	0	0

Source/fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007
1A1b Petroleum Refining Fuel Consumption									
Total	TJ	10'091	10'909	11'447	10'525	14'360	14'579	15'998	13'640
Heavy fuel oil	TJ	1'952	1'936	1'518	1'769	1'339	906	692	1'159
Gas (refinery LPG)	TJ	8'139	8'973	9'929	8'756	11'901	11'678	13'311	10'766
Petroleum coke	TJ	0	0	0	0	1'120	1'995	1'995	1'715

The table above documents the increase of gas (refinery LPG) consumption for petroleum refining by 134% from 1990 to 2007. This is explained by the fact that in 1990 one of the two Swiss refineries operated at reduced capacity and in later years resumed full production, leading to higher fuel consumption. This increase is the major reason for CO<sub>2</sub> emissions from category 1A1 Gaseous Fuels being a key category regarding trend.

Since 2004, one of the Swiss refineries is using petroleum coke as a fuel.

### b) Manufacturing Industries and Construction (1A2)

#### Key categories 1A2

CO<sub>2</sub> from the combustion of Gaseous Fuels (level and trend)

CO<sub>2</sub> from the combustion of Liquid Fuels (level and trend)

CO<sub>2</sub> from the combustion of Solid Fuels (level and trend)

CO<sub>2</sub> from the combustion of Other Fuels (level and trend)

### Methodology

For fuel combustion in Manufacturing Industries and Construction (1A2) a country specific Tier 2/3 method is used. The method combines both bottom-up and top-down elements (see table below). Emissions of GHGs are calculated by multiplying levels of activity by emission factors.

- A *top-down* method based on aggregated fuel consumption data from the Swiss overall energy statistics and energy-economic modelling is used to calculate overall emissions of each of the categories 1A2a to 1A2f. Identical emission factors for each fuel type are applied throughout these sources with the exception of the emission factor for coal in 1A2f, because it is the only category in which the use of lignite occurs. The unit of emission factors refers to fuel consumption (in TJ).
- A *bottom-up* (Tier2/Tier3) method is used to calculate the emissions for a part of the activities in the categories in 1A2a, 1A2b, 1A2d and 1A2f (see Table 3-14). This bottom-up approach does not change overall emissions of the gases CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O in these categories, as in each of the categories, the difference between the bottom-up part and the top-down allocation for the entire category is allocated to other sources in this category (with the exception of the fossil part of waste combustion in cement industry). Estimates for heavy fuel oil and coal consumption for the bottom-up part of 1A2f exceeded the amounts allocated top-down for 1A2f in some years. It was interpreted that this was due to stock changes, and corresponding corrections were made. Activities which were determined bottom-up are: Cupola furnaces in iron foundries and reheating furnaces in steel plants (1A2a); Aluminium second smelter and non-ferrous metal foundries (1A2b); biomass use in Pulp, Paper and Print (1A2d); Cement, Lime, Brick and tile, Fine ceramics, Asphalt concrete plants, Container glass, Glass, Glass wool, Mineral wool, Fibreboard production and industrial biogas boilers and engines that do not provide heat or electricity to the public (all in 1A2f). For this submission, Mineral wool impregnation has been added as a new process in addition to Mineral wool production in 1A2f. The calculations are based on measurements and data from individual point sources from industry. Emission factors refer both to fuel consumption (in TJ) or production data (e.g. in tons of steel or cement produced). A bottom-up approach is also used to estimate CO<sub>2</sub> emissions from waste derived fuels used in cement industry ("Other fuels").

Table 3-14 Overview on methods applied to calculate GHG emissions in 1A2.

Source	Specification	Data Source
1A2a Iron and Steel Cupola furnaces in iron foundries and reheating furnaces in steel plants Other sources in 1A2a	Bottom-up Top-down	EMIS 2009/1A2a
1A2b Non-Ferrous Metals Aluminium second smelter and non-ferrous metal foundries Other sources in 1A2b	Bottom-up Top-down	EMIS 2009/1A2b
1A2c Chemicals	Top-down	
1A2d Pulp, Paper and Print Biomass (waste derived fuels from paper and pulp) All other fuels	Bottom-up Top-down	Industry data, EMIS 2009/1A2d
1A2e Food Processing, Beverages, and Tobacco	Top-down	
1A2f Other Cement/Lime/Glass/... industry Other sources in 1A2f	Bottom-up Top-down	Industry data, EMIS 2009/1A2f

An oxidation factor of 100% is assumed for all combustion processes and fuels (see subsection on oxidation factors in the beginning of Section 3.2.2).

## Emission factors

### *Top-down approach*

For all sources and gases where a top-down approach is applied, emission factors are the same as for source category 1A1a.

The emission factors for CO<sub>2</sub> are country specific and based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (EMPA 1999; carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61. See also Annex A2.1.1).

The activity data on LFO use from the Swiss overall energy statistics (SFOE 2008) includes also LPG consumption. Therefore the LFO emission factor for CO<sub>2</sub> is a mixed emission factor that results as a weighted average of the LFO emission factor and LPG emission factor as in 1A1a (See Section 3.2.2 a).

The coal emission factor for CO<sub>2</sub> is the emission factor of hard coal. Unlike in previous submissions, a mixed emission factor resulting from a weighted average of hard coal and lignite is only applied to cement production in category 1A2f, because lignite consumption is accounted for exclusively in this activity (see below, bottom-up approach). For net calorific values see Annex A2.1.1.

Emission factors for CH<sub>4</sub>, NO<sub>x</sub>, CO and NMVOC are country specific based on comprehensive life cycle analysis of industrial boilers, documented in SAEFL 2000 (pp. 14-27). For NO<sub>x</sub> emission factors, expert judgement has been used to estimate the fraction of low-NO<sub>x</sub> burners. For top-down N<sub>2</sub>O emissions the default emission factors from IPCC 1997c

have been used.  $\text{NO}_x$ , CO, NMVOC and  $\text{SO}_2$  implied emission factors for each of the categories (see Table 3-15) were revised to have a more coherent allocation of emissions to fuel use in different processes.

All emission factors for biomass are based on SAEFL 2000 (pp. 26ff).

Since the fraction of stationary engines in total fuel consumption is rather small, emission factors for industrial combustion boilers are used for all sources and fuels. This simplification leads to a potential underestimation of  $\text{CH}_4$  emissions from stationary sources in 1A2 of less than 4 tons of  $\text{CH}_4$  per year (expert estimate FOEN).

The following table presents the emission factors used for the sources in categories 1A2a-f that are calculated with the top-down approach:

Table 3-15 Emission factors for sources in 1A2a-f for 2007. For sources that include activities calculated bottom-up (see Table 3-14 further above), the table shows implied emission factors.

Source/fuel	CO <sub>2</sub> t/TJ	CO <sub>2</sub> bio. t/TJ	CH <sub>4</sub> kg/TJ	N <sub>2</sub> O kg/TJ	NO <sub>x</sub> kg/TJ	CO kg/TJ	NM VOC kg/TJ	SO <sub>2</sub> kg/TJ
<b>1A2 "top-down" sources</b>								
<b>1A2a Iron and Steel (Total)</b>								
LFO	73.50		1.0	0.6	32	11	2	32
HFO	77.00		4.0	0.8	125	15	4	344
Coal	94.00		10.0	1.6	41	1960	9	339
Gas	55.00		6.0	0.1	43	4	2	1
Biomass								
Other Fuels								
<b>1A2b Non-Ferrous Metals</b>								
LFO	73.50		1.0	0.6	32	271	54	32
HFO	77.00		4.0	0.8	125	15	4	344
Coal								
Gas	55.00		6.0	0.1	14	14	2	1
Biomass								
Other Fuels								
<b>1A2c Chemicals</b>								
LFO	73.50		1.0	0.6	32	11	2	32
HFO	77.00		4.0	0.8	125	15	4	344
Coal	94.00		10.0	1.6	200	100	10	500
Gas	55.00		6.0	0.1	14	14	2	1
Biomass								
Other Fuels								
<b>1A2d Pulp, Paper and Print</b>								
LFO	73.50		1.0	0.6	32	11	2	32
HFO	77.00		4.0	0.8	125	15	4	344
Coal								
Gas	55.00		6.0	0.1	14	14	2	1
Biomass (Black liquor)		80.56	IE	IE	47	133	IE	49
Other Fuels								
<b>1A2e Food Processing, Beverages and Tobacco</b>								
LFO	73.50		1.0	0.6	32	11	2	32
HFO	77.00		4.0	0.8	125	15	4	344
Coal	94.00		10.0	1.6	200	100	10	500
Gas	55.00		6.0	0.1	14	14	2	1
Biomass								
Other Fuels								
<b>1A2f Other</b>								
LFO	73.50		1.0	0.6	33	25	6	34
HFO	77.00		3.7	0.8	223	449	2	162
Coal	96.23		1.3	1.6	55	549	3	67
Gas	55.00		6.0	0.1	57	68	8	9
Biomass		85.38	17.6	1.1	116	352	5	14
Other Fuels	83.46		NO	16.3	IE	IE	IE	IE

*Remark:* In the table above, the CO<sub>2</sub> emission factor of light fuel oil of 73.50 t/TJ (2007) is a weighted average emission factor including both LFO (73.7t/TJ) and LPG (65.5t/TJ) emissions (the same as in 1A1a; see Section 3.2.2 a)). The CO<sub>2</sub> emission factor for coal in 1A2f Other (96.23 t/TJ in 2007) is a weighted average emission factor including hard coal (94 t/TJ), petroleum coke (94 t/TJ) and lignite (104 t/TJ) emissions<sup>7</sup>. In the other categories, the CO<sub>2</sub> emission factor for coal refers to hard coal or petroleum coke (both have the same emission factor). Note that in the CRF files, source category 1A2f is further differentiated into glass, cement etc. on the one hand and other non-specified sources on the other hand, implying also a distinction of emission factors for coal, because lignite is attributed only to cement production. It is planned to merge these sources into a single category 1A2f.

Emissions of CH<sub>4</sub>, N<sub>2</sub>O and NMVOC from the use of biomass (black liquor) in 1A2d Pulp, Paper and Print are included in the emissions from the related heavy fuel oil use for the biomass boiler.

Emission factors from the use of light fuel oil in 1A2b Non-Ferrous Metals are the weighted average of related emission factors of aluminium second smelter and other Non-Ferrous metals.

### *Bottom-up approach*

By default, also for the bottom-up approach the same emission factors for CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O as for the top-down approach are used, unless more specific information is available on emission factors. Following IPCC Tier 3, bottom-up emission factors for emissions other than CO<sub>2</sub>, CH<sub>4</sub> or N<sub>2</sub>O are based on production data (e.g. tons of cement or steel produced) or on fuel consumption. NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> implied emission factors for each of the categories (see Table 3-15) were revised to have a more coherent allocation of emissions to fuel use in different processes.

The emission factors for CO<sub>2</sub> are country specific and based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (EMPA 1999; carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61). For net calorific values see Annex A2.1.1.

The coal emission factor for CO<sub>2</sub> in source category 1A2f is a mixed emission factor that results as a weighted average of the hard coal, petroleum coke and lignite emission factors.

Emission factors for CH<sub>4</sub>, N<sub>2</sub>O, CO and NMVOC are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2009/1A2, see Section 1.4.3). They have been updated for the recent years by expert judgement.

The following two tables present the emission factors used in the bottom-up approach for emissions of Iron and Steel (1A2a) and for the cement industry.

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<sup>7</sup> Calculation:

$96.23 \text{ t/TJ} = (1'709 \text{ TJ} * 104 \text{ t/TJ} + 5'956 \text{ TJ} * 94 \text{ t/TJ}) / (1'709 \text{ TJ} + 5'956 \text{ TJ})$  for 2006, where 1'709 TJ refers to lignite and 5'956 TJ to petroleum coke and hard coal.. The amount of lignite used increased significantly from 2004 to 2006 (from 80 TJ to 1'729 TJ, while total coal consumption increased from 7'267 TJ to 9'719 TJ) and remained at this level in 2007 (lignite 1'709 TJ, total coal 10'146 TJ). Therefore, the emission factor for coal is slightly higher in 2006 and 2007 than in previous years.

Table 3-16 Emission factors for sources in Iron and Steel 1A2a in 2007.

1A2a Iron and Steel (Coke and gas)	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	NO <sub>x</sub>	CO	NM VOC	SO <sub>2</sub>
	t/TJ	kg/TJ		g per ton of iron			
Coke cupolas	94.00	10.0	1.6	67	11000	40	1500
	t/TJ	kg/TJ		g per ton of steel			
Gas (steel plants)	55	6.0	0.1	75	0.5	2.8	0.7

Table 3-17 Emission factors for cement industry in 2007 (NO: not occurring). Source: EMIS data base (EMIS 2009/1A2f). Emission factors for CO<sub>2</sub> are fuel specific; they are the same as in the top-down approach (see Table 3-15).

Cement industry (part of 1A2f)	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	NO <sub>x</sub>	CO	NM VOC	SO <sub>2</sub>
	t/TJ	kg/t cement					
Cement	fuel specific	NO	0.0213	0.884	0.7	0.0045	0.036

These cement fuel consumption emission factors describe emissions from average fuel mix (of liquid, solid, gaseous and waste derived fuels).

The consumption of "Other" fuels in 1A2 refers to the use of waste derived fuels in the cement industry. The following table provides an overview of the emission factors per ton of waste used. The net calorific values are taken from FOEN internal data sources and the other characteristics of waste derived fuels are from Hackl, A., Mauschitz, G. 2003<sup>8</sup>.

<sup>8</sup> As cited in the EMIS data base. These emission factors are preliminary and may be revised for future submissions.

Table 3-18 Emission factors and other characteristics of waste derived fuels ("Other fuels") used in the cement industry. Sources: FOEN internal data sources, Hackl and Mauschwitz 2003.

	NCV	EF CO <sub>2</sub> Tot.	EF CO <sub>2</sub> Tot	Fraction biomass-C	EF CO <sub>2</sub> - fossil	EF CO <sub>2</sub> - biogenic
Waste derived fuel	MJ/kg	kg CO <sub>2</sub> / GJ	kg CO <sub>2</sub> /t of fuel	%	kg CO <sub>2</sub> /t of fuel	kg CO <sub>2</sub> /t of fuel
Waste oil	36.06	82.00	2957.31	0.00	2957.31	0.00
Sewage sludge (dried)	9.97	80.00	797.39	100.00	0.00	797.39
Wood	14.50	99.70	1445.60	100.00	0.00	1445.60
Solvents and residues from distillation	27.38	75.00	2053.85	0.00	2053.85	0.00
Waste tyres and rubber	25.57	84.00	2148.11	27.00	1568.12	579.99
Plastics	22.31	74.00	1650.85	3.00	1601.32	49.53
Animal fat	36.36	79.00	2872.07	100.00	0.00	2872.07
Animal meat	17.31	85.00	1471.37	100.00	0.00	1471.37
Mix of special waste with saw dust (CSS)	12.50	75.00	937.50	80.00	187.50	750.00
Waste coke from coke filters	23.70	97.00	2298.90	0.00	2298.90	0.00
Sawdust	13.90	104.00	1445.60	100.00	0.00	1445.60

For CSS (mix of special waste with saw dust), the share of biogenic C is estimated to be 80%.

### Activity data

#### *Top-down approach*

Activity data on fuel consumption (TJ) for "top-down" sources in category 1A2 (see Table 3-14 above) are based on aggregated fuel consumption data from the Swiss overall energy statistics (SFOE 2008) and energy-economic modelling. A detailed description of the modelling work for the disaggregation of fuel consumption to the level of 1A2a-f is provided in Annex A3.1.2.

The resulting disaggregated fuel consumption data for 1990 to 2007 is provided in the table below.

Table 3-19 Activity data fuel consumption in 1A2 Manufacturing Industries and Construction 1990 to 2007; "Other Fuels" occur only in the category 1A2f, where they refer to waste fuels in cement production. The consumption of these fuels has been calculated (in TJ) bottom-up from the amount (in tons) of waste derived fuels used.

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<b>1A2 Manufacturing Industries and Constr. (Total)</b>	TJ	88'496	88'339	87'519	85'842	87'651	86'340	86'113	88'906	90'979	91'860
Light fuel oil	TJ	25'590	28'300	28'353	27'580	27'169	26'979	28'433	31'260	33'316	33'499
Heavy fuel oil	TJ	18'870	17'386	16'851	14'379	14'914	11'678	10'883	9'964	9'582	9'370
Coal	TJ	14'737	11'362	8'748	7'616	7'866	8'018	5'292	4'691	4'295	4'234
Natural gas	TJ	19'394	21'354	23'440	25'587	27'091	28'292	28'843	30'484	31'098	32'259
Biomass	TJ	7'859	7'854	8'010	8'081	8'287	8'398	9'153	9'068	9'102	9'079
Other Fuels	TJ	2'047	2'082	2'118	2'598	2'324	2'974	3'509	3'439	3'586	3'420
<b>1A2a Iron and Steel</b>	TJ	3'213	3'266	3'493	3'412	3'392	2'891	3'040	3'260	3'377	3'367
Light fuel oil	TJ	815	829	833	815	795	652	662	722	763	776
Heavy fuel oil	TJ	349	339	347	342	335	96	96	104	109	107
Coal	TJ	489	530	560	441	473	352	306	314	330	314
Natural gas	TJ	1'559	1'569	1'753	1'815	1'789	1'791	1'977	2'120	2'175	2'170
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
<b>1A2b Non-Ferrous Metals</b>	TJ	511	600	457	468	459	647	688	886	976	1'117
Light fuel oil	TJ	240	241	225	201	206	216	214	251	268	271
Heavy fuel oil	TJ	2	2	2	1	1	2	1	1	1	1
Coal	TJ	0	0	0	0	0	0	0	0	0	0
Natural gas	TJ	269	358	230	266	252	429	473	634	707	845
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
<b>1A2c Chemicals</b>	TJ	15'425	14'676	14'560	13'955	14'401	15'504	15'835	15'409	15'281	14'446
Light fuel oil	TJ	3'117	3'197	2'753	2'874	2'731	3'750	3'736	3'409	2'985	2'726
Heavy fuel oil	TJ	1'739	1'151	896	1'146	892	465	486	459	361	266
Coal	TJ	226	213	198	184	188	179	155	136	124	118
Natural gas	TJ	10'343	10'116	10'712	9'751	10'590	11'109	11'459	11'404	11'811	11'336
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
<b>1A2d Pulp, Paper and Print</b>	TJ	11'665	11'285	12'698	12'476	13'302	11'788	10'960	11'276	11'119	10'882
Light fuel oil	TJ	539	788	986	927	861	954	1'051	992	1'036	1'124
Heavy fuel oil	TJ	5'226	4'701	4'307	3'671	3'337	3'120	2'972	3'179	3'150	2'999
Coal	TJ	1'014	619	112	0	0	0	0	0	0	0
Natural gas	TJ	2'800	3'280	5'581	6'354	7'662	6'357	5'495	5'579	5'323	5'064
Biomass	TJ	2'085	1'898	1'711	1'524	1'441	1'358	1'442	1'526	1'610	1'694
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
<b>1A2e Food Processing, Beverages and Tobacco</b>	TJ	7'301	7'697	7'134	7'513	7'252	8'044	8'919	8'792	9'054	9'568
Light fuel oil	TJ	4'636	4'806	4'741	4'843	4'822	4'847	5'071	4'989	5'237	5'241
Heavy fuel oil	TJ	1'162	1'050	917	824	760	738	662	525	493	494
Coal	TJ	441	369	440	379	284	340	429	377	217	215
Natural gas	TJ	1'061	1'472	1'036	1'467	1'385	2'119	2'757	2'902	3'107	3'617
Biomass	TJ	0	0	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0	0	0
<b>1A2f Other</b>	TJ	50'381	50'815	49'179	48'018	48'846	47'467	46'670	49'282	51'172	52'480
Light fuel oil	TJ	16'243	18'440	18'815	17'921	17'753	16'560	17'699	20'896	23'027	23'360
Heavy fuel oil	TJ	10'390	10'144	10'382	8'394	9'588	7'258	6'667	5'696	5'468	5'502
Coal	TJ	12'567	9'632	7'438	6'613	6'922	7'147	4'402	3'864	3'624	3'587
Natural gas	TJ	3'361	4'560	4'127	5'935	5'413	6'487	6'683	7'845	7'976	9'226
Biomass	TJ	5'774	5'956	6'299	6'557	6'846	7'040	7'711	7'542	7'491	7'384
Other Fuels (waste incineration in cement industry)	TJ	2'047	2'082	2'118	2'598	2'324	2'974	3'509	3'439	3'586	3'420

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007
<b>1A2 Manufacturing Industries and Constr. (Total)</b>	TJ	95'032	96'138	95'690	96'061	97'381	98'254	99'121	100'514
Light fuel oil	TJ	33'145	33'587	33'875	33'796	32'930	32'663	31'947	29'998
Heavy fuel oil	TJ	7'315	7'134	6'144	5'415	5'721	5'703	5'727	4'772
Coal	TJ	6'160	6'284	5'838	5'931	5'773	6'671	7'351	8'057
Natural gas	TJ	34'876	34'800	34'452	35'007	36'530	37'008	37'357	39'210
Biomass	TJ	9'615	9'601	10'080	10'362	10'659	10'795	11'421	13'415
Other Fuels	TJ	3'922	4'732	5'301	5'549	5'767	5'415	5'319	5'061
<b>1A2a Iron and Steel</b>	TJ	3'747	3'924	3'880	3'922	3'558	3'375	3'450	3'488
Light fuel oil	TJ	816	828	819	803	775	712	733	730
Heavy fuel oil	TJ	124	128	117	118	114	101	101	105
Coal	TJ	273	370	454	484	192	226	246	207
Natural gas	TJ	2'534	2'598	2'490	2'517	2'477	2'336	2'369	2'446
Biomass	TJ	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0
<b>1A2b Non-Ferrous Metals</b>	TJ	1'104	1'011	972	1'000	1'069	1'061	864	742
Light fuel oil	TJ	272	259	262	262	251	243	212	187
Heavy fuel oil	TJ	1	1	1	0	1	1	1	0
Coal	TJ	0	0	0	0	0	0	0	0
Natural gas	TJ	831	751	709	738	817	817	652	554
Biomass	TJ	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0
<b>1A2c Chemicals</b>	TJ	14'985	15'946	15'382	15'004	15'257	15'453	16'379	16'442
Light fuel oil	TJ	3'034	3'213	3'120	3'059	3'103	3'146	3'301	3'510
Heavy fuel oil	TJ	263	335	183	123	150	159	265	254
Coal	TJ	111	95	86	80	75	70	70	72
Natural gas	TJ	11'577	12'302	11'992	11'743	11'929	12'078	12'743	12'607
Biomass	TJ	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0
<b>1A2d Pulp, Paper and Print</b>	TJ	11'126	11'197	11'716	11'602	10'540	10'773	9'556	8'980
Light fuel oil	TJ	1'092	1'043	1'081	1'031	1'000	987	953	636
Heavy fuel oil	TJ	2'529	2'624	2'473	2'376	2'270	2'206	2'353	1'998
Coal	TJ	0	0	0	0	0	0	0	0
Natural gas	TJ	5'811	6'084	6'420	6'310	5'241	5'527	4'174	4'247
Biomass	TJ	1'694	1'447	1'741	1'885	2'029	2'053	2'076	2'099
Other Fuels	TJ	0	0	0	0	0	0	0	0
<b>1A2e Food Processing, Beverages and Tobacco</b>	TJ	9'356	8'829	9'037	8'996	9'134	9'188	9'299	9'126
Light fuel oil	TJ	5'168	5'049	5'006	4'958	4'737	4'688	4'535	4'255
Heavy fuel oil	TJ	466	434	406	371	407	422	420	359
Coal	TJ	128	127	222	195	94	119	106	114
Natural gas	TJ	3'593	3'219	3'403	3'472	3'896	3'960	4'238	4'398
Biomass	TJ	0	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0	0
<b>1A2f Other</b>	TJ	54'715	55'230	54'703	55'535	57'823	58'404	59'573	61'736
Light fuel oil	TJ	22'763	23'194	23'587	23'683	23'064	22'888	22'213	20'679
Heavy fuel oil	TJ	3'932	3'613	2'964	2'426	2'780	2'814	2'587	2'056
Coal	TJ	5'647	5'691	5'074	5'172	5'412	6'256	6'928	7'665
Natural gas	TJ	10'530	9'846	9'438	10'228	12'171	12'290	13'181	14'958
Biomass	TJ	7'921	8'154	8'339	8'477	8'630	8'742	9'345	11'316
Other Fuels (waste incineration in cement industry)	TJ	3'922	4'732	5'301	5'549	5'767	5'415	5'319	5'061

The table above documents the increase of Natural Gas consumption for manufacturing industries by 102% from 1990 to 2007 as well as the net decrease of liquid fuel consumption by -22% and the decrease of coal consumption by -45% over this period. This shift in fuel mix is the reason for CO<sub>2</sub> emissions from the use of Gaseous, Liquid and Solid Fuels in category 1A2 being key categories regarding trend.

*Bottom-up approach*

Activity data on iron and steel production that is used to calculate bottom-up emissions from cupola furnaces in iron foundries and reheating furnaces in steel plants is based on data from EMIS 2009/1A2a.

Table 3-20 Activity data: Production in Iron and Steel that is used to calculate bottom-up emissions from sources in 1A2a (EMIS 2009/1A2a).

Source/production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A2a Iron and Steel											
Iron foundries: cupol ovens	Gg	90	72	68	54	55	60	51	53	57	56
Steel plants: reheating furnaces	Gg	1'108	1'155	1'245	1'276	1'230	716	738	789	880	918

Source/production	Unit	2000	2001	2002	2003	2004	2005	2006	2007
1A2a Iron and Steel									
Iron foundries: cupol ovens	Gg	55	49	37	34	35	35	34	37
Steel plants: reheating furnaces	Gg	1'022	1'048	1'125	1'143	1'226	1'159	1'254	1'267

Activity data on cement production have been received from the industry association Cemsuisse (2008a) (See Table 4-4 in Chapter 4.2.2 a). For the year 1990, activity data for fuel use in cement production from EKV 1991 has been used.

The amount of waste derived fuels used in cement industry (in tons) is provided by the following table. Data has been collected from the following sources<sup>9</sup>: Estimates by FOEN experts, and Cemsuisse (2008, 2008a) . The activity data is used to calculate CO<sub>2</sub> emissions from "Other fuels" in 1A2f.

<sup>9</sup> As cited in the EMIS data base.

Table 3-21 Activity data: Amount of waste derived fuels ("Other fuels") in cement industry. Sources: Estimates by SAEFL experts (in *italics*), EKV (1991) and Cemsuisse (2008, 2008a).

Year	Waste oil	Sewage sludge (dried)	Waste wood	Solvents and residues from distillation	Waste tyres and rubber	Plastics	Animal fat and meal	Other waste fuels	Total
	t	t	t	t	t	t	t	t	t
1990	42'203	5'418	3'724	1'000	6'000	0	0	20'000	78'344
1991	42'936	5'418	3'724	1'000	6'000	0	0	20'000	79'077
1992	42'230	5'418	3'724	3'500	6'000	0	0	20'000	80'872
1993	42'937	5'418	4'966	5'500	15'250	0	0	20'000	94'070
1994	37'205	6'897	6'534	5'354	15'245	1'089	0	18'421	90'745
1995	45'705	13'651	19'745	7'679	15'723	2'194	0	17'185	121'881
1996	46'600	18'600	24'300	11'600	15'900	7'000	9'100	14'500	147'600
1997	38'701	25'538	19'610	17'353	13'861	10'855	10'759	13'368	150'045
1998	46'474	23'046	0	15'874	13'740	20'130	10'294	15'241	144'799
1999	43'199	29'707	0	11'493	12'152	21'894	9'743	16'780	144'968
2000	46'775	35'374	0	18'063	15'929	22'680	9'113	19'619	167'553
2001	41'299	37'076	0	21'863	18'047	23'776	47'472	16'534	206'067
2002	48'735	38'296	0	30'711	17'437	20'860	54'034	15'098	225'171
2003	45'850	41'100	0	31'300	21'500	20'800	63'550	14'798	238'898
2004	42'577	40'803	0	36'583	20'277	34'496	62'685	15'253	252'674
2005	39'125	49'598	0	35'647	25'215	37'691	45'846	13'311	246'432
2006	35'477	56'154	0	35'823	22'218	41'499	43'285	14'463	248'919
2007	25'247	57'696	0	53'396	19'295	41'905	38'974	17'169	253'682

The table above documents the increase of the use of waste derived fuels ("Other fuels") in cement industry by more than 200% from 1990 to 2007 (in tons; and by 150% in energy units). This increase is the reason for CO<sub>2</sub> emissions from category 1A2 Other fuels being a key category regarding trend. Please note that for some waste derived fuels no data on their use in cement production is available for the years before 1994 and that estimates by SFOE experts had to be made for these years.

The following table provides an overview of fuel use in cement industry in energy units (TJ):

Table 3-22 Activity data: Overview on fuel use in cement industry.

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Cement industry											
Cement, total incl. waste	TJ	16'435	14'267	13'512	12'074	13'493	12'829	11'171	10'321	10'169	10'062
Cement fossil without waste	TJ	14'388	12'185	11'394	9'475	11'169	9'855	7'663	6'883	6'583	6'641
HFO	TJ	1'907	2'957	4'377	3'263	4'589	2'825	3'507	3'206	3'168	3'260
Coal	TJ	12'119	9'214	6'950	6'164	6'552	6'862	4'123	3'666	3'353	3'260
Gas	TJ	362	14	67	48	27	168	34	10	62	121
Cement, waste derived fuel	TJ	2'047	2'082	2'118	2'598	2'324	2'974	3'509	3'439	3'586	3'420
Cement waste biomass	TJ	122	105	88	191	429	680	973	988	693	753
Cement waste fossil	TJ	1'925	1'977	2'030	2'408	1'895	2'295	2'535	2'450	2'893	2'668

Source	Unit	2000	2001	2002	2003	2004	2005	2006	2007
Cement industry									
Cement, total incl. waste	TJ	10'872	11'361	11'046	10'982	11'298	11'551	11'663	11'907
Cement fossil without waste	TJ	6'951	6'629	5'746	5'433	5'531	6'136	6'344	6'846
HFO	TJ	1'530	1'194	1'079	621	754	637	220	175
Coal	TJ	5'399	5'424	4'656	4'812	4'762	5'495	6'120	6'653
Gas	TJ	22	11	11	0	16	4	4	17
Cement, waste derived fuel	TJ	3'922	4'732	5'301	5'549	5'767	5'415	5'319	5'061
Cement waste biomass	TJ	850	1'698	1'835	2'098	2'026	1'657	1'656	1'524
Cement waste fossil	TJ	3'071	3'033	3'466	3'452	3'741	3'758	3'662	3'537

### c) Transport (1A3)

#### Key category 1A3a

CO<sub>2</sub> from the combustion of Jet Kerosene of civil aviation (trend)

#### Key categories 1A3b

CO<sub>2</sub> from the combustion of Diesel Oil (level and trend)

CO<sub>2</sub> from the combustion of Gasoline (level and trend)

CH<sub>4</sub> from the combustion of Gasoline (trend)

N<sub>2</sub>O from the combustion of Diesel (trend)

N<sub>2</sub>O from the combustion of Gasoline (level)

#### Key category 1A3e

CO<sub>2</sub> from the combustion of Jet Kerosene of military aviation (trend)

In Switzerland, Transport (1A3) contains the sub-categories

- Aviation (1A3a, national civil aviation),
- Road Transportation (1A3b),
- Railways (1A3c),
- Navigation (1A3d, national navigation),
- Military Aviation (Other Transportation 1A3e).

### Aviation (1A3a)

#### Key category 1A3a

CO<sub>2</sub> from the combustion of Jet Kerosene of Civil Aviation (trend)

### *Methodology*

The emissions of civil aviation are modelled by a Tier 3a method developed by FOCA (2006). FOCA is represented in the emissions technical working group (CAEP WG3) and in the environmental operations working group (CAEP WG2) of the International Civil Aviation Organisation (ICAO). FOCA is directly involved in the development of ICAO guidance material for the calculation of aircraft emissions and in the update of the IPCC guidelines (via the secretariat of ICAO CAEP (Committee on Aviation Environmental Protection)). The Tier 3a method applied for the emission modelling is in line with the methods developed in the working groups mentioned. Note that the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) have been prepared by the IPCC Task Force on National Greenhouse Gas Inventories and have been adopted in April 2006 by the IPCC. Under the UNFCCC, they have not yet been adopted for mandatory use in reporting on GHG inventories. Formally, the method therefore should be considered as a country specific method until improvement.

The Tier 3a method follows standard modelling procedures on the level of single movements based on detailed movement statistics. The primary key for all calculations is the aircraft tail number, which allows to calculate on the most precise level, namely on the level of the individual aircraft and engine type. Every aircraft is linked to the FOCA engine data base containing emission factors for more than 520 individual engines with different power settings. Emissions in the landing and take-off cycle (LTO) are calculated with aircraft category dependant flight times and corresponding power settings. Cruise emissions are calculated based on the individual aircraft type and the trip distance for every flight. For piston-engine powered aircraft, so far, FOCA has been the only provider of publicly available engine data and a full methodology. All piston engine data and study results have been published in 2007 (FOCA 2007a).

All flights from and to Swiss airports are separated into domestic (national) and international flights prior to the emission calculation. The emissions of domestic flights are reported under 1A3a Civil Aviation, the emissions of international flights are reported under international bunker emissions (memo items).

The emission factors used are country specific or are taken from the ICAO engine emissions databank, from EMEP/CORINAIR databases (EEA 2002), Swedish Defence Research Agency (FOI) and Swiss FOCA measurements (precursors). Cruise emission factors are generally calculated from the values of the ICAO engine emissions databank, adjusted to cruise conditions by using the Boeing Fuel Flow Method 2. For N<sub>2</sub>O, the IPCC default emission factor is used. Activity data are derived from a detailed movement statistics.

A complete emission modelling (LTO and cruise emissions for domestic and international flights) has been carried out by Swiss FOCA for 1990, 1995, 2000, 2002, 2004–2007. The results of the emission modelling have been transmitted from FOCA to FOEN in a aggregated form. FOEN (the NIC) calculated the implied emission factors 1990, 1995, 2000, 2002, 2004 and carried out a linear interpolation for the years in-between. The interpolated implied emission factors were multiplied with the annual fuel sold from Swiss overall energy statistics (SFOE 2008), providing the missing emissions of civil aviation for the years 1991-1994, 1996-1999, 2001 and 2003.

Details of emission factors and activity data follow below. Further tables containing more information are also given in Annex A3.1.3, more detailed descriptions of the emission modelling may be found in FOCA (2006).

### *Emission Factors*

Kyoto gases:

- CO<sub>2</sub>: The value of 73.2 t/TJ is country specific and is based on measurements and analyses of fuel samples (see Table 3-3). Small yearly variations have been neglected so far.
- CH<sub>4</sub>, NMVOC (country specific; CORINAIR): VOC emissions (see “Precursors” below) are split into CH<sub>4</sub> and NMVOC by a constant share of 0.1 (CH<sub>4</sub>) and 0.9 (NMVOC)<sup>10</sup>. For CH<sub>4</sub>, the average emission factor for domestic flights 2.1 kg/TJ in 2007, average LTO is 4.0 kg/TJ, cruise 0.90 kg/TJ (FOCA 2007).
- N<sub>2</sub>O: The IPCC default value 2.3 kg/TJ is used for the whole period 1990–2007 (IPCC 1997b).

#### SO<sub>2</sub> (IPCC):

- The emission factor is taken from the IPCC Guidelines 1996, 23.0 kg/TJ, and is assumed to be constant over the period 1990–2007 (IPCC 1997c, chp 1.4.2.6)

#### Precursors (country specific; CORINAIR):

- Assignment of emission factors for the 1990 and 1995: The fleet that operated in and from Switzerland during those years has been analysed. The corresponding most frequent engines within an aircraft category (ICAO Code) have been assigned to every aircraft type.
- Assignment of emission factors for the 2000, 2002 and 2004: The actual engine of every single aircraft operating in and from Switzerland has been assigned. FOCA uses the aircraft tail number as the key variable which links activity data and individual aircraft engine information (see Annex A3.1.3 Table “Aircraft Engine Combinations”).

FOCA uses the following emission factors of NO<sub>x</sub>, VOC, CO and further pollutants:

#### LTO:

The Swiss FOCA engine emissions database consists of more than 520 individual engine data sets. Jet engine factors for engines above 26.7 kN thrust (emission certificated) are identical to the ICAO engine emissions databank. Emission factors for lower thrust engines, piston engines and helicopters were taken from manufacturers or from own measurements. Emission factors for turboprops could be obtained in collaboration with the Swedish Defence Research Agency (FOI).

#### Cruise:

Part of the cruise emission factors are taken from EMEP/CORINAIR (EEA 2002). Aircraft cruise emission factors are dependent on representative flight distances per aircraft type and a load factor of 65% are assumed. Part of the cruise factors are also taken from former CROSSAIR (FOCA 1991 The whole Airbus fleet (which produces a great portion of the Swiss inventory) has been modelled on the basis of real operational aircraft data from flight data recorders (FDR) of Swiss International Airlines.

Some of the old or missing aircraft cruise factors had to be modelled on the basis of the ICAO engine emissions databank, using the Boeing Fuel Flow Method 2. For piston engine aircraft, Swiss FOCA has produced its own data, which were taken under real flight conditions (2005 data).

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<sup>10</sup> for the previous submissions, a split of 0.53 : 0.47 has been used. The share of 0.1 for methane is maintained until general acceptance of necessary corrections is reached. Studies indicate that during cruise, Methane exhaust concentrations are lower than Methane ambient concentrations (Wiesen et al. 1994, Spicer et al, 1994). A first remark has been made in Table 1-52 of the IPCC Guidelines 1996.

## Activity Data

### Scheduled and charter aviation

The statistical basis has been extended after 1996. Therefore, the modelling details are not exactly the same for the years 1990/1995 as for the subsequent years. The source for the 1990 and 1995 modelling is the movement statistics, which records information for every movement on airline, number of seats, Swiss airport, arrival/departure, origin/destination, number of passengers, distance. From 1996 onwards, every movement in the FOCA statistics also contains the individual aircraft tail number (aircraft registration). This is the key variable to connect airport data and aircraft data. The statistics may contain more than one million records with individual tail numbers. All annual aircraft movements recorded are split into domestic and international flights (there are 421'780 aircraft movements in the total of domestic and international in 2007).

### Non-scheduled, non-charter and General Aviation (including Helicopters)

- Airports and most of the airfields report individual aircraft data (aircraft registration). FOCA may therefore compute the inventory for small aircraft with Tier 3a method, too. However, for 1990 and 1995, the emissions data for non-scheduled, non-charter and General Aviation (helicopters etc.) could not be calculated with a Tier 3a method. Its fuel consumption is estimated to 10% of the domestic fuel consumption. Data were taken from two FOCA studies (FOCA 1991, FOCA 1991a). For 2000-2007, all movements from airfields are known, which allows a more detailed modelling of the emissions (FOCA 2007a).
- Helicopters: The movements are taken from "Unternehmensstatistik der Schweizer Helikopterunternehmen" (FOCA 2004), which is updated yearly. From fleet composition data, a split of 87% single engine helicopters and 13% twin engine helicopter can be derived. Note that all emissions from helicopter are considered domestic. There is a helicopter base in the Principality of Liechtenstein consuming a certain very small amount of fuel contained in the Swiss statistics. Thus, its consumption leads to domestic instead of international bunker emissions (about 0.4 Gg CO<sub>2</sub>). FOCA and FOEN decided to report these emissions as Swiss-domestic since it is a very small amount and the effort for a separation would be considerable. In 2007, the determination of the activity data has been changed to electronical transmission and plausibility checks (software E-Plaus). Due to a higher resolution, the number of helicopter movements increased statistically (not in real-world) leading to an overestimation of the helicopter emissions in 2007. However, the development of detailed helicopter emissions modelling has to be considered as fine tuning, given the fact that helicopter emissions usually represent less than 1% of the civil aviation total emissions.

Fuel consumption: Table 3-23 summarises the activity data for domestic (1A3a). As well, international aviation, which belongs to the memo items, international bunkers/aviation, is indicated too (see also 3.4).

Table 3-23 Fuel consumption of civil aviation in TJ. The "domestic" consumption and the corresponding emissions are reported under 1A3a, the "international" consumption is reported under Memo items, international bunkers/aviation (FOCA 2007a, 2007, 2008).

Civil Aviation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Fuel consumption in TJ									
Total domestic (1A3a)	3'450	3'194	3'217	3'165	3'077	3'075	2'972	2'850	2'742	2'684
Total international	41'884	40'872	43'499	45'342	46'840	49'918	51'975	53'983	56'599	60'805
Sum	45'334	44'067	46'717	48'508	49'917	52'993	54'946	56'833	59'341	63'489
1990 = 100%	100%	97%	103%	107%	110%	117%	121%	125%	131%	140%

Civil Aviation	2000	2001	2002	2003	2004	2005	2006	2007
	Fuel consumption in TJ							
Total domestic (1A3a)	2'539	2'296	2'028	1'951	1'963	1'699	1'658	1'891
Total international	63'687	60'097	55'468	49'763	46'896	47'671	50'109	53'543
Sum	66'225	62'393	57'495	51'714	48'859	49'370	51'766	55'434
1990 = 100%	146%	138%	127%	114%	108%	109%	114%	122%

### Road Transportation (1A3b)

#### Key categories 1A3b

CO<sub>2</sub> from the combustion of Diesel Oil (level and trend)

CO<sub>2</sub> from the combustion of Gasoline (level and trend)

CH<sub>4</sub> from the combustion of Gasoline (trend)

#### Methodology

##### CO<sub>2</sub>

The CO<sub>2</sub> emissions are calculated with a Tier 1 method (top-down) as suggested by IPCC Good Practice Guidance (IPCC 2003) using country specific emission factors. The emission factors are derived from the carbon content of fuels (see Table 3-3). The activity data corresponds to the amounts of gasoline and diesel fuel sold in Switzerland (sales principle). The numbers are taken from the national fuel statistics which is part of the Swiss overall energy statistics (SFOE 2008).

In the current submission, the consumption of biofuels is reported for Road Transportation for the first time. Fuels involved, emission factors and activity data are summarised in a comment to the EMIS database (EMIS/2009 1A3b). Most important data sources are of the Swiss overall energy statistics (SFOE 2008) and the Swiss Federal Customs Administrations (SFCA 2008)

##### Other gases

The other gases are modelled with a well-documented country specific method (SAEFL 1995, 2004, 2004a, INFRAS 2004, RWTÜV 2003, Hausberger et al. 2002). The approach corresponds methodologically to Box 1 in the decision tree of Figure 2.5 (p. 2.45) of IPCC Good Practice Guidance.

For the determination of the other greenhouse gases and for further splitting into vehicle categories, a national road traffic model (operated by the Federal Office of Spatial Development) and a database with country specific emission factors are used ("Handbook of Emission Factors for Road Transport", SAEFL 1995, 2004, 2004a, INFRAS 2004, 2004a). The traffic model is based on an origin-destination matrix that is assigned to a network of about 20'000 road segments. The model is calibrated partly bottom-up and partly top-down: Bottom-up by a number of traffic counts from the national traffic-counter network (239 stations all over Switzerland, FEDRO 2004), and top-down by the total of the mileage per vehicle category. The mileage is calculated from the specific mileage per vehicle (based on

household surveys/Mikrozensus ARE/SFSO 2000) times the number of vehicles. The traffic model generates the average daily traffic (vehicles per day) per road segment and per vehicle category. Furthermore, it attributes a “traffic situation” to every road segment which characterises a specific pattern of the dynamic driving behaviour. For every traffic situation, emission factors are defined in the handbook of emission factors. The traffic situation, therefore, works as a key to select the appropriate emission factor from the handbook and assigns it to a single road segment. The daily traffic multiplied by the emission factor results in the hot exhaust emission. This procedure is carried out for all gases. Additionally, cold start excessive and evaporative emissions are modelled using data of vehicle stocks<sup>11</sup>, number of starts, trip length distributions and parking time distributions. The fleet composition also accounts for foreign vehicles (SAEFL 2004, SAEFL/ARE 2004). Further details of emission modelling are given in Annex A3.1.4.

Due to fuel price differences in the vicinity of the national borders, gasoline stations sell relevant amounts of gasoline to foreign car owners. This amount of fuel is mainly consumed abroad (“tank tourism”) but the whole amount must be reported as national under 1A3b Road Transportation. The non-CO<sub>2</sub> emissions related to the “tank tourism” are not captured by the traffic model. For the purpose of assuring completeness within the GHG inventory, these emissions are quantified on the basis of the difference between fuel consumption according to the Swiss overall energy statistics (sales principle) and fuel consumption derived from the traffic model. The resulting amount of “tank tourism” fuel is multiplied with mean emission factors to determine the related emissions of CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>x</sub>, CO, NMVOC, and SO<sub>2</sub>. For CO<sub>2</sub>, which dominates the emissions by a factor of ca. 1000-10'000, the use of Swiss mean factors is correct, since the carbon content constitutes the emission factor. For CH<sub>4</sub> and N<sub>2</sub>O there are differences between the Swiss mean factors and the implied emission factors of the four neighbouring countries Austria (A), France (F), Germany (G), Italy (I) as a comparison with their implied emission factors for 1990 and 2004 has shown. The differences are small between Switzerland, A and G because all three countries use the same emission factors (SAEFL 2004a), whereas there are some differences to F and I who use other emission factors (COPERT<sup>12</sup>) Nevertheless, the use of the mean Swiss emission factors seems to be the consistent approach.

### *Emission Factors*

The emission factors for fossil CO<sub>2</sub> are country specific and based on measurements and analyses of fuel samples (see Table 3-3). Emission factors for the further gases are country specific derived from “emission functions” which are determined from measurements of a large number of driving patterns within an international measurement program of Switzerland together with Austria, Germany and the Netherlands. The method has been developed in 1990-1995 and has been extended and updated in 2000 and 2004. The latest version is presented and documented on the website <http://www.hbefa.net/>. Several reports may be downloaded from there:

- Documentation of the general emission factor methodology (INFRAS 2004a; in German),
- Emission Factors for Passenger Cars and Light Duty Vehicles Switzerland, Germany, Austria (INFRAS 2004; in English),
- Update of the Emission Factors for Heavy Duty Vehicles (Hausberger et al. 2002; in English),

<sup>11</sup> The vehicle registration in Switzerland delivers all inputs to build up the fleet composition 1990-2004 which is characterised e.g. by vehicle category, engine capacity, fuel type, total weight, vehicle age and exhaust technology.

<sup>12</sup> see European Environment Agency <http://reports.eea.europa.eu/TEC05/en>

- Update of the Emission Factors for Two-wheelers (RWTÜV 2003; in German).

The resulting emission factors are published on CD ROM ("Handbook of emission factors for Road Transport", SAEFL 2004a). The underlying database contains a dynamic fleet compositions model simulating the release of new exhaust technologies and the dying out of old technologies. Corrective factors are provided to account for future technologies. Further details are shown in Annex A3.1.4.

The following table gives a selection of mean emission factors. The CO<sub>2</sub> factors are constant over the whole period 1990–2007. Changes in the carbon content of the fuels have not been considered so far due to (approximately) constant fuel qualities. For the other gases, more or less pronounced decreases of the emission factors occur due to new emission regulations and subsequent new exhaust technologies (mandatory use of catalytic converters for gasoline cars and lower limits for sulphur content in diesel fuels). Early models of catalytic converters have been substantial sources of N<sub>2</sub>O, leading to an emission increase until 1998. Recent converter technologies have overcome this problem resulting in a decrease of the (mean) emission factor. It should be noted that the N<sub>2</sub>O emission factors are much smaller than the IPCC default values. The factors used in Switzerland are taken from a recent Dutch measurement programme (Gense and Vermeulen 2002, 2002a; Riemersma et al. 2003). Emission factors per emission concept are given in Annex A3.1.4. A separate table shows the details of the N<sub>2</sub>O emission factors (Table A - 21).

### **Emission factors from the combustion of biofuels**

In lieu of reviewed emission factors for biofuels the following assumption were made.

- Biodiesel and vegetable/waste oil: The implied emission factors 1A3b for fossil diesel are used. Values for 2007:
  - CO<sub>2</sub> 73.6 t/TJ; CH<sub>4</sub> 0.68 kg/TJ; N<sub>2</sub>O 1.46 kg/TJ
- Bioethanol: The implied emission factors 1A3b for gasoline are used. Values for 2007:
  - CO<sub>2</sub> 73.9 t/TJ; CH<sub>4</sub> 5.92 kg/TJ; N<sub>2</sub>O 1.83 kg/TJ
- Biogas: The implied emission factors 1A5b for CNG are used. Values for 2007:
  - CO<sub>2</sub> 55.0 t/TJ; CH<sub>4</sub> 5.4 kg/TJ; N<sub>2</sub>O 3.0 kg/TJ

Table 3-24 Mean emission factors for road transport for passenger cars and heavy duty vehicles. For more details see Annex A3.1.4.

Gas	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<b>Passenger Cars</b>											
t/TJ (= kg/GJ = g/MJ)											
CO <sub>2</sub>	gasoline	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9
	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH <sub>4</sub>	gasoline	0.0239	0.0212	0.0183	0.0162	0.0143	0.0126	0.0111	0.0099	0.0089	0.0081
	Diesel	0.0012	0.0012	0.0011	0.0009	0.0009	0.0008	0.0007	0.0007	0.0007	0.0007
N <sub>2</sub> O	gasoline	0.0020	0.0024	0.0028	0.0031	0.0034	0.0036	0.0038	0.0038	0.0037	0.0036
	Diesel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
NO <sub>x</sub>	gasoline	0.452	0.398	0.345	0.307	0.279	0.255	0.233	0.213	0.194	0.177
	Diesel	0.227	0.230	0.221	0.216	0.219	0.214	0.213	0.213	0.215	0.218
CO	gasoline	3.133	2.816	2.501	2.291	2.113	1.963	1.835	1.734	1.648	1.576
	Diesel	0.218	0.223	0.198	0.181	0.177	0.161	0.155	0.149	0.145	0.141
NMVOC	gasoline	0.539	0.472	0.405	0.356	0.309	0.269	0.233	0.205	0.181	0.162
	Diesel	0.049	0.051	0.043	0.038	0.037	0.032	0.030	0.029	0.028	0.027
SO <sub>2</sub>	gasoline	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094	0.0094
	Diesel	0.0654	0.0607	0.0561	0.0467	0.0203	0.0159	0.0174	0.0165	0.0188	0.0207

Gas	Fuel	2000	2001	2002	2003	2004	2005	2006	2007
<b>Passenger Cars</b>									
t/TJ (= kg/GJ = g/MJ)									
CO <sub>2</sub>	gasoline	73.9	73.9	73.9	73.9	73.9	73.9	73.9	73.9
	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH <sub>4</sub>	gasoline	0.0073	0.0065	0.0058	0.0052	0.0046	0.0041	0.0037	0.0034
	Diesel	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005	0.0005
N <sub>2</sub> O	gasoline	0.0034	0.0032	0.0030	0.0027	0.0025	0.0023	0.0021	0.0019
	Diesel	0.0010	0.0013	0.0016	0.0017	0.0019	0.0020	0.0020	0.0021
NO <sub>x</sub>	gasoline	0.156	0.142	0.129	0.120	0.110	0.100	0.092	0.084
	Diesel	0.221	0.221	0.215	0.211	0.204	0.195	0.185	0.177
CO	gasoline	1.518	1.453	1.372	1.312	1.252	1.182	1.123	1.060
	Diesel	0.133	0.128	0.123	0.118	0.108	0.106	0.104	0.102
NMVOC	gasoline	0.142	0.127	0.111	0.100	0.090	0.081	0.074	0.067
	Diesel	0.026	0.025	0.024	0.023	0.021	0.021	0.020	0.020
SO <sub>2</sub>	gasoline	0.0067	0.0057	0.0048	0.0038	0.0004	0.0004	0.0004	0.0004
	Diesel	0.0127	0.0117	0.0110	0.0093	0.0005	0.0005	0.0005	0.0005

Gas	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<b>Heavy duty vehicles</b>											
t/TJ (= kg/GJ = g/MJ)											
CO <sub>2</sub>	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH <sub>4</sub>	Diesel	0.0020	0.0020	0.0019	0.0019	0.0018	0.0018	0.0018	0.0017	0.0016	0.0016
N <sub>2</sub> O	Diesel	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012	0.0012	0.0012
NO <sub>x</sub>	Diesel	1.027	1.028	1.028	1.022	0.994	0.961	0.938	0.924	0.926	0.928
CO	Diesel	0.220	0.218	0.217	0.213	0.205	0.201	0.197	0.192	0.186	0.179
NMVOC	Diesel	0.081	0.080	0.079	0.077	0.073	0.072	0.071	0.070	0.066	0.063
SO <sub>2</sub>	Diesel	0.065	0.061	0.056	0.047	0.020	0.016	0.017	0.016	0.019	0.021

Gas	Fuel	2000	2001	2002	2003	2004	2005	2006	2007
<b>Heavy duty vehicles</b>									
t/TJ (= kg/GJ = g/MJ)									
CO <sub>2</sub>	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH <sub>4</sub>	Diesel	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
N <sub>2</sub> O	Diesel	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
NO <sub>x</sub>	Diesel	0.911	0.893	0.859	0.827	0.786	0.750	0.711	0.676
CO	Diesel	0.172	0.160	0.157	0.155	0.151	0.150	0.145	0.140
NMVOC	Diesel	0.059	0.051	0.048	0.046	0.042	0.041	0.040	0.040
SO <sub>2</sub>	Diesel	0.013	0.012	0.011	0.009	0.000	0.000	0.000	0.000

### Activity Data

The amount of gasoline and diesel fuel sold in Switzerland serves as the activity data for the calculation of the CO<sub>2</sub> emissions: The Swiss overall energy statistics gives the amount of 147 PJ of gasoline and 85 PJ of diesel oil in 2007 (SFOE 2008). From these numbers, the off-road consumption and the fugitive emissions from transmission, storage and fuelling of gasoline (reported under 1B2av Distribution of oil products) are subtracted. The result gives the inventory-relevant consumption for estimating the CO<sub>2</sub> emissions. It contains the fuel consumption due to the traffic model plus the amount of "tank tourism" (see above). The following table shows the details.

Note that a double-counting was detected and was corrected. So far, the fugitive emissions from transmission, storage and fuelling of gasoline have not been subtracted but have been

reported under 1A3b and under 1B2av. In the current submission, this was corrected by subtracting the emissions under 1A3b in the EMIS database and correspondingly in the CRF Reporter/tables. The whole time series 1990–2006 was recalculated, see Chp. 3.2.5 and Chp. 9.1).

Table 3-25 Upper part of table: Split of fuel sales into territorial on-road (modelled), off-road (modelled) and tank tourism (residual value to sales amounts) for gasoline and diesel oil. (Numbers may not add to totals due to rounding.)

Lower part of table: Consumption of biofuels for road transportation. Consumption starts in 1997.

Note that the unit is TJ (not PJ like fossil fuels in the upper part of the table)

Activity data	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		PJ									
<b>Gasoline</b>											
on-road consumption (model)	1A3b	137.5	139.5	136.7	133.4	135.9	138.4	139.8	140.4	141.3	142.5
"tank tourism"	1A3b	15.9	20.3	29.0	20.2	17.8	10.6	13.1	18.5	18.9	23.1
off-road consumption (models)	1A3a,c,d,e;1A4c;1A5	2.4	2.4	2.4	2.4	2.4	2.4	2.3	2.3	2.3	2.3
Gasoline and Diesel sold in Switzerland	1A3; 1A4c; 1A5	155.8	162.2	168.1	155.9	156.1	151.3	155.2	161.2	162.5	168.0
<b>Diesel</b>											
on-road consumption (model)	1A3b	38.2	38.3	39.4	39.3	39.7	39.7	40.4	41.2	42.6	44.7
"tank tourism"	1A3b	-2.2	-2.0	-4.7	-6.7	-4.5	-3.9	-7.8	-7.0	-6.7	-6.1
off-road consumption (models)	1A3a,c,d,e;1A4c;1A5	11.6	11.8	12.1	12.3	12.6	12.8	13.0	13.2	13.4	13.6
Gasoline and Diesel sold in Switzerland	1A3; 1A4c; 1A5	47.6	48.2	46.7	45.0	47.7	48.6	45.6	47.4	49.2	52.2
<b>Total</b>											
on-road consumption (model)	1A3b	175.7	177.8	176.1	172.7	175.6	178.0	180.2	181.6	183.9	187.2
"tank tourism"	1A3b	13.7	18.4	24.3	13.5	13.3	6.7	5.3	11.4	12.1	17.0
off-road consumption (models)	1A3a,c,d,e;1A4c;1A5	14.0	14.2	14.5	14.7	14.9	15.2	15.3	15.5	15.7	15.9
Gasoline and Diesel sold in Switzerland	1A3; 1A4c; 1A5	203.3	210.4	214.8	200.9	203.8	199.9	200.8	208.6	211.7	220.1

Activity data	Source category	2000	2001	2002	2003	2004	2005	2006	2007	
		PJ								
<b>Gasoline</b>										
on-road consump. (model)	1A3b	144.1	144.3	143.6	141.5	138.9	135.8	132.5	129.1	
"tank tourism"	1A3b	21.7	16.8	14.4	15.7	15.6	13.9	12.5	14.6	
off-road consump. (models)	1A3a,c,d,e;1A4c;1A5	2.3	2.3	2.2	2.2	2.2	2.2	2.1	2.1	
gasoline, diesel sold in Switzerland	1A3; 1A4c; 1A5	168.0	163.4	160.2	159.4	156.6	151.8	147.2	145.8	
<b>Diesel</b>										
on-road consump. (model)	1A3b	48.0	49.6	51.3	54.0	57.8	59.6	63.1	66.6	
"tank tourism"	1A3b	-6.1	-6.8	-6.6	-5.8	-5.0	-0.8	1.6	3.9	
off-road consump. (models)	1A3a,c,d,e;1A4c;1A5	13.8	13.8	13.9	14.0	14.0	14.1	14.1	14.2	
gasoline, diesel sold in Switzerland	1A3; 1A4c; 1A5	55.6	56.7	58.7	62.2	66.8	72.9	78.9	84.7	
<b>Total</b>										
on-road consump. (model)	1A3b	192.0	194.0	194.9	195.5	196.6	195.5	195.7	195.7	
"tank tourism"	1A3b	15.6	10.0	7.8	9.9	10.5	13.0	14.1	18.4	
off-road consump. (models)	1A3a,c,d,e;1A4c;1A5	16.0	16.1	16.1	16.2	16.2	16.3	16.3	16.3	
gasoline, diesel sold in Switzerland	1A3; 1A4c; 1A5	223.7	220.1	218.9	221.6	223.4	224.8	226.1	230.4	

Biofuel	1990-1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
		TJ										
<b>Biodiesel</b>	0	57	51	48	56	60	55	72	101	196	273	305
<b>Bioethanol</b>	0	0	0	0	0	0	0	0	0	19	22	67
<b>Vegetable/waste oil</b>	0	0	0	0	0	0	2	5	11	18	29	64
<b>Biogas</b>	0	3	5	8	19	24	20	22	32	47	49	66
<b>Sum</b>	0	60	57	56	76	85	77	99	143	281	374	502
<b>Share of total fuel consump. 1A3b</b>	0.00%	0.03%	0.03%	0.03%	0.03%	0.04%	0.04%	0.04%	0.06%	0.12%	0.16%	0.22%

Further activity data needed for modelling the non-CO<sub>2</sub> emissions are the mileages (vehicle kilometres) per vehicle category in Table 3-26.

Table 3-26 Mileages in millions of vehicle kilometres. PC passenger cars, LDV light duty vehicles, HDV heavy duty vehicles)

Veh. category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	million vehicle-km									
PC	42'648	43'744	43'176	42'260	43'278	44'638	45'564	46'136	47'053	48'163
LDV	2'758	2'742	2'867	2'923	3'048	3'025	3'112	3'258	3'421	3'577
HDV	2'044	1'997	2'046	2'038	2'069	1'996	2'014	2'048	2'110	2'224
Coaches	110	110	111	111	112	112	111	110	103	100
Urban Bus	175	187	188	191	190	193	189	189	190	193
2-Wheelers	2'025	1'946	1'866	1'793	1'717	1'744	1'756	1'823	1'872	1'941
Sum	49'759	50'726	50'254	49'314	50'413	51'708	52'745	53'564	54'749	56'198
(1990=100%)	100%	102%	101%	99%	101%	104%	106%	108%	110%	113%

Veh. category	2000	2001	2002	2003	2004	2005	2006	2007
	million vehicle-km							
PC	49'552	50'713	51'697	52'423	53'082	53'689	54'284	54'860
LDV	3'792	3'971	4'128	4'207	4'276	4'343	4'408	4'471
HDV	2'385	2'291	2'228	2'213	2'291	2'138	2'167	2'197
Coaches	101	97	98	96	95	94	94	93
Urban Bus	197	205	208	208	209	209	209	209
2-Wheelers	1'998	2'061	2'123	2'179	2'233	2'282	2'328	2'371
Sum	58'024	59'337	60'481	61'327	62'185	62'755	63'490	64'201
(1990=100%)	117%	119%	122%	123%	125%	126%	128%	129%

In 2007, 85.5% of total vehicle kilometres are driven by passenger cars, 7.0% and 3.4% by light and heavy duty vehicles, respectively. The mileages increased for all vehicle categories (except coaches), totalling 29% in the period 1990–2007 or 1.5% per year. In the same period, fuel consumption increased less strongly, by 11%, indicating improved fuel efficiency. The effect is shown in Table 3-27 indicating the specific fuel consumption per vehicle-km. For most vehicle categories, the specific consumption has decreased in the period 1990-2007 (between -6% and -23%); only two-wheelers have enhanced their average specific consumption (1%). On an average over the whole car fleet, a decrease of 14% has been reached.

Table 3-27 Fuel consumption of road transport, not including "tank tourism" (abbreviations: PC passenger cars, LDV light duty vehicles, HDV heavy duty vehicles).

Veh. cat.	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		specific fuel consumption (MJ/veh-km)									
PC	gasoline	3.17	3.15	3.13	3.13	3.11	3.09	3.08	3.05	3.03	3.00
	Diesel	3.06	3.07	3.05	3.11	3.04	3.03	3.02	3.02	2.99	2.94
LDV	gasoline	4.14	4.05	3.97	3.91	3.86	3.83	3.79	3.74	3.68	3.63
	Diesel	4.93	4.86	4.78	4.71	4.60	4.53	4.47	4.41	4.36	4.31
HDV	Diesel	10.85	10.85	10.85	10.74	10.75	10.61	10.47	10.34	10.20	10.10
Coach	Diesel	12.24	12.21	12.16	12.06	11.96	11.86	11.75	11.64	11.52	11.41
Urban Bus	Diesel	16.17	16.18	16.15	16.10	16.04	15.97	15.86	15.74	15.65	15.53
2-Wheeler	gasoline	1.21	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.28	1.28
Average		3.53	3.50	3.50	3.50	3.48	3.44	3.42	3.39	3.36	3.33
		100%	99%	99%	99%	99%	98%	97%	96%	95%	94%

Veh. cat.	Fuel	2000	2001	2002	2003	2004	2005	2006	2007
		specific fuel consumption (MJ/veh-km)							
PC	gasoline	2.97	2.94	2.92	2.90	2.87	2.85	2.83	2.80
	Diesel	2.88	2.78	2.70	2.65	2.61	2.57	2.53	2.50
LDV	gasoline	3.58	3.52	3.46	3.42	3.36	3.30	3.24	3.18
	Diesel	4.24	4.14	4.06	4.01	3.96	3.91	3.87	3.83
HDV	Diesel	10.00	10.19	10.17	10.15	10.13	10.25	10.23	10.22
Coach	Diesel	11.26	11.09	10.99	10.91	10.86	10.82	10.80	10.79
Urban Bus	Diesel	15.42	15.33	15.20	15.11	15.03	14.97	14.93	14.90
2-Wheeler	gasoline	1.28	1.28	1.27	1.27	1.26	1.24	1.23	1.22
Average		3.31	3.27	3.22	3.19	3.16	3.11	3.08	3.05
		94%	93%	91%	90%	90%	88%	87%	86%

For modelling of cold start and evaporative emissions of passenger cars and light duty vehicles, also vehicle stock and start numbers are used for activity data. The corresponding numbers are summarised in the next table. Vehicle stock figures correspond to registration data. The starts per vehicle are based on specific household surveys (ARE/SFSO 2000).

Table 3-28 Vehicle stock numbers and average number of starts per vehicle per day (PC passenger cars, LDV light duty vehicles).

Veh. Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	stock in 1000 vehicles									
PC	2'985	3'058	3'091	3'110	3'165	3'229	3'268	3'323	3'383	3'467
LDV	221	228	229	228	232	238	241	243	247	254
2-Wheelers	764	747	729	720	708	704	699	709	718	728
	starts per vehicle per day									
PC	2.91	2.90	2.88	2.86	2.84	2.83	2.82	2.80	2.78	2.76
LDV	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97
2-Wheelers	1.59	1.58	1.57	1.56	1.55	1.54	1.54	1.53	1.52	1.51

Veh. Category	2000	2001	2002	2003	2004	2005	2006	2007
	stock in 1000 vehicles							
PC	3'545	3'630	3'701	3'754	3'801	3'846	3'889	3'931
LDV	260	268	274	275	277	279	280	282
2-Wheelers	731	740	741	746	749	752	755	758
	starts per vehicle per day							
PC	2.75	2.74	2.72	2.71	2.69	2.68	2.67	2.66
LDV	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96
2-Wheelers	1.50	1.51	1.52	1.52	1.53	1.54	1.54	1.55

## Railways (1A3c)

### *Methodology*

The entire Swiss railway system is electrified. Electric locomotives are used in passenger as well as freight railway traffic. Diesel locomotives are used for shunting purposes in marshalling yards and for construction activities only.

The complete revision of the emissions of the whole off-road sector that began in 2005 was completed in 2008. The emissions of all off-road categories like railways, navigation etc. are modelled by the same approach. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.5 Off-road vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008). Emissions are calculated for the years 1990, 1995, 2000, 2005 etc. up to 2020. For the years in-between, the emissions are interpolated linearly.

### *Emission Factors*

Only diesel oil is being used as fuel, therefore all emission factors refer to diesel oil.

- The emission factor for CO<sub>2</sub> is country specific and assumed to be constant in the period 1990-2007 with value 73.6 t/TJ (diesel oil, see Table 3-3, SFOE 2001).
- For SO<sub>2</sub> the emission factors country specific and are given in Table A - 12 in Annex A2.2, row diesel oil: Continuous decrease from 65.4 kg/TJ in 1990 to 12.7 kg/TJ in 2000 and to 0.47 kg/TJ in 2007.
- The emission factors for all other gases are country specific and are shown in Table A - 26 in Annex A3.1.5. Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated as the difference of VOC and CH<sub>4</sub> emissions.
- For differences of the emission factors compared to IPCC default values, Table A - 22 in the Annex A3.1.5.

Note that emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database INFRAS (2008)<sup>13</sup>.

### *Activity data*

The fuel consumption is calculated by using the formula given above for the emission modelling. Instead of the emission factor, consumption factors are used (see Table A - 23). The operating hours depend on the number of vehicles per age and size class. In 2005 e.g., 1'260 vehicles were operating 0.77 million hours per year with an average number of 611 operating hours per year per vehicle (INFRAS 2008). The resulting fuel consumption is shown in Table 3-29.

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<sup>13</sup> <http://www.bafu.admin.ch/luft/00596/06906/offroad-daten/index.html?lang=en> [04.03.2009]

Table 3-29 Activity data (diesel oil consumption) for railways.

Railways	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Diesel (TJ)	390	400	410	420	430	441	444	447	449	452
1990=100%	100.0%	102.6%	105.2%	107.8%	110.4%	113.0%	113.8%	114.6%	115.3%	116.1%

Railways	2000	2001	2002	2003	2004	2005	2006	2007
Diesel (TJ)	455	461	467	473	478	484	490	496
1990=100%	116.8%	118.3%	119.8%	121.3%	122.7%	124.2%	125.7%	127.2%

## Navigation (1A3d)

### Methodology

The complete revision of the emissions of the whole off-road sector that began in 2005 was completed in 2008. The emissions of all off-road categories like railways, navigation etc. are modelled by the same approach. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.5 Off-road vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008).

There are passenger ships, dredgers, fishing boats, motor and sailing boats on the lakes of Switzerland and on the river Rhine. Every boat is registered at the cantonal authorities. The emissions are calculated for the years 1990, 1995, 2000, 2005 etc. up to 2020. For the years in-between, the emissions are interpolated linearly.

On the river Rhine, some of the boats cross the border and go abroad (Germany, France). Fuels bought in Switzerland will therefore become bunker fuel. The amount of bunker diesel oil has not been estimated so far. However, it is assumed to be very small compared to the domestic consumption of navigation (see Section 3.4.1). The emissions of navigation reported in the CRF under 1A3c include, therefore, the bunker emissions.

### Emission Factors

- The emission factor for CO<sub>2</sub> is country specific and is assumed to be constant in the period 1990-2007 with value 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 73.7 t/TJ for gas oil (Table 3-3, SFOE 2001).
- For SO<sub>2</sub> the emission factors are country specific and are given in Table A - 12 in Annex A2.2 (diesel oil, gasoline, gas oil).
- The emission factors for all other gases are country specific and are shown in Table A - 27 to Table A - 30 in Annex A3.1.5. Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated as the difference of VOC and CH<sub>4</sub> emissions.

Note that emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database INFRAS (2008), see footnote 13 on page 104.

### Activity data

The numbers of vehicles and of operating hours are given in Annex A3.1.5 (INFRAS 2008). Table 3-30 shows the fuel consumption. In 2007, the fuel-split was 51%, 39% and 10% for diesel oil, gasoline and gas oil.

Table 3-30 Fuel consumption of navigation.

Navigation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Diesel (TJ)	705	703	701	698	696	694	708	723	738	753
Gasoline (TJ)	701	692	682	673	664	654	647	639	631	623
Gas oil (TJ)	110	116	122	127	133	139	141	142	144	145
Sum (TJ)	1'517	1'511	1'505	1'499	1'493	1'487	1'496	1'504	1'513	1'521
1990 = 100%	100%	100%	99%	99%	98%	98%	99%	99%	100%	100%

Navigation	2000	2001	2002	2003	2004	2005	2006	2007
Diesel (TJ)	767	771	776	780	784	788	795	801
Gasoline (TJ)	616	614	613	612	611	609	609	608
Gas oil (TJ)	147	150	152	155	157	160	160	160
Sum (TJ)	1'530	1'535	1'541	1'547	1'552	1'558	1'563	1'569
1990 = 100%	101%	101%	102%	102%	102%	103%	103%	103%

### Military Aviation (Other Transportation 1A3e)

#### Key category 1A3e

CO<sub>2</sub> from the combustion of Jet Kerosene of military aviation (trend)

#### Methodology

To calculate the emissions from military aviation, a Tier 1 method is used.

The fuel consumption 1990–2007 is known yearly since it is being copied from the logbooks of the military aircrafts (VTG 2008). A very small fraction of fuel is consumed for training abroad and might be allocated under “International Bunkers” (less than 3% of total military aviation consumption). Since the exact number is not known, it is not subtracted from the total consumption but included under national military aviation, as recommended by the IPCC Good Practice Guidance (IPCC 2000, chapter 2.5.1.3). Emissions of NO<sub>x</sub>, CO and VOC have been modelled in detail by the Federal Office for Military Aviation (Bundesamt für Betriebe der Luftwaffe) for 1990 and 1995. From these inputs, FOEN determined average emission factors 1990 and 1995. For 1991–1994 the emission factors are linearly interpolated between 1990 and 1995. For 1996–2007, the factors for 1995 are used. The emissions are then calculated yearly by multiplying the average emission factors with the activity data.

The extension of the emission modelling to CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, NMVOC and SO<sub>2</sub> is also accomplished by FOEN.

#### Emission Factors

- CO<sub>2</sub>: The emission factor of 73.2 t/TJ is country specific and is based on measurements and analyses of fuel samples (see Table 3-3, SFOE 2001).
- NO<sub>x</sub>, VOC, CO: Engine producer information is used (CORINAIR, for details see SAEFL 1996: p. 202) for calculation of the emission factors in 1990 and 1995. For 1991–1994 the values are linearly interpolated between 1990 and 1995. For 1996–2007, the values 1995 are used.
- CH<sub>4</sub>, NMVOC: For VOC, aircraft-specific information used for calculation of the emission factors in 1990 and 1995. For 1991–1994 the values are linearly interpolated between 1990 and 1995. For 1996–2007, the values 1995 are used. The division of VOC into CH<sub>4</sub> and NMVOC is carried out by a constant split of 53% : 47% (country specific).
- N<sub>2</sub>O: The IPCC default value 23 kg/TJ is used (IPCC 1997b) for the full period 1990–2007.

- SO<sub>2</sub>: The emission factor is taken from the IPCC Guidelines 1996, 23.3 kg/TJ, and is assumed to be constant over the period 1990–2007 (IPCC 1997c, Table 1-50)

#### Activity data

The fuel consumption is copied from the logbooks of the military aircrafts and summed up yearly (see Table 3-31).

Table 3-31 Activity data (jet kerosene consumption) for military aviation. The data is provided annually by VTG (2008).

Military aviation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
fuel cons. (TJ)	2'733	2'495	2'382	2'268	2'192	1'955	1'806	1'941	1'927	1'734
1990 = 100%	100%	91%	87%	83%	80%	72%	66%	71%	71%	63%

Military aviation	2000	2001	2002	2003	2004	2005	2006	2007
fuel cons. (TJ)	1'793	1'755	1'837	1'641	1'488	1'621	1'672	1'572
1990 = 100%	66%	64%	67%	60%	54%	59%	61%	58%

#### d) Other Sectors (Commercial, Residential, Agriculture, Forestry; 1A4)

##### Key categories 1A4a

CO<sub>2</sub> from the combustion of Gaseous Fuels in the Commercial/Institutional Sector (level and trend)

CO<sub>2</sub> from the combustion of Liquid Fuels in the Commercial/Institutional Sector (level and trend)

##### Key categories 1A4b

CO<sub>2</sub> from the combustion of Gaseous Fuels in the Residential Sector (level and trend)

CO<sub>2</sub> from the combustion of Liquid Fuels in the Residential Sector (level and trend)

##### Key category 1A4c

CO<sub>2</sub> from the combustion of Liquid Fuels in Agriculture/Forestry (level)

“Other Sectors” (source category 1A4) comprises

- “Commercial/ Institutional” (1A4a)
- “Residential” (1A4b)
- “Agriculture/Forestry/Fisheries” (1A4c)

#### Commercial/ Institutional (1A4a) and Residential (1A4b)

##### Methodology

For Fuel Combustion in Commercial and Institutional Buildings (1A4a) and in Households (1A4b), a country specific Tier 2 method is used. A top-down method based on aggregated fuel consumption data from the Swiss overall energy statistics is used to calculate emissions. For the calculation of non-CO<sub>2</sub> emissions from the use of light fuel oil and natural gas the following sources are differentiated: (i) heat only boilers, (ii) combined heat and power production in turbines and (iii) combined heat and power production in engines. Emissions of GHGs are calculated by multiplying levels of activity by emission factors. An oxidation factor

of 100% is assumed for all combustion processes and fuels (see sub-section on oxidation factors in the beginning of Section 3.2.2).

### *Emission Factors*

The emission factors for CO<sub>2</sub> are country specific and based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (EMPA 1999; carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61. See also Annex A2.1.1).

The activity data on LFO use in the CRF includes LPG consumption. This is due to statistical reasons in the Swiss overall energy statistics (SFOE 2008). Therefore the LFO emission factor for CO<sub>2</sub> (see table below) is a mixed emission factor that results as a weighted average of the LFO emission factor and LPG emission factor.

Emission factors for CH<sub>4</sub>, NO<sub>x</sub>, CO and NMVOC for heat only boilers are country specific based on comprehensive life cycle analysis of combustion boilers, turbines and engines in the residential, commercial institutional and agricultural sectors, documented in SAEFL 2000 (pp. 42-56) and EMIS. For NO<sub>x</sub> emission factors, expert judgement has been used to estimate the fraction of low-NO<sub>x</sub> burners.

Emission factors for CH<sub>4</sub>, NO<sub>x</sub>, CO and NMVOC for combined heat and power generation in turbines and engines are country specific based on comprehensive measurements (EMIS 2009/1A4).

For N<sub>2</sub>O emissions the default emission factors from IPCC 1997c have been used.

The coal emission factor for CO<sub>2</sub> (see table below) is the emission factor for hard coal. Lignite consumption is accounted for exclusively in cement production in category 1A2f. For net calorific values see Annex A2.1.1.

All emission factors for biomass are based on SAEFL 2000 (pp. 26ff) and EMIS.

The following table presents the emission factors used in 1A4a and 1A4b:

Table 3-32 Emission Factors for 1A4a and 1A4b: Commercial/Institutional and Residential in "Other Sectors" for 2007.

Source/fuel	CO <sub>2</sub> t/TJ	CO <sub>2</sub> bio. t/TJ	CH <sub>4</sub> kg/TJ	N <sub>2</sub> O kg/TJ	NO <sub>x</sub> kg/TJ	CO kg/TJ	NM VOC kg/TJ	SO <sub>2</sub> kg/TJ
<b>1A4 a Other Sectors: Commercial/Institutional</b>								
LFO (weighted average)	73.50		1.02	0.60	31.07	11.25	6.05	31.91
LFO (heat only boilers)	73.50		1.00	0.60	30.00	11.00	6.00	31.92
LFO (turbines)	NO		NO	NO	NO	NO	NO	NO
LFO (engines)	73.50		3.80	0.60	214.00	54.00	15.20	29.11
Natural gas (weighted average)	55.00		7.36	0.10	22.41	16.97	1.94	0.50
NG (heat only boilers)	55.00		6.00	0.10	13.80	14.00	2.00	0.50
NG (turbines)	55.00		2.60	0.10	90.00	18.00	0.10	0.50
NG (engines)	55.00		23.00	0.10	120.00	51.00	1.30	0.50
Coal	NO		NO	NO	NO	NO	NO	NO
Biomass (weighted average)	NO	90	113.8	1.5	142.6	1'892	37.9	18.9
Biomass (wood)		92	120	1.6	150	2'000	40	20
Biomass (biogas)		55	6.00	0.10	13.8	14.00	2.00	0.50
<b>1A4 b Other Sectors: Residential</b>								
LFO (weighted average)	73.50		1.00	0.60	31.16	11.04	6.01	31.92
LFO (heat only boilers)	73.50		1.00	0.60	30.00	11.00	6.00	31.92
LFO (turbines)	NO		NO	NO	NO	NO	NO	NO
LFO (engines)	73.50		4.40	3.80	244.00	60.00	15.20	29.11
Natural gas (weighted average)	55.00		6.19	0.10	14.44	14.46	1.99	0.50
NG (heat only boilers)	55.00		6.00	0.10	13.80	14.00	2.00	0.50
NG (turbines)	55.00		2.80	2.60	90.00	18.00	0.10	0.50
NG (engines)	55.00		20.00	0.10	60.00	48.00	1.00	0.50
Coal	94.00		300	1.6	65	2'900	100	350
Biomass		92	120	1.6	150	2'000	40	20

*Remark:* In the table above, the CO<sub>2</sub> emission factor of light fuel oil (73.50 t/TJ) is a weighted average emission factor including both LFO (73.7t/TJ) and LPG (65.5t/TJ) emissions, the same emission factor as in 1A1a and in 1A2 (see Section 3.2.2 a). The CO<sub>2</sub> emission factor for coal refers to the emission factor for hard coal (94 t/TJ), the same emission factor as for all 1A2 "top-down" sources except cement industry in 1A2f Other, in which also emissions from lignite occur (see Section 3.2.2 b).

### Activity Data

Activity data on fuel consumption for Commercial/Institutional and Residential (1A4a and b) correspond to the consumption of light fuel oil (including LPG), natural gas, coal and biomass in the categories "Services" (for 1A4a) and "Households" (for 1A4b) of the Swiss overall energy statistics (SFOE 2008; Table 17).

The amount of light fuel oil and natural gas that is used for co-generation in turbines and engines is taken from Kaufmann (2008).

Table 3-33 Activity data in 1A4a Commercial/Institutional and 1A4b Residential.

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A4a Commercial/Institutional	TJ	80'788	91'579	90'367	89'865	81'544	86'524	93'419	86'686	88'952	88'615
Light fuel oil	TJ	60'433	67'531	66'014	63'915	57'335	59'033	63'366	59'817	61'192	60'443
LFO heat only boilers	TJ	60'409	67'481	65'956	63'859	57'214	58'858	63'135	59'529	60'894	60'115
LFO turbines	TJ	0	0	0	0	0	0	0	0	0	0
LFO engines	TJ	24	51	58	56	122	175	231	288	298	327
Natural gas	TJ	17'072	19'670	20'052	21'427	20'073	22'379	23'889	21'938	22'663	23'098
NG heat only boilers	TJ	16'795	19'235	19'492	20'801	19'250	21'208	22'478	20'472	21'061	21'388
NG turbines	TJ	85	114	109	106	107	78	21	5	12	4
NG engines	TJ	192	321	451	520	715	1'093	1'390	1'460	1'590	1'706
Coal	TJ	0	0	0	0	0	0	0	0	0	0
Biomass (wood)	TJ	3'228	4'322	4'247	4'471	4'086	5'066	6'117	4'888	5'051	5'024
Biomass (biogas)	TJ	56	55	54	51	49	46	46	43	45	51
Biomass (total)	TJ	3'284	4'377	4'301	4'522	4'135	5'112	6'163	4'931	5'097	5'075
1A4b Residential	TJ	185'858	197'896	197'391	188'702	177'729	191'809	199'474	185'107	191'361	188'350
Light fuel oil	TJ	138'916	145'507	145'175	136'252	128'901	137'597	139'992	131'915	136'508	131'838
LFO heat only boilers	TJ	138'915	145'506	145'173	136'251	128'900	137'593	139'961	131'877	136'459	131'785
LFO turbines	TJ	0	0	0	0	0	0	0	0	0	0
LFO engines	TJ	1	1	1	1	1	4	32	38	49	53
Natural gas	TJ	25'574	29'158	30'560	30'944	29'380	33'692	37'778	34'326	35'842	37'751
NG heat only boilers	TJ	25'514	29'056	30'416	30'777	29'176	33'434	37'471	34'013	35'492	37'347
NG turbines	TJ	0	0	0	0	0	0	0	0	0	0
NG engines	TJ	60	102	144	168	204	258	307	313	350	405
Coal	TJ	607	701	486	495	449	430	243	206	131	131
Biomass	TJ	20'760	22'530	21'170	21'010	19'000	20'090	21'460	18'660	18'880	18'630

Source/Fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007
1A4a Commercial/Institutional	TJ	81'517	86'807	81'843	88'040	86'427	89'667	85'102	75'034
Light fuel oil	TJ	54'701	57'491	53'952	57'198	55'216	55'739	51'850	45'042
LFO heat only boilers	TJ	54'339	57'111	53'587	56'852	54'878	55'410	51'530	44'781
LFO turbines	TJ	0	0	0	0	0	0	0	0
LFO engines	TJ	362	380	365	346	338	329	320	261
Natural gas	TJ	22'543	24'523	23'364	25'671	26'138	27'300	26'568	24'548
NG heat only boilers	TJ	20'804	22'706	21'440	23'657	24'150	25'260	24'562	22'550
NG turbines	TJ	0	3	12	28	31	28	23	28
NG engines	TJ	1'738	1'814	1'911	1'987	1'957	2'012	1'983	1'969
Coal	TJ	0	0	0	0	0	0	0	0
Biomass (wood)	TJ	4'216	4'729	4'457	5'092	4'979	6'504	6'492	5'149
Biomass (biogas)	TJ	58	63	70	79	93	124	192	295
Biomass (total)	TJ	4'274	4'793	4'527	5'170	5'072	6'628	6'683	5'444
1A4b Residential	TJ	174'096	183'651	177'450	187'801	188'031	190'874	183'867	164'082
Light fuel oil	TJ	120'784	127'553	122'470	129'328	128'194	129'613	124'415	107'798
LFO heat only boilers	TJ	120'731	127'498	122'414	129'269	128'120	129'536	124'339	107'720
LFO turbines	TJ	0	0	0	0	0	0	0	0
LFO engines	TJ	53	55	56	58	74	76	76	78
Natural gas	TJ	36'000	37'666	37'449	39'961	41'253	42'358	40'649	38'940
NG heat only boilers	TJ	35'562	37'206	36'984	39'444	40'746	41'831	40'116	38'407
NG turbines	TJ	0	0	5	3	2	0	0	3
NG engines	TJ	438	461	460	514	506	527	532	530
Coal	TJ	121	121	121	121	374	374	374	374
Biomass	TJ	17'190	18'310	17'410	18'390	18'210	18'530	18'430	16'970

The table above documents the increase of Natural Gas consumption by 44% (1A4a) and 52% (1A4b) from 1990 to 2007 as well as the net decrease of liquid fuel consumption by -25.5% (1A4a) and -22.4% (1A4b) over the period. This shift in fuel mix is the reason for CO<sub>2</sub> emissions from the use of these fuels in category 1A4a/b being key categories regarding trend.

## Agriculture/Forestry (1A4c)

### Methodology

For source category 1A4c, a country specific Tier 2 method is used. Emissions stem from two sources within the agriculture sector:

- Fuel combustion for grass drying,
- Fuel combustion in off-road machinery.

Emissions from both sources are calculated bottom up. For grass drying, emission factors refer both to fuel consumption (in TJ) and production data (i.e. in tons of dried grass).

The complete revision of the emissions of the whole off-road sector that began in 2005 was completed in 2008. The emissions of all off-road categories like railways, navigation etc. are modelled by the same approach. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.5 Off-road Vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008). Emissions are calculated for the years 1990, 1995, 2000, 2005 etc. up to 2020. For the years in-between, the emissions are interpolated linearly.

An oxidation factor of 100% is assumed for all combustion processes and fuels (see subsection on oxidation factors in the beginning of Section 3.2.2).

#### *Emission Factors drying of grass*

The emission factors for CO<sub>2</sub> are country specific and based on measurements and analysis of fuel samples carried out by the Swiss Federal Laboratories for Materials Testing and Research EMPA (EMPA 1999, carbon emission factor documented in SFOE 2001, Table 45: p. 51; net calorific values on p. 61). Emission factors for CH<sub>4</sub>, N<sub>2</sub>O, CO and NMVOC are country specific based on comprehensive life cycle analysis of a drying unit, documented in the EMIS database (EMIS 2009/1A4c, see Section 1.4.3). Some of the emission factors have been updated based on expert judgement.

#### *Emission Factors off-road machinery*

- The emission factor for CO<sub>2</sub> is country specific and is assumed to be constant in the period 1990-2007 with value 73.6 t/TJ for diesel oil and 73.9 t/TJ for gasoline (Table 3-3, SFOE 2001).
- For SO<sub>2</sub> the emission factors are country specific and are given in Table A - 12 in Annex A2.2(diesel oil, gasoline).
- The emission factors for all other gases are country specific and are shown in Table A - 22 to Table A - 25 in the Annex A3.1.5 (INFRAS 2008). Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated as the difference of VOC and CH<sub>4</sub> emissions.

Note that emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database INFRAS (2008), see footnote 13 on page 104.

#### *Activity Data*

Drying of grass: Activity data on grass drying (in tons of dried grass) is extracted from the EMIS database (EMIS 2009/1A4c).

Off-road machinery: Activity data is shown in Annex A3.1.5 (INFRAS 2008). Note that due to recalculation, fuel consumption has significantly been reduced in 1A4c. The reduction is compensated by increasing the tank tourism (see Section 3.2.2) since the national total remains unchanged. The modification corresponds to a reallocation of fuel consumption.

Table 3-34 Activity data in 1A4c Agriculture/Forestry.

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A4c Agriculture/Forestry	TJ	8'167	8'129	8'092	8'056	8'021	7'987	7'951	7'916	7'882	7'850
Drying of Grass	TJ	1'895	1'823	1'752	1'683	1'614	1'547	1'481	1'416	1'352	1'289
of which light fuel oil	TJ	1'162	1'118	1'075	1'032	990	949	908	868	829	791
of which natural gas	TJ	733	705	677	651	624	598	572	547	523	498
Machinery	TJ	6'273	6'306	6'340	6'373	6'407	6'440	6'471	6'501	6'531	6'561

Source/Fuel	Unit	2000	2001	2002	2003	2004	2005	2006	2007
1A4c Agriculture/Forestry	TJ	7'818	7'671	7'663	7'655	7'647	7'600	7'455	7'555
Drying of Grass	TJ	1'227	1'077	1'066	1'054	1'043	992	847	945
of which light fuel oil	TJ	753	661	654	647	640	609	519	580
of which natural gas	TJ	474	416	412	408	403	384	327	366
Machinery	TJ	6'591	6'594	6'598	6'601	6'604	6'608	6'608	6'609

### e) Other / Mobile (Off-road): Construction, Garden/Hobby, Industry and Military (1A5b)

#### Key category 1A5

CO<sub>2</sub> from the combustion of Liquid and Gaseous Fuels (level and trend)

#### Methodology

The complete revision of the emissions of the whole off-road sector that began in 2005 was completed in 2008. The emissions of all off-road categories like railways, navigation etc. are modelled by the same approach. The emissions are calculated with a Tier 2 method. Some details of the emission modelling that hold for all off-road families are described in Annex A3.1.5 Off-road vehicles. Activity data and emission factors were updated and the emission calculation was carried out in a new database structured in analogy to the on-road database (INFRAS 2008).

The emission modelling is carried out for 1990, 1995, 2000, 2005 etc. For the GHG inventory the missing years 1991, 1992 etc. are interpolated linearly by vehicle category.

In 1A5b only diesel oil and gasoline are used as fuels. Exceptionally, there is consumption of some CNG in the sub-category "Industry" (forklifts). Note that the corresponding CO<sub>2</sub> emissions are reported under 1A5b Gaseous Fuels whereas CH<sub>4</sub> and N<sub>2</sub>O emissions are reported under 1A5b Liquid Fuels.

#### Emission Factors

- The emission factors for CO<sub>2</sub> are country specific and are assumed to be constant in the period 1990-2007 with values 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 55.0 t/TJ for CNG (equal to natural gas). See Table 3-3.
- For SO<sub>2</sub> the emission factors are country specific and are given in Table A - 12 in Annex A2.2.
- The emission factors for all other gases are country specific and shown in Table A - 22 to Table A - 25 in the Annex A3.1.5 (INFRAS 2008) The NMVOC emissions are calculated as the difference of VOC and CH<sub>4</sub> emissions.

Note that emission factors in the unit of kg/h may be downloaded by query from the public part of the off-road database INFRAS (2008), see footnote 13 on page 104.

### Activity Data

Fuel consumption data is shown in Table 3-35. The underlying data like vehicle stock and operating hours are shown in Table A - 31 to Table A - 33 in Annex A3.1.5.

Table 3-35 Activity data (fuel consumption) for off-road activities Construction, Garden/Hobby, Industry and Military (without Military Aviation, see 1A3e).

Off-road family 1A5b	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		fuel consumption in TJ									
Construction	Diesel	3'900	4'023	4'146	4'269	4'392	4'515	4'577	4'639	4'701	4'763
	Gasoline	127	129	130	131	132	134	130	127	124	121
Hobby	Gasoline	353	367	381	396	410	424	437	450	463	476
Industry	Diesel	1'433	1'494	1'555	1'616	1'677	1'737	1'798	1'858	1'919	1'979
	Gasoline	51	55	59	63	67	71	75	80	84	88
	CNG	157	172	188	204	220	235	251	268	284	300
Military	Diesel	48	48	48	48	49	49	49	49	50	50
	Gasoline	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Off-road family 1A5b	Fuel	2000	2001	2002	2003	2004	2005	2006	2007
		fuel consumption in TJ							
Construction	Diesel	4'825	4'861	4'897	4'933	4'969	5'005	5'025	5'045
	Gasoline	117	116	114	112	110	109	107	106
Hobby	Gasoline	489	480	471	462	453	445	439	433
Industry	Diesel	2'040	2'045	2'051	2'056	2'062	2'067	2'052	2'038
	Gasoline	92	92	92	92	92	92	91	91
	CNG	316	316	317	317	318	318	318	319
Military	Diesel	50	50	49	49	49	48	48	47
	Gasoline	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

### 3.2.3. Uncertainties and Time-Series Consistency

A quantitative **Tier 1** analysis (following Good Practice Guidance; IPCC 2000: p. 6.13ff) was used to estimate uncertainties of key categories in the NIR. First, uncertainties of activity data and emission factors were estimated separately. The combined uncertainty for each source was then calculated using a Rule B approximation (IPCC 2000 p. 6.12). Furthermore, the Rule A approximation was used to arrive at the overall uncertainty in national emissions and the trend in national emissions between the base year and the current year.

A quantitative **Tier 2** analysis (**Monte Carlo**) following Good Practice Guidance; IPCC (2000): p. 6.18ff was performed for the submission April 2008 for the emissions 2007 (but was not repeated for the current submission). It started with the same uncertainties for activity data and emission factors as Tier 1 analysis. Other than Tier 1, the uncertainty of activity data of sector 1A Fuel Combustion were prepared on a disaggregated level. For each key category within 1A the uncertainty of the corresponding activity data and emission factor were determined (see Annex A7.2). In addition, correlation coefficients were implemented and adequate probability distributions were adopted: normal, lognormal and triangle distributions were chosen. See Table A - 40 and Table A - 41 for details.

#### a) Uncertainties

Uncertainties of activity data and emission factors are derived from a mixture of empirical data and expert judgment. All uncertainties are consistently defined as half the 95% confidence interval.

#### Uncertainty in aggregated fuel consumption activity data (1A Fuel Combustion)

The level of disaggregation that has been chosen for the key category analysis provides a rather fine disaggregation of combustion related CO<sub>2</sub> emissions in category 1 Energy. E.g.

the key category analysis distinguishes between Emissions from Commercial/Institutional (1A4a), Residential (1A4b), and Agriculture/Forestry (1A4c).

However, the data on fuel consumption originates at the aggregated level of import, export, and sales data. It is only later disaggregated using models leading to the consumption in different branches (see Annex A3.1.2). In order to avoid errors that are introduced in the process of disaggregation, but do not apply to the aggregated emissions on the national level, the analysis of uncertainties for CO<sub>2</sub> emissions from fuel combustion is carried out on the level of aggregated total national emissions (1A) for Gaseous, Liquid, Solid and Other fuels.

Details of uncertainty analysis of activity data (fuel consumption) in 1A are provided in the table below. For each fuel type, uncertainties of net import or net production data (column C) and uncertainties of estimates of stock changes (if applicable) have been estimated. From this, the combined uncertainty of final consumption of fuels has been calculated (column H).

Table 3-36 Details of uncertainty analysis of fuels in 1A.

A	B	C	D	E	F	G	H	I
Fuel type (IPCC 2000)	Corresponding fuel type in SFOE 2007	Net import/net production [TJ]	Import/production data uncertainty [%]	Correction for stock changes etc. [TJ]	Correction uncertainty [%]	Consumption [TJ]	Final consumption uncertainty [%]	Comment
Liquid fuels	Erdölprodukte	398'027	1.0	40'920	20	438'947	2.1	1
Gaseous fuels	Gas	110'310	5	0	0	110'310	5.0	2
Solid fuels	Kohle	8'720	5	-1'270	100	7'450	18.0	3
Other fuels	Müll- und Industrieabfälle	53'430	10	0	0	53'430	10.0	4

Comments:

- Col. D: Expert estimate from carbura (email M. Ruffer 24.1.05; overall uncertainty has been doubled to account for 95% interval). - Col. F: Conservative interpretation of rough expert estimate from carbura ("one-digit uncertainty", i.e. 10% is one sigma, resulting in  $unc = 2 \cdot \sigma = 20\%$ ).
- Col. D: 5% is GPG default value for developed countries (IPCC 2000 p. 2.1).
- Col. D: 5% is GPG default value for developed countries (IPCC 2000 p. 2.1). - Col. G: expert estimate
- Col. D: An uncertainty of amount of waste of 10% is assumed (expert judgement), because waste input is reasonably well measured since the nineties.

The uncertainties in Table 3-36 are directly used for Tier 1 uncertainty analysis. For Tier 2 analysis, the activity data is divided into NFR sub-categories 1A1, 1A2 etc. The uncertainty of the activity data in the sub-categories are (on the relative level) higher than on the aggregated level because of some additional uncertainty arising from the splitting. The increase of the uncertainties is carried by a suitable "expansion factor" which is derived explicitly and described in Annex A7.2.

Data on stock changes is taken from the Swiss overall energy statistics (SFOE 2008; Table 4). Accordingly, also net import/net production data were taken from the Swiss overall energy statistics for the present uncertainty analysis. It is planned to link the uncertainty analysis to the EMIS database also for stock changes and aggregated fuel consumption in the next uncertainty analysis, in order to increase consistency.

### Uncertainty in CO<sub>2</sub> emission factors in fuel combustion (1A)

*Liquid fuels:* Total uncertainty of net calorific values for liquid fuels are taken as a proxy for the uncertainty of the CO<sub>2</sub> emission factor of liquid fuels. Net calorific values are based on the determination of the gross calorific value and the calculation of the net calorific value by the Swiss Federal Laboratories for Materials Testing and Research EMPA. To this aim, a set of fuel samples of different sources has been selected that is representative for the fuels traded in Switzerland in the year 1998. Assuming that this data on the uncertainty of the net calorific value is representative for the uncertainty of the emission factors in fuel combustion,

a combined uncertainty of 0.55% (defined as two standard deviations, STD) results for the emission factor. These data will be updated by new measurements.

Table 3-37 Results from the 1998 analysis of the low calorific values of liquid fuels in Switzerland (EMPA 1999).

Fuel	Net calorific value liquid fuels						Share 2007 (approx.)
	Mean [GJ/t]	STD [GJ/t]	STD [%]	Uncertainty [%]	$=(C \cdot G)^2$ [GJ <sup>2</sup> /t <sup>2</sup> ]	No. of samples	
Heavy fuel oil	41.2	0.85	2.06	4.13	0.000064	6	1%
Light fuel oil	42.6	0.13	0.31	0.61	0.003225	10	44%
Diesel	42.8	0.10	0.23	0.47	0.000402	10	20%
Gasoline	42.5	0.29	0.68	1.36	0.009979	30	35%
Jet kerosene	43.0	0.25	0.58	1.16	0.000004	10	1%
Sum	42.6				0.013673	66	100%
Combined STD/Unc		0.117	0.27	0.55			

**Gaseous fuels:** The uncertainty of the emission factor for CO<sub>2</sub> has been derived from data on measurements of the low calorific value of natural gas in the grid. SGWA (2007a) provides a range of -2.3% and +2.3%. Interpreting 2.3% as one standard deviation, an uncertainty of 4.6% results (i.e. two standard deviations).

**Solid fuels:** For the uncertainty of the emission factor for CO<sub>2</sub>, the IPCC Good Practice Guidance default value of 5% for countries with well developed energy data systems is used (IPCC 2000: p. 2.15).

**Other fuels (waste to energy):** The dominant factor influencing the uncertainty of CO<sub>2</sub> emissions from municipal solid waste incineration (1A1) is the fraction of fossil carbon in the waste. For the fraction of C in incinerated waste an uncertainty of 20% has been estimated, and for the fraction of fossil C in total C an uncertainty of 10% has been estimated, resulting in a preliminary uncertainty estimate of 30% for the waste incineration CO<sub>2</sub> emission factor (SAEFL 2005h).

### Resulting uncertainty in CO<sub>2</sub> emissions in fuel combustion (1A)

Table 3-38 below provides the results of the quantitative Tier 1 analysis [following Good Practice Guidance; IPCC (2000): p. 6.13ff] estimating uncertainties of CO<sub>2</sub> emissions from fuel combustion activities.

Table 3-38 Results from Tier 1 uncertainty calculation and reporting for CO<sub>2</sub> emissions in 1A Fuel Combustion.

A	B	C	D	E	F	G	H	I	J	K	L	M	
IPCC Source category	Gas	Base year emissions 1990	Year 2007 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total CO <sub>2</sub> combustion emission in year t	Type A sensitivity (CO <sub>2</sub> from combustion)	Type B sensitivity (CO <sub>2</sub> from combustion)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (CO <sub>2</sub> from combustion)	Uncertainty in trend in national emissions introduced by activity data uncertainty (CO <sub>2</sub> from combustion)	Uncertainty introduced into the trend in total CO <sub>2</sub> combustion emissions	
		Gg CO <sub>2</sub> equivalent	Gg CO <sub>2</sub> equivalent	%	%	%	%	%	%	%	%	%	
1A Gaseous fuels	CO <sub>2</sub>	3'696.03	5'952.67	5.0	4.6	6.8	0.980	0.0545	0.1448	0.25	1.02	1.05	
1A Liquid fuels	CO <sub>2</sub>	34'249.14	31'874.30	2.1	0.55	2.14	1.657	-0.0601	0.7753	-0.03	2.27	2.27	
1A Solid fuels	CO <sub>2</sub>	1'491.85	970.81	18.0	5.0	18.7	0.440	-0.0128	0.0236	-0.06	0.60	0.61	
1A Other fuels	CO <sub>2</sub>	1'676.60	2'457.20	10.0	30.0	31.6	1.883	0.0188	0.0598	0.57	0.85	1.02	
Total CO <sub>2</sub> Emissions Fuel		41'113.63	41'254.98										
Overall uncertainty CO <sub>2</sub> combustion emissions in the year (%):							2.73	CO <sub>2</sub> combustion emissions trend uncertainty (%):					2.77

The analysis results in an overall uncertainty of the CO<sub>2</sub> emissions from 1A Fuel Combustion of 2.73% for the year 2007 and in a trend uncertainty for the period 1990 to 2007 of 2.77%. In particular the large stock changes in liquid fuels with their relatively high uncertainty have led to a higher uncertainty than in the previous submission. The stock changes were due to high prices of liquid fuels, which caused a depletion of stocks in residential fuel tanks.

### **Uncertainty in N<sub>2</sub>O emissions from the use of (waste derived) "Other fuels" in 1A1 Energy Industries**

The uncertainty for the activity data is 10%, the same as for the CO<sub>2</sub> emissions. Emission factor uncertainty for N<sub>2</sub>O from municipal solid waste incineration is estimated at 80%.

### **Uncertainty in CH<sub>4</sub> emissions from Gasoline consumption in 1A3 Road Transportation**

The uncertainty for the activity data is 10%. For the CH<sub>4</sub> emission factor, a value of 59.2% has been chosen leading to a combined uncertainty for the CH<sub>4</sub> emission of 60%. The values for the activity data and for CH<sub>4</sub> emission factor are taken from an extended uncertainty analysis (Kühlwein 2004).

### **Qualitative estimate of uncertainties of non- CO<sub>2</sub> non-key category emissions in 1A Fuel Combustion**

*Non-CO<sub>2</sub> emissions in Energy Industries (1A1), Manufacturing Industries and Construction (1A2) and Other Sectors (Commercial, Residential, Agriculture, Forestry; 1A4)*

A preliminary uncertainty assessment for non-CO<sub>2</sub> emissions from source categories 1A1, 1A2 and 1A4 based on expert judgement results in high confidence in estimations of SO<sub>2</sub> emissions, because of the high quality of activity data and emission factors. Uncertainty in emissions of other non-CO<sub>2</sub> gases are estimated to be medium: 30% for CH<sub>4</sub> and 80% for N<sub>2</sub>O (see Table 1-12).

*N<sub>2</sub>O emissions in Road Transportation (1A3)*

A preliminary uncertainty assessment for N<sub>2</sub>O from source category 1A3 based on expert judgement results in a high uncertainty (150%, see Table 1-12).

### **b) Consistency and Completeness in 1A Fuel Combustion**

Consistency:

- Time series for 1A1, 1A2, 1A3, 1A4 and 1A5 are all consistent.
- CO<sub>2</sub> emissions from biomass in 1 Energy (memo item) are only partly included in the CRF, see Section 3.5.

Completeness:

All estimates in the sector 1A are assumed to be complete.

### **3.2.4. Source-Specific QA/QC and Verification**

At the level of total energy-related CO<sub>2</sub> emissions, a quality control consists in the comparison of emissions modelled using the Sectoral Approach with emissions calculated from fuel consumption according to the Swiss overall energy statistics of SFOE. The differences in total CO<sub>2</sub> emissions for the years 1990–2007 are negligible - indicating the completeness of the inventory.

The cross-check of the Reference and Sectoral Approach is also used for an assessment of emissions related to the consumption of fuels in the energy sector. Again, a good agreement between the two approaches is found (see Chapter 3.6).

Another quality control measure consists in the default calculation of implied emission factors in the CRF. These emission factors are compared to those in the CRF tables of previous years. No peculiar features have been detected.

The quality control activities have been documented in checklists as described in Chapter 1.6.

### **Energy Industries (1A1) and Manufacturing Industries and Construction (1A2)**

To date, no specific quality control measures are applied to this sector.

### **Transport (1A3)**

#### **Civil Aviation (1A3a)**

Emissions: Total calculated emissions for domestic and international flights have been compared between different years. The development of total emissions with time is consistent with a fleet renewal of former Swissair in the early nineties, the technological improvements and changes in fleet composition.

Emission factors:

- From total fuel burn, total distance, number of passenger (without freight) per aircraft type, the fuel consumption per 100 passenger km has been calculated (backward calculation). The result of 2 to 10 kg fuel/100 passenger km is in line with expectations for 1990 passenger fleets.
- The implied emission factors were calculated for 2007 and compared with previous years.

Activity data

- In an independent Tier 3b calculation, EUROCONTROL performed a fuel calculation for Switzerland's international flights, based on collected flight plan data and single movements. The results for the years 2004, 2005 and 2007 matched the FOCA calculations better than 97.4%. The FOCA results were generally 1% to 2% higher but included the total number of actual flight movements of all flights, including VFR (visual flight rules) and non-scheduled flights.
- Comparison between total movement numbers in the calculation and in the corresponding published statistics. Example: In 1990 calculation, FOCA considered all flights for which there was a form 'Traffic report to the airport authorities' filled in (total heavy aircraft). The total number of movements in 1990 is 266'487 (without Basel). The published number of movements for scheduled and charter flights in 1990 is: 263'952 (without Basel). The difference is due to pure cargo, post and rerouted flights, which are not considered as scheduled or charter movements.
- The bottom-up calculation of total fuel matches the total fuel sold within a few percents. The remaining difference can be attributed to fuelling.
- Real-world fuel consumption was compared with modelled consumption for selected aircrafts of four Swiss airlines. The difference between the two methods was smaller than 1%.

#### **Road Transportation (1A3b)**

The international project for the update of the emission factors for road vehicles is overseen by a group of external and international experts that guarantees an independent quality control. For the update of the modelling of Switzerland's road transport emissions, which has been carried out between 2001 and 2004, several experts from the federal administration

have conducted the project. The results have undergone large plausibility checks and comparisons with earlier estimates.

#### **Other sectors (1A4)**

To date, no specific quality control measures are applied to this sector.

#### **Other, Off-road (1A5)**

The off-road emissions have been updated. For this purpose, FOEN mandated national experts. Input data, methods and results were checked by the members of the working group including FOEN specialists and representatives of several professional associations (a list of the members is published in Annex 15 of INFRAS 2008).

### **3.2.5. Source-Specific Recalculations**

#### **1A Fuel Combustion Activities**

- The modelling of the disaggregation of fuel consumption in the sectors 1A2a-f and 1A4a has been updated according to the latest industry data (Basics 2008, CEPE 2008). Sources 1A2 and 1A4a have been recalculated for 1990-2006.
- 1A3b: Due to double-counting of fugitive emissions from transmission, storage and fuelling of gasoline, the emissions had to be subtracted from 1A3b (they are reported under 1B2av Distribution of oil products). The CO<sub>2</sub> emissions of 1A3b were recalculated for time series 1990–2006.
- Off-road emissions have been recalculated due to the update of the off-road database. 1A3c Railways, 1A3d Navigation, 1A4c agriculture/forestry machinery and 1A5 Other/Off-road are concerned.
- Activity data for Municipal solid waste and special waste (1A1a Other fuels) have been recalculated for the year 2006. A minor correction was also made to activity data for natural gas in 1A1a.
- Activity data in 1A2a has been recalculated for 2003-2006 due to new industry data.
- In 1A2f, activity data and emission factors have been updated due to new data from industry and the Swiss overall energy statistics for several processes from 2000-2006.
- In 1A4b implied emission factors for CH<sub>4</sub> of liquid fuels and gaseous fuels have been slightly changed for the period 1994-2006. Activity data were updated and emission factors for CH<sub>4</sub> are not similar for the different sectors.

For quantitative results of the recalculations see Chapter 9.

### **3.2.6. Source-Specific Planned Improvements**

#### **Energy Industries (1A1), Manufacturing Industries and Construction (1A2)**

CO<sub>2</sub> emission factors for the use of waste derived fuels in cement industry are preliminary and may be revised for future submissions.

Activity data for the use of wood for district heating has not yet been updated to include new data from the Swiss overall energy statistics for the years 2002-2005. It is planned to include these data in the next submission.

### **Transport (1A3)**

Civil Aviation (1A3a): FOCA has completed a project (ECERT) to compile data on fuel consumption and emission factors for small (piston) aircraft (FOCA 2007a). A corresponding project for improved helicopter emissions modelling (HELEN) will be completed in 2009. The results will be used for further improving the emission modelling in future years.

The artefact of increased helicopter emissions in 2007 will be corrected for the next submission.

### **Other Sectors (1A4)**

There are no source-specific planned improvements.

### **Other: Off-road (1A5)**

There are no source-specific planned improvements.

## **3.3. Source Category 1B – Fugitive Emissions from Fuels**

### **3.3.1. Source Category Description**

<b>Key category 1B2</b>
-------------------------

Fugitive Emissions of CH <sub>4</sub> from Oil and Natural Gas (trend)
--

Fugitive emissions arise from the production, processing, transmission, storage and use of fuels. According to IPCC guidelines, emissions from flaring at oil and gas production facilities are included while emissions from vehicles are not included in 1B.

Source Category 1B "Fugitive Emissions from Fuels" comprises the following sub-categories:

- Solid fuels (1B1)
- Oil and Natural Gas (1B2)

#### **a) Solid fuels (1B1)**

Coal mining is not occurring in Switzerland.

## b) Oil and Natural Gas (1B2)

Table 3-39 Specification of source category 1B2 "Fugitive Emissions from Oil and Natural Gas".

1B2	Source	Specification	Data Source
1B2 a	Oil	Emissions from refining/storage of oil and the distribution of oil products	AD: SFOE 2008 EF: EMIS 2009/1B
1B2 b	Natural Gas	Emissions from gas pipelines and the compressor station in Ruswil, Lucerne.	AD: SFOE 2008, SGWA 2005, SGIA 2008, Swissgas 2007 EF: Battelle 1994, Xinmin 2004, SGWA 2007
1B2 c	Venting / Flaring	The release/combustion of excess gas at the oil refinery	AD: SFOE 2008 EF: EMIS 2009/1B

### 3.3.2. Methodological Issues

#### a) Solid fuels (1B1)

Coal mining is not occurring in Switzerland.

#### b) Oil and Natural Gas (1B2)

##### Methodology

For source 1B2a Oil, the emissions of CO<sub>2</sub>, CH<sub>4</sub> and NMVOC are reported.

For source 1B2b Natural Gas, the emissions of CH<sub>4</sub> and NMVOC leakages from gas pipelines are calculated with a new country specific Tier 3 method. The method considers the length, type and pressure of the gas pipelines as well as the annual gas consumption. The distribution network components (regulators, shut off fittings and gas meters), the losses from maintenance and extension as well as the end user losses are separately taken into account. Also, emissions of CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> from a compressor station located in Ruswil are considered.

For source category 1B2c Venting/Flaring (Oil), CO<sub>2</sub> as well as CH<sub>4</sub>, NO<sub>x</sub>, CO and NMVOC are considered.

The indirect CO<sub>2</sub> emissions from the decomposition of NMVOC in the atmosphere have been calculated from the average carbon contents of NMVOC emissions for the subcategory 1B2a and 1B2b.

The emissions from oil and venting/flaring (1B2a and 1B2c) are calculated based on annual production/consumption data which is consistent with the IPCC Tier 1 approach. Emissions of greenhouse gases are calculated by multiplying level of activity by emission factor.

##### Emission factors

1B2a and 1B2c: The emission factors for direct CO<sub>2</sub>, CH<sub>4</sub> and NMVOC are based on data from the refining and gas industry and expert estimates.

The emission factors for gas distribution losses (source 1B2b) depend on the type and pressure of the natural gas pipeline (see Table 3-40; sources: Battelle 1994, Xinmin 2004, SGWA 2007). The CH<sub>4</sub>-emissions due to gas meters are considered with the emission factor of 5.1 m<sup>3</sup> CH<sub>4</sub> per gas meter and year. The emission factors for 1B2b are calculated for each year separately.

Table 3-40 CH<sub>4</sub>-Emission Factors for 1B2 "Fugitive Emissions from Oil and Natural Gas" (Battelle 1994, Xinmin 2004, SGWA 2007)

1B2 Fugitive Emissions from Oil and Natural Gas	< 100 mbar	100-1000 mbar	1- 5 bar	> 5 bar
	Emission factors in [m <sup>3</sup> /h/km]			
Cast iron	0.80000	1.20000	0.19200	-
Cast steel	0.08800	0.13200	0.00230	-
Steel normal	0.08800	0.01320	0.00062	-
Steel cath.	0.00800	0.01200	0.00002	0.028
HDPE (Polyethylene)	0.00800	0.01600	0.00062	-
other	0.00800	0.01600	0.00002	-

The indirect CO<sub>2</sub> emissions from the decomposition of NMVOC in the atmosphere have been calculated from the average carbon contents of NMVOC emissions from the EMIS database. Resulting emission factors are 3.15 Gg CO<sub>2</sub>/Gg NMVOC for 1B2a (Oil) and 2.93 Gg CO<sub>2</sub>/Gg NMVOC for 1B2b (Natural gas).

### Activity data

The activity data for fugitive emissions such as the total annual gasoline consumption and gas imports are extracted from the Swiss overall energy statistics (SFOE 2008).

The activity data for methane of Natural Gas (source 1B2b) are provided by the Swiss gas and water industry association (SFOE 2008), but an extrapolation of data from 2005 is made based on aggregate increases in grid length in order to include the length of junction tubes (SFOE 2008, SGIA 2008, SGWA 2005, Swissgas 2007). Fugitive emissions from a high pressure natural gas transfer pipeline, crossing Switzerland from France to Italy, are included in the inventory. The data on fuel consumption for the operation of the compressor station in Ruswil is based on the Swiss overall energy statistics (SFOE 2008; Table 13).

### 3.3.3. Uncertainties and Time-Series Consistency

#### Uncertainty in fugitive CH<sub>4</sub> emissions from natural gas pipelines in 1B2

Following Good Practice Guidance (IPCC 2000: p. 2.92) overall uncertainty of bottom-up inventories of fugitive methane losses from gas activities are expected to result in errors of 25-50%. From this a conservative uncertainty of 50% is estimated for Switzerland.

#### Qualitative estimate of uncertainties of non-key category emissions in 1B Fugitive Emissions from Fuels

A preliminary uncertainty assessment of all other sources in source category 1B2 based on expert judgement results in medium confidence in the emissions estimate.

The time series is consistent.

### 3.3.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### 3.3.5. Source-Specific Recalculations

The implied CO<sub>2</sub> emission factor in 1B2a v. Distribution of oil products was recalculated from 1995 to 2006.

The implied CO<sub>2</sub> emission factor in 1B2b iii Transmission of natural gas was recalculated for 2006, because an extrapolation was replaced by a calculation.

N<sub>2</sub>O emissions in 1B2d Other was recalculated for 2006 due to updated data in the Swiss overall energy statistics (SFOE 2008).

### 3.3.6. Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry is ongoing.

## 3.4. Source Category International Bunker Fuels

### 3.4.1. Source Category Description

By definition, greenhouse gas emissions from the use of International Bunker Fuels are **not a key category** (IPCC 2000).

For Switzerland, the only source of international bunker emissions is aviation. Marine bunker emissions are not estimated: The only candidate for marine bunker are the navigation activities on the river Rhine between Basel and Rotterdam (NL). Due to an economic and a technical reason, fuelling will predominantly take place abroad, i.e. out of Switzerland:

- The price for diesel oil is higher in Switzerland than in the other Rhine-abutting nations Netherlands, Germany, France.
- The main fuel consumption takes place in the upstream direction, which ends in Basel-Birsfelden, 10 km from the Swiss border (farther up the river is no more navigable).

For these reasons, the bunker fuel consumption is estimated to be very low.

Table 3-41 Specification of Swiss source category International Bunkers for civil aviation.

International Bunker Fuels	Specification	Data Source
Civil Aviation	Country specific model (Tier 3a)	FOCA 2006, 2007, 2008

### 3.4.2. Methodological Issues

The methodologies used are described in chapter 3.2.2.c. The emissions from civil aviation (domestic and international) are calculated with a Tier 3a method. The emission factors are country specific with one exception N<sub>2</sub>O (IPCC default). The activity data of the bunker is summarised in Table 3-42 (see also Table 3-23).

Due to the detailed information about activity data, the resulting fuel consumption is considered complete. In spite of this, there remain small differences between the fuel consumption modelled bottom-up and the total fuel sold (SFOE 2008). In 1990, the modelled consumption adds up to 1.01 million tons, whereas 1.05 million tons were sold. The difference of 4% is considered to be acceptable, because discrepancies of 10% can easily result from fuelling strategies of airlines (FOCA investigation showed that airlines are calculating whether it is economically beneficial to refuel at a place with lower fuel prize.) In order to match the bottom up calculation with the fuel quantity sold, any occurring difference is attributed to international bunker emissions. The factor between calculated international fuel consumption and adjusted international fuel consumption is used to scale the bunker emissions linearly. For instance in 1990, the bunker fuel consumption and the emissions had

to be expanded by the factor 1.045. For 2006, they had to be reduced by the factor 0.974 (FOCA 2007). For 2007, the correction factor was 0.968.

Table 3-42 International bunker fuels. Consumption of kerosene in TJ. (Note that Liechtenstein's kerosene consumption is subtracted, see Chapter 3.1.4.)

Civil Aviation (bunker)	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Fuel consumption in TJ									
Total international	41'884	40'872	43'499	45'342	46'840	49'918	51'975	53'983	56'599	60'805
1990 = 100%	100%	98%	104%	108%	112%	119%	124%	129%	135%	145%

Civil Aviation (bunker)	2000	2001	2002	2003	2004	2005	2006	2007
	Fuel consumption in TJ							
Total international	63'687	60'097	55'468	49'763	46'896	47'671	50'109	53'543
1990 = 100%	152%	143%	132%	119%	112%	114%	120%	128%

### 3.4.3. Uncertainties and Time-Series Consistency

See remarks in Chapter 3.2.3, sections Aviation (1A3a).

### 3.4.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the QA/QC measures described in Sections 1.6 and 3.2.4 have been carried out.

### 3.4.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

### 3.4.6. Source-Specific Planned Improvements

See remarks in Chapter 3.2.6., Aviation (1A3a).

## 3.5. CO<sub>2</sub> Emissions from Biomass

A description of the methodology for calculating CO<sub>2</sub> emissions from the combustion of biomass is included in the relevant Chapters 3 (Energy) and 8 (Waste).

Energy related emissions from municipal solid waste (MSW) incineration plants are reported under 1A1 Energy Industries (see Section 3.2.2 a). For technical reasons, it has not been possible to include the biomass CO<sub>2</sub> emissions from energy related MSW incineration in Table 1.A(a) of the CRF. Also CO<sub>2</sub> emissions related to the combustion of waste derived biomass fuels in cement production in source categories 1A2f, from 2D2 (Industrial Processes, Food and Drink), from 2G (Industrial Processes, Other), from 3D (Other – consumption of tobacco), from 4F (Burning of Agricultural Residues), from 6A (Solid Waste Disposal on Land) and 6D (composting and fermentation of waste) are not foreseen for reporting in the CRF.

Therefore, the CO<sub>2</sub> emissions from biomass in the CRF are incomplete. The following table provides an overview of effective biomass CO<sub>2</sub> emissions in Switzerland 2007 and their reporting in the CRF (without land-use, land-use change and forestry). Data stems from the CRF and the SAEFL internal GHG files.

Biomass CO<sub>2</sub> emissions do not count for the national total emissions and are a memo item only.

Table 3-43 Effective biomass CO<sub>2</sub> emissions in Switzerland and their representation in the CRF.

Biomass CO <sub>2</sub> emissions	Unit	Value 2007	Note
1A1 Energy Industries (without MSW incineration)	Gg	69	Included in CRF
1A1 Energy generation from MSW Incineration	Gg	2'730	Not included in CRF
1A2d Use of waste derived fuels in cellulose production	Gg	169	Included in CRF
1A2f Manufacturing Ind. and Constr. - Other (excl. waste fuels in cement prod.)	Gg	958	Included in CRF
1A2f Use of waste derived fuels in cement production	Gg	138	Included in CRF
1A3 Transport	Gg	NO	
1A4 Other Sectors (Commercial/Institutional, Residential)	Gg	2'051	Included in CRF
2D2 Industrial Processes, Food and Drink	Gg	14	Not included in CRF
2G Industrial Processes, Other	Gg	0	Not included in CRF
3D Other (consumption of tobacco)	Gg	14	Not included in CRF
4F Agriculture, Burning of Residues	Gg	116	Not included in CRF
6A Solid Waste Disposal on Land	Gg	45	Not included in CRF
6B Wastewater Handling	Gg	NO	
6C Waste Incineration (without MSW incineration)	Gg	131	Included in CRF
6D Other Waste (compost and fermentation of waste)	Gg	372	Not included in CRF
Total biomass combustion CO <sub>2</sub> emissions included in CRF	Gg	3'378	
Total energy related biomass combustion CO <sub>2</sub> emissions included in CRF 1A	Gg	3'247	See table "Summary 2" in CRF
Total biomass CO <sub>2</sub> emissions in Switzerland 2007	Gg	6'807	

### 3.6. Comparison of Sectoral Approach with Reference Approach

The apparent consumption, the net carbon emissions, and the effective CO<sub>2</sub> emissions are calculated for the Reference Approach as prescribed in the CRF tables 1A(b)–1A(d). Figures are taken from the Swiss overall energy statistics (SFOE 2008) and from the yearly report of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2008). These statistics account for production, imports, exports, transformation and stock changes.

The Reference approach covers the CO<sub>2</sub> emissions of all imported fuels (import, export, stock changes), i.e. emissions from crude oil treatment (secondary fuel production) in the two Swiss refineries and emissions of imported secondary fuels. Nearly 40% of the secondary liquid fossil fuels sold in Switzerland stem from the Swiss refineries.

The following table and the figure show the differences between the Reference and the Sectoral (National) Approaches 1990–2007. The CO<sub>2</sub> emissions agree very well, for all years the differences are between 0.75% and 1.80%. For the energy consumption (excluding non-energy use and feedstocks) the differences are somewhat larger and lie between -0.40% and 2.01%.

Table 3-44 Differences in energy consumption and CO<sub>2</sub> emissions between the Reference and the Sectoral (National) Approach. The difference is calculated according to  $[(RA-SA)/SA]$  100% with RA = Reference Approach, SA = Sectoral (National) Approach. Energy consumption: excluding non-energy use and feedstocks

Difference between Reference and Sectoral Approach										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	%									
Energy Consumption	-0.40	0.72	0.95	1.03	1.29	1.43	1.35	1.23	2.01	1.12
CO <sub>2</sub> Emissions	1.08	1.29	1.37	1.25	1.52	1.80	1.21	1.13	1.74	0.85

	2000	2001	2002	2003	2004	2005	2006	2007
	%							
Energy Consumption	0.84	0.67	0.35	0.48	0.76	0.16	0.48	-0.20
CO <sub>2</sub> Emissions	1.13	1.14	0.75	0.89	1.35	1.08	1.77	1.58

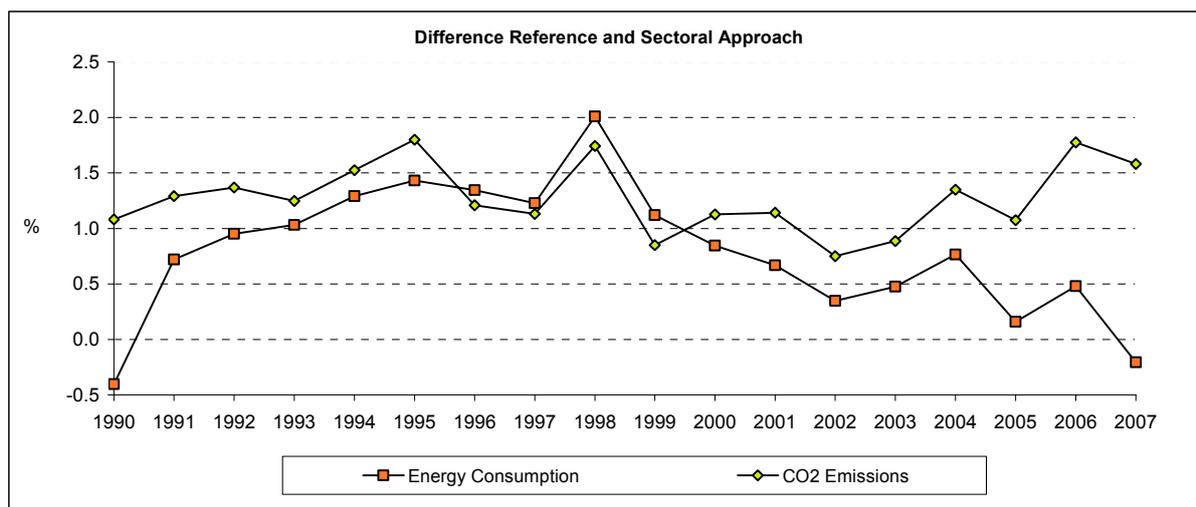


Figure 3-5 Time series for the differences between Reference and Sectoral Approach. Numbers are taken from Table 3-44.

Note that in the former submissions, the apparent energy consumption included feedstocks (only bitumen), which was not in line with the footnote 4 of the CRF Table 1.A(c)<sup>14</sup>. For the current submission, the feedstocks have now been subtracted from the energy consumption in Table 3-44 and in Figure 3-5.

The Reference Approach is calculated and documented in the CRF under the following conditions:

- Only bitumen production from national refineries is shown in CRF Table 1.A (d). It is a refinery product and included in the crude oil amount. In the Swiss inventories, bitumen emissions (NMVOC) appear under industrial processes and not under energy use.
- Gaseous fuels: Gas distribution emissions (including emissions from compressor stations) are reported under 1B Fugitive Emissions (CRF Table 1.B.2) and do not appear in CRF Table 1.A (d).
- Liquid fuels/Solid fuels: In the Sectoral (National) Approach, petroleum coke is subsumed under solid fuels (used by cement industry where petroleum coke is treated as coal).
- The oxidations factor is consequently set to 1.0 due to the following reason: combustion installations in Switzerland have very good combustion properties; combined emissions of CO and unburnt VOC lie in the range of only 0.1 to 0.3 percent of CO<sub>2</sub> emissions for oil and gas combustion. Since most of the coal used in Switzerland goes to the cement industry, also for coal an oxidation factor of 1.0 was chosen (cf. Chapter 3.2.2.)
- For the Reference Approach, Liechtenstein's fuel consumption is subtracted from the input figures of fuel consumption, which originally include Liechtenstein's consumption (see also Chapter 3.1.4).

<sup>14</sup> "For the purposes of comparing apparent energy consumption from the Reference approach with energy consumption from the Sectoral approach, Parties should ... subtract from the apparent energy consumption (Reference approach) the energy content corresponding to the fuel quantities used as feedstocks and/or for non-energy purposes, in accordance with the accounting of energy use in the Sectoral approach" [footnote 4 of CRF Table 1.A(c)].

## 4. Industrial Processes

### 4.1. Overview

This chapter provides information on the estimation of the greenhouse gas emissions from industrial processes. The following source categories are reported:

- 2A. Mineral Products
- 2B. Chemical Industry
- 2C. Metal Production
- 2D. Other Production and 2E. Production of Halocarbons and SF<sub>6</sub> are not occurring
- 2F. Consumption of Halocarbons and SF<sub>6</sub>
- 2G. Other

According to IPCC guidelines, emissions within this sector comprise greenhouse gas emissions as by-products from industrial processes and also emissions of synthetic greenhouse gases during production, use and disposal. Emissions from fuel combustion in industry are reported under sector energy.

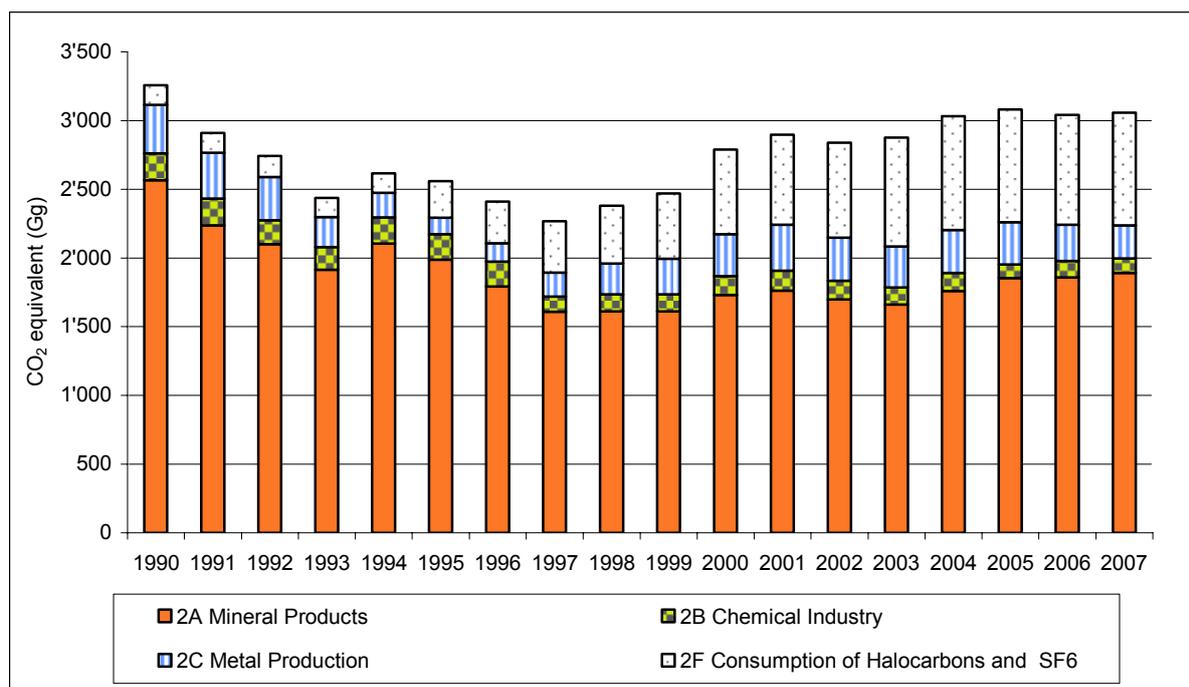


Figure 4-1 Switzerland's GHG emissions of source category 2 "Industrial Processes" 1990–2007. The emissions of the source category 2G "Other" are small (< 1 Gg CO<sub>2</sub> eq) compared to the other sources in category 2 and are not visible in the figure.

Category 2A Mineral Products remains the dominant source amongst the Industrial Processes although its emissions have decreased by over -26% in the period 1990-2007. Also 2B Chemical Industry and 2C Metal Production have decreased (-46% and -31% respectively), whereas 2F Consumption of Halocarbons and SF<sub>6</sub> is of increasing importance: The emissions – exclusively synthetic gases of 2F- have increased by a factor of 5.7 in the same period (see Figure 4-2), primarily because of the change from CFC to HFC in a lot of technical applications. The sum of all synthetic gases have increased by the factor 3.6.

Table 4-1 GHG emissions of source category 2 "Industrial Processes" 1990-2007 by gases in CO<sub>2</sub> equivalent (Gg).

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO <sub>2</sub> equivalent (Gg)									
CO <sub>2</sub>	2'831	2'500	2'362	2'117	2'282	2'108	1'925	1'747	1'767	1'811
CH <sub>4</sub>	9.1	8.7	8.3	8.0	7.7	7.3	7.3	7.2	7.2	7.2
N <sub>2</sub> O	174	172	151	144	168	165	160	89	103	104
Synth. gases	244	231	224	169	159	278	318	424	503	547
Sum	3'258	2'912	2'745	2'438	2'617	2'559	2'410	2'268	2'380	2'470

Gas	2000	2001	2002	2003	2004	2005	2006	2007
	CO <sub>2</sub> equivalent (Gg)							
CO <sub>2</sub>	1'948	1'985	1'937	1'911	2'021	2'104	2'071	2'086
CH <sub>4</sub>	7.2	7.2	7.2	7.2	7.2	7.1	7.0	6.9
N <sub>2</sub> O	115	121	113	101	109	79	98	83
Synth. gases	718	784	782	857	897	891	865	882
Sum	2'789	2'897	2'840	2'876	3'034	3'081	3'041	3'058

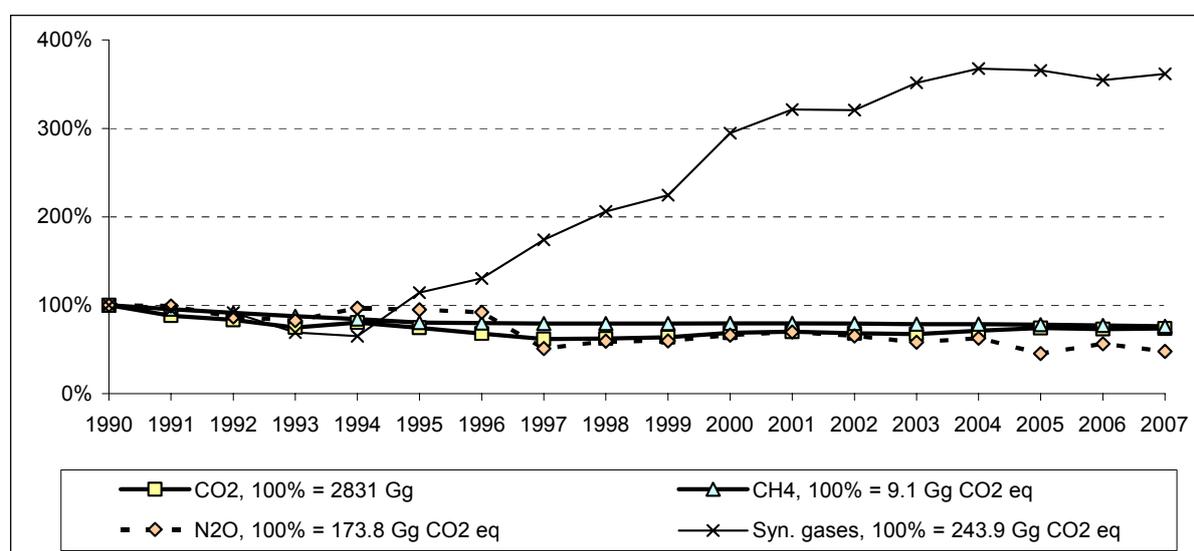


Figure 4-2 Relative trends of the greenhouse gases of source category 2 "Industrial Processes" in the period 1990-2007. The base year 1990 represents 100%.

The CO<sub>2</sub> emissions have declined to 74% whereas the synthetic gases have increased to 362% in the period 1990-2007.

## 4.2. Source Category 2A – Mineral Products

### 4.2.1. Source Category Description

#### Key category 2A1

Non-energy CO<sub>2</sub> emissions in Cement Production (level and trend).

Source category 2A1 "Mineral Products" comprises non-energy emissions from Cement Production, Lime Production and Road Paving with Asphalt. Limestone and Dolomite Use as well as Soda Ash Production and Use are not occurring in Switzerland.

Table 4-2 Specification of source category 2A "Mineral Products".

2A	Source	Specification	Data Source
2A1	Cement Production	Emissions from calcination process in cement production and emissions from blasting operations.	AD: Cemsuisse 2008 EMIS 2009/2A1  EF: calcination-CO <sub>2</sub> : WBCSD 2001;  EF Other gases: EMIS 2009/2A1
2A2	Lime Production	Emissions from calcination process in lime production.	AD: EMIS 2009/2A2 EF: Industry data
2A3	Limestone and Dolomite Use	Not occurring in Switzerland	
2A4	Soda Ash Production and Use	Not occurring in Switzerland	
2A5	Asphalt Roofing	Emissions from asphalt roofing	AD: EMIS 2009/2A5 EF: Industry data
2A6	Road Paving with Asphalt	Emissions from road paving	AD: EMIS 2009/2A6 EF: EMIS 2009/2A6
2A7	Other	Not occurring in Switzerland	

## 4.2.2. Methodological Issues

### a) Cement Production (2A1)

#### Methodology

*Calcination:* For the CO<sub>2</sub> emissions in Cement Production (2A1) from calcination the Tier 2 approach of IPCC Good Practice Guidance is used. Emissions of CO<sub>2</sub> related to calcination are calculated bottom-up by multiplying the annual clinker output (level of activity) by emission factors. In the Swiss cement plants no cement kiln dust or bypass dust is discarded. For non-CO<sub>2</sub> emissions from calcination, a country specific approach based on the annual cement (not clinker) output is applied. Emissions are calculated by multiplying the annual cement (not clinker) output by emission factors.

*Blasting:* In addition to the IPCC approach, emissions resulting from blasting operations during the working of limestone are included, following a country specific method. Emissions of GHGs related to blasting operations are calculated by multiplying the annual cement (not clinker) output by emission factors. Please note that the CO<sub>2</sub> emissions from "blasting" are related to the usage of the explosive itself and are not related to fuel consumption of e.g. bulldozers etc.

Total emissions reported for Cement Production (1A2) are the sum of emissions from calcination and blasting.

#### Emission Factors

*Calcination:* The emission factor for CO<sub>2</sub> per ton of clinker is an improved IPCC default value and amounts to 525 kg per ton of clinker produced.

Switzerland follows the approach provided by the Working Group Cement of the World Business Council on Sustainable Development (WBCSD 2001; Appendix 4). The IPCC approach neglects CO<sub>2</sub> from decomposition of MgCO<sub>3</sub>. In the Swiss inventory, these emissions are included based on an assumed MgO content in clinker of 2%. A CaO content of clinker of 64.2% is used following the WBCSD, broadly in line with the IPCC default weight fraction of 65%. Possible non-carbonate feeds e.g. from raw materials are not considered. Together, this results in a CO<sub>2</sub> emission factor of 525 kg/t clinker. This emission factor has been recommended as a default value by the Working Group Cement of the World Business Council on Sustainable Development (WBCSD 2001; Appendix 4). In 2006, measurements were carried out and an emission factor of 528 kg per ton of clinker was determined (Cemsuisse 2007a).

Calcination emission factors for CH<sub>4</sub>, CO, NMVOC and SO<sub>2</sub> per ton of cement are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (see Section 1.4.3).

*Blasting*: Emission factors for CO<sub>2</sub>, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> per ton of cement are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2009/2A1, see Section 1.4.3).

The following table presents the emission factors used in 2A1:

Table 4-3 Emission Factors for 2A1 Cement Production for 2007 (cem.: cement).

2A1 Cement Production	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	NO <sub>x</sub>	CO	NMVOC	SO <sub>2</sub>
	kg/t clinker	kg/t cem.			kg/t cem.	kg/t cem.	kg/t cem.
Calcination	525	0.0057			0.80	0.046	0.37
	kg/t cement			g/t cem.	g/t cem.	g/t cem.	g/t cem.
Blasting Operations	0.096			3.70	22	9.6	0.16

## Activity Data

Activity data on both annual clinker and cement production is provided by the Association of the Swiss Cement Industry (cemsuisse).

Table 4-4 Activity data in 2A1 Cement Production.

Source/production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2A1 Cement Production											
Cement production	Gg	5'117	4'683	4'268	4'043	4'432	3'994	3'648	3'485	3'371	3'540
Clinker production	Gg	4'808	4'189	3'927	3'564	3'930	3'706	3'337	2'994	2'995	2'992

Source/production	Unit	2000	2001	2002	2003	2004	2005	2006	2007
2A1 Cement Production									
Cement production	Gg	3'754	3'891	3'771	3'592	3'957	4'136	4'143	4'243
Clinker production	Gg	3'214	3'275	3'150	3'081	3'265	3'442	3'452	3'512

The table above shows that Swiss cement production in 2007 was 17% lower than in 1990. This decline results in category 2A1 being a key category regarding trend.

**b) Lime Production****Methodology**

For CO<sub>2</sub> emissions in Lime Production (2A2) the approach of IPCC 1997c is used. Emissions of CO<sub>2</sub> are calculated by multiplying the annual lime output (level of activity) by the emission factor. Other GHGs are not considered.

**Emission Factors**

The emission factor for CO<sub>2</sub> per ton of lime produced is country specific and amounts to 560 kg/t. It takes into consideration measurements and data from the one existing plant, the European BREF default value and expert estimates, documented in the EMIS database (EMIS 2009/2A2, see Section 1.4.3).

**Activity Data**

Activity data on annual lime production is based on data from industry and expert estimates, documented in the EMIS database (EMIS 2009/2A2, see Section 1.4.3).

**c) Asphalt Roofing****Methodology**

For determination of CO and NMVOC emissions from Road Paving with Asphalt a country specific method is used, based on CORINAIR. The method was updated in 2008, as documented in the EMIS database (EMIS 2009/2A5, see Section 1.4.3). Emissions of NMVOC are calculated by multiplying the annual amounts of asphalt roofing products produced and used as well as the amounts of primers produced and used (level of activity) by the corresponding emission factors. Other GHGs are not considered.

**Emission Factors**

The emission factor for NMVOC emissions from Asphalt Roofing is country specific. It is based on measurements, industry data and expert estimates, documented in the EMIS database (EMIS 2009/2A5, see Section 1.4.3).

**Activity Data**

Activity data is based on industry and expert estimates, documented in the EMIS database (EMIS 2009/2A5, see Section 1.4.3).

**d) Road Paving with Asphalt****Methodology**

For determination of NMVOC emissions from Road Paving with Asphalt a country specific method is used, based on CORINAIR. Emissions of NMVOC are calculated by multiplying the annual amount of asphalt products used for road paving (level of activity) by the emission factor. Other GHGs are not considered.

**Emission Factors**

The emission factor for NMVOC emissions from Road Paving with Asphalt is country specific and amounts to 0.80 kg/t (2007). The emission factor includes emissions from both ground paint and asphalt products. It is based on measurements, industry data and expert estimates, and has been recalculated for 1990-2006, as documented in the EMIS database (EMIS 2009/2A6, see Section 1.4.3).

**Activity Data**

Activity data on the amount of asphalt products ("Mischgut"; containing about 5% of bitumen) used for Road Paving with Asphalt is based on data from the asphalt products industry and

expert estimates, and has been updated for 2004-2007, as documented in the EMIS database (EMIS 2009/2A6, see Section 1.4.3).

### **4.2.3. Uncertainties and Time-Series Consistency**

#### **Uncertainty in non-energetic CO<sub>2</sub> emissions from Cement Production in 2A1**

Estimate of uncertainty of CO<sub>2</sub> emissions from clinker calcination follows the steps in Table 3.2 in IPCC Good Practice Guidance (IPCC 2000: p. 3.15). As CO<sub>2</sub> emissions are calculated based on plant level clinker production data (Tier 2), activity data uncertainty of 2% is assumed. Uncertainty of the emission factor is based on the fact that an average CaO content of clinker of 64.2% is assumed. For the IPCC default value table 3.2 in the GPG estimates a default uncertainty of 4-8%; 6% is chosen for Switzerland.

Together, a combined uncertainty of 6.3% for CO<sub>2</sub> emissions from calcinations results.

#### **Qualitative estimate of uncertainties of non-key category emissions in 2A**

For the most important source, cement production, emissions are based on actual cement and clinker production data provided by the cement industry.

Preliminary expert judgment estimates confidence in emissions to be medium in general, whereas confidence in CO<sub>2</sub> emissions is high.

The time series is consistent.

### **4.2.4. Source-Specific QA/QC and Verification**

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### **4.2.5. Source-Specific Recalculations**

Recalculations have been carried out for the whole time series for CO and NMVOC emissions in 2A5 and for NMVOC emissions in 2A6.

### **4.2.6. Source-Specific Planned Improvements**

In the calculation of the CO<sub>2</sub> emission factor in 2A Cement production, the WBCSD default weight fraction of 64.2% for the CaO content of clinker is used (which is close to the IPCC default value of 65%). It is planned to use a country specific CO<sub>2</sub> emission factor.

## **4.3. Source Category 2B – Chemical Industry**

### **4.3.1. Source Category Description**

#### **Key category 2B**

N<sub>2</sub>O emissions in Chemical Industry (trend).

Source category 2B "Chemical Industry" comprises non-energy emissions from the Production of Nitric Acid, Carbide and Organic Chemicals. The production of Adipic Acid is not occurring in Switzerland.

Table 4-5 Specification of source category 2B "Chemical Industry".

2B	Source	Specification	Data Source
2B1	Ammonia Production	Emissions from the production of Ammonia, including NH <sub>3</sub> emissions	AD, EF: EMIS 2009/2B1
2B2	Nitric Acid Production	Emissions from the production of Nitric Acid	AD, EF: Industry data, EMIS 2009/2B2
2B3	Adipic Acid Production	Not occurring in Switzerland	
2B4	Carbide Production	Emissions from the production of Silicon Carbide	AD, EF: EMIS 2009/2B4
2B5	Other	Emissions from the production of Organic Chemicals (Ethylene, PVC, Formaldehyde, Acetic Acid)	AD, EF: EMIS 2009/2B5

### 4.3.2. Methodological Issues

#### a) Ammonia Production (2B1)

##### Methodology

For CO<sub>2</sub>, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> emissions from Ammonia Production (2B1), a country specific approach is used. The emissions are calculated by multiplying the annual ammonia production output (levels of activity) by emission factors.

##### Emission Factors

Emission factors for CO<sub>2</sub>, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> per ton of Ammonia produced are country specific based on measurements, data from industry and expert estimates, documented in the EMIS database (EMIS 2009/2B1, see Section 1.4.3).

##### Activity Data

Activity data on annual production has been revised for 1991 to 2006 based on new industry data, as documented in the EMIS database (EMIS 2009/2B1, see Section 1.4.3). In 2007, ammonia production amounted to 33'970 tons.

#### b) Nitric Acid Production (2B2)

##### Methodology

For N<sub>2</sub>O and NO<sub>x</sub> emissions from Nitric Acid Production (2B2), a country specific approach is used. The emissions are calculated by multiplying the annual nitric acid production output (levels of activity) by emission factors.

##### Emission Factors

Emission factors for N<sub>2</sub>O and NO<sub>x</sub> per ton of Nitric Acid are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (see Section 1.4.3).

The following table presents the emission factors used in 2B2 for 2007:

Table 4-6 Emission Factors for 2B2 Nitric Acid Production in 2007.

<b>2B2 Nitric Acid Production</b>	<b>N<sub>2</sub>O</b>	<b>NO<sub>x</sub></b>
	kg/t	kg/t
Nitric Acid Production	5.0	0.89

The emission factor for NO<sub>x</sub> has been provided by industry. The emission factor for N<sub>2</sub>O was not available from plant operators; therefore an older value of 5 kg of N<sub>2</sub>O per ton of nitric acid has been assumed (EMIS 2009/2B2). This value is in line with the value given in IPCC 1997c of 2-9 kg/t for the USA and 4-5 kg/t given for atmospheric pressure plants in Norway.

### Activity Data

Activity data on annual production of nitric acid since 1990 has been provided by industry and has been recalculated for 1997-2006. (EMIS 2009/2B2). The reduction of activity from 112'100 t nitric acid in 1990 to 53'650 t in 2007 is the reason why N<sub>2</sub>O emissions from 2B are a key category. An error has been identified in the activity data which will be corrected in the next submission.

### c) Carbide Production (2B4)

#### Methodology

For CO<sub>2</sub> and SO<sub>2</sub> emissions from Silicon and Calcium Carbide Production (2B4), a country specific approach is used. The emissions are calculated by multiplying the annual production output (level of activity) by emission factors.

Source category 2B4 contributes less than 1% to total CO<sub>2</sub> emissions from 2 Industrial Processes.

#### Emission Factors

Emission factors for CO<sub>2</sub> and SO<sub>2</sub> are from EMIS (EMIS 2009/2B4).

#### Activity Data

Activity data on annual production are from industry and are confidential, but available to reviewers.

### d) Other (Organic Chemicals; 2B5)

#### Methodology

For CH<sub>4</sub>, CO, NMVOC and SO<sub>2</sub> emissions from Organic Chemicals Production (2B5), a country specific approach is used. The emissions are calculated by multiplying the annual production output (level of activity) by emission factors. The organic chemicals considered are ethylene, PVC, formaldehyde, and acetic acid.

#### Emission Factors

Emission factors for CH<sub>4</sub>, CO, NMVOC and SO<sub>2</sub> are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2009/2B5, see Section 1.4.3). The CH<sub>4</sub> emission factor has been updated for 2005 and 2006.

## Activity Data

Activity data on annual production have been provided by industry and updated for 2005 and 2006 based on new data as documented in the EMIS database (EMIS 2009/2B5).

### 4.3.3. Uncertainties and Time-Series Consistency

Time series on production data and emission factors in the EMIS database use in some cases expert judgment to estimate data for the period after 1995.

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

The uncertainty of the (implied) N<sub>2</sub>O emission factor in Category 2B Chemical Industry is estimated to be 40% (expert estimate). The uncertainty of the related activity data is estimated to be 10% (expert estimate).

The time series is consistent.

### 4.3.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### 4.3.5. Source-Specific Recalculations

Activity data in 2B1 Ammonia production has been recalculated for 1991 to 2006 based on new industry data.

Activity data in 2B2 Nitric Acid Production has been recalculated for 1997-2006 based on new industry data.

In 2B5 Other the CH<sub>4</sub> emission factor and activity data have been recalculated for 2005 and 2006 based on new industry data.

### 4.3.6. Source-Specific Planned Improvements

The CO<sub>2</sub> emission factor for 2B1 Ammonia Production will be subject to further revision in future submissions. Activity data for 2B2 Nitric Acid Production will be corrected in the next submission. The N<sub>2</sub>O emission factor for 2B2 Nitric Acid Production will be reevaluated in coordination with industry.

## 4.4. Source Category 2C – Metal Production

### 4.4.1. Source Category Description

**Key category 2C\_o (2C Metal Production without 2C3 Aluminium Production)**  
CO<sub>2</sub> emissions from Metal Production without Aluminium Production (trend)

Source category 2C "Metal Production" comprises non-energy emissions from the production of steel and aluminium as well as from the use of SF<sub>6</sub> in aluminium and magnesium foundries and from other metal production.

For the key category analysis 2C has been divided into a subcategory 2C3 Aluminium Production and a category 2C\_o comprising the remainder of the sources in 2C and defined as Metal Production without Aluminium Production. CO<sub>2</sub> emissions in 2C\_o occur mainly in 2C1, Iron and Steel Production. Other CO<sub>2</sub> emissions in 2C\_o occur only in 2C5 and contributed only 1% to total CO<sub>2</sub> emissions in 2C\_o in 2007. In 2006 the last aluminium production plant in Switzerland was closed down. Since activity in 2C3 decreased to zero in 2007, emissions from 2C\_o are in 2007 effectively equivalent to the emissions in all of 2C.

Table 4-7 Specification of source category 2C "Metal Production".

2C	Source	Specification	Data Source
2C1	Iron and Steel Production	Emissions from the production of Iron and Steel.	AD, EF: EMIS 2009/2C1
2C2	Ferroalloys Production	Included in 1A2b.	
2C3	Aluminium Production	Emissions from the production of Aluminium	AD: Industry Data EF for PFC: Industry Data EF other gases: EMIS 2009/2C3
2C4	Use of SF <sub>6</sub> in Aluminium and Magnesium Foundries	Emissions from use of SF <sub>6</sub> in Aluminium and Magnesium Foundries	AD, EF: Industry Data EF: Carbotech 2009
2C5	Other	Emissions from the production of non-ferrous metals	AD, EF: Industry Data, EMIS 2009/2C5

## 4.4.2. Methodological Issues

### Methodology

In Iron and Steel Production (2C1) a country specific approach is used to calculate CO<sub>2</sub>, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> emissions, based on CORINAIR and documented in the EMIS database (EMIS 2009/2C1). The emissions are calculated by multiplying the annual production output of steel or iron (level of activity) by emission factors. CO<sub>2</sub> emissions accounted for in this category are only due to the production of steel in electric arc furnaces by smelting scrap steel. Emissions occur due to consumed electrodes and organic contaminants in scrap material. The emissions are calculated by multiplying the annual production output of steel (level of activity) by emission factors. CO<sub>2</sub> emissions from cupola furnaces are accounted for in category 1A2. There is no production of crude iron in Switzerland from iron oxide ores in blast furnaces.

In Aluminium Production (2C3) a country specific approach is used to calculate CO<sub>2</sub>, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> emissions, based on CORINAIR. The emissions are calculated by multiplying the annual production output of aluminium (level of activity) by emission factors.

PFC emissions from source category 2C "Metal Production" are not occurring in 2007 as the last production site with Aluminium production in Switzerland has been closed down in April 2006. Historic emission data for PFC is based on a Tier 3b approach. Operating smelter emissions have been monitored periodically by the industry for selected years. The only Swiss factory has its own measurements for 1990, 1999 and 2000, which demonstrate smaller EFs than the European average (by factors of 3.9, 4.7 and 5.1, respectively, for those years) (Alcan 2003). Therefore a "general reduction factor" of 4.0 for both gases is adopted on the average European values as reported from the European Aluminium Association (Alcan 2002). The resulting emission factors for Switzerland are still within the

uncertainty range as per IPCC GPG. To calculate the emissions factor for the year 2006 without measured emission data a European average emission factor ( $0.14 \text{ kg}_{\text{PFC}}/\text{t}_{\text{AL}}$ ) (based on IAI 2005, reduced by  $0.1 \text{ kg}_{\text{PFC}}/\text{t}_{\text{AL}}$  for technical progress since 2004) with a correction factor of 0.25 is being used. This results to  $0.035 \text{ kg}_{\text{PFC}}/\text{t}_{\text{AL}}$  and the ratio of 90%  $\text{CF}_4$  and 10%  $\text{C}_2\text{F}_6$  is being applied. Historic emissions are calculated by multiplying annual production by emission factors.

$\text{SF}_6$  is used in aluminium foundry industry in the cleaning process. The Swiss Foundry Association (GVS) has not provided information on emission factors and hence the total imported amount of  $\text{SF}_6$  as per the import statistic is reported as actual emission. The emissions are assumed to be constant and are based on import information of 2003.

In the production of non-ferrous metals (2C5), a country specific approach is used to calculate  $\text{CO}_2$ ,  $\text{NO}_x$ , CO, NMVOC and  $\text{SO}_2$  emissions. The emissions are calculated by multiplying the annual production output (level of activity) by emission factors.

### Emission Factors

The emission factors for  $\text{CO}_2$ ,  $\text{NO}_x$ , CO, NMVOC and  $\text{SO}_2$  emissions per ton of metal product are country specific. They are based on measurements and data from industry and expert estimates, documented in the EMIS database (see Section 1.4.3).

$\text{CO}_2$  emissions from Iron and Steel Production (2C1) are due to emissions from steel production in electric arc furnaces, for which an emission factor of  $140 \text{ kg CO}_2$  per ton of steel produced is used (EMIS 2009/2C1). For the years 1990-1998, a lower emission factor of  $100 \text{ kg CO}_2$  per ton of steel produced was used, based on older measurements also documented in EMIS. This change in emission factors is one of the reasons that 2C\_o became a key category.  $\text{CO}_2$  emissions also occur in cupola furnaces for iron production, the  $\text{CO}_2$  emissions of which are accounted for exclusively in category 1A2. In previous submissions, activity data for iron production in cupola furnaces was also included in 2C1, leading to an implied emission factor englobing steel production and iron production, although for the latter no emissions were reported in 2C1. For this submission, activity data from iron production are no longer included in 2C1, and they are now reported as it has already been the case for the emissions exclusively in 1A2.

For  $\text{CO}_2$  emissions from Aluminium Production (2C3), an emission factor of  $1.6 \text{ ton CO}_2$  per ton of aluminium is used (EMIS 2009/2C3). This  $\text{CO}_2$  stems from the oxidation of the anode in the electrolysis process ("Schmelzflusselektrolyse"). The emissions factor is based on an estimate of the amount of anode material used. In Switzerland only pre-backed processes are used. The  $\text{CO}_2$ -EF is calculated with 0.43 tons of anode per ton of aluminium; it is assumed that the anode consists completely of carbon and that it is fully oxidized during the process (value from Swiss foundries, value for 1990, assumed to be constant over the time series).

For PFC emissions the emission factors have decreased by a factor of more than 4 between 1990 and 2006 due to technical efforts to reduce emissions (Alcan 2003). For 2007 there is no emission factor, because there was no aluminium production.

The factors according to Table 4-8 are used.

Table 4-8 PFC emissions factors for aluminium production in Switzerland.

Gas	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CF <sub>4</sub>	kg/t	0.1530	0.1373	0.1215	0.1058	0.0900	0.0833	0.0765	0.0698	0.0630	0.0540
C <sub>2</sub> F <sub>6</sub>	kg/t	0.0170	0.0153	0.0135	0.0118	0.0100	0.0093	0.0085	0.0078	0.0070	0.0060

Gas	Unit	2000	2001	2002	2003	2004	2005	2006	2007
CF <sub>4</sub>	kg/t	0.0360	0.0360	0.0360	0.0360	0.0338	0.0315	0.0315	0.0000
C <sub>2</sub> F <sub>6</sub>	kg/t	0.0040	0.0040	0.0040	0.0040	0.0038	0.0035	0.0035	0.0000

### Activity Data

Activity data on metal production (without aluminium and magnesium) is based on data from industry and expert estimates, documented in the EMIS database (EMIS 2009/2C, see Section 1.4.3). 2C1 Iron and Steel production activity data have been improved for the years 2003-2006 based on more precise industry data for 2006 and industry data for 2003-2005 that replace a previous interpolation (EMIS 2009/2C1).

Since 1995 until 2006 data on aluminium production is based on data published regularly by the Swiss Aluminium Association. For earlier years, the data provided directly from aluminium industry is used. In 2006 the last production site of aluminium was closed.

SF<sub>6</sub> is used in Swiss magnesium foundries since 1997. There are two factories which are known to use SF<sub>6</sub> and they both directly report their imports of SF<sub>6</sub>. As only import data is reported the mean value of 2006 and 2007 imports is used for calculating the emissions.

Activity data for source categories 2C1 Iron and Steel and 2C3 Aluminium are given in the following table:

Table 4-9 Activity data for 2C1 and 2C3 in Metal Production.

Source/production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2C Metal Production											
2C1 Steel	Gg	1'108	1'155	1'245	1'276	1'230	716	738	789	880	918
2C3 Aluminium	Gg	87	82	75	36	24	21	27	27	32	34

Source/production	Unit	2000	2001	2002	2003	2004	2005	2006	2007
2C Metal Production									
2C1 Steel	Gg	1'022	1'048	1'125	1'143	1'226	1'159	1'254	1'267
2C3 Aluminium	Gg	36	36	40	44	45	45	12	0

The table above shows that aluminium production was not occurring in 2007 and was more than 85% lower in 2006 compared to 1990. In April 2006 the last production site of aluminium in Switzerland has been closed down which explains the sharp reduction in source category 2C3 from 2005 to 2006. Activity data for steel production shown in this table refers to electric arc furnaces. Activity increased by 14% from 1990 to 2007. Together with the increase of the CO<sub>2</sub> emission factor by 40%, this results in an increase of related CO<sub>2</sub> emissions by 60%. This explains why CO<sub>2</sub> emissions from category 2C<sub>o</sub> increased by 59% and why this category became a key category regarding trend accordingly. CO<sub>2</sub> emissions occur also in cupola furnaces for iron production, but are accounted for exclusively in category 1A2. In previous submissions, activity data for iron production in cupola furnaces were nevertheless also included in 2C1. For this submission, activity data from iron production are no longer included in 2C1, and they are now reported as the emissions exclusively in 1A2.

### 4.4.3. Uncertainties and Time-Series Consistency

#### Uncertainty in CO<sub>2</sub> emissions from Metal Production without Aluminium Production (2C<sub>o</sub>)

The uncertainty estimate is based on uncertainty estimates for iron and steel production (2C1), which accounts for 99% of emissions in 2C\_o. Production data of iron and steel industry have high confidence (estimated uncertainty 2%, as documented in EMIS 2009/2C1). The uncertainty for the emission factor is estimated to be 40% (EMIS 2009/2C1).

#### **Uncertainty in use of SF<sub>6</sub> in Aluminium and Magnesium Foundries 2C4**

For use of SF<sub>6</sub> in Aluminium and Magnesium Foundries, an uncertainty of 9.6% (with normal distribution) is assumed, which is a result of the Monte Carlo simulation of the emissions of synthetic gases (Carbotech 2009).

#### **Qualitative estimate of uncertainties of non-key category emissions in 2C**

A preliminary uncertainty assessment of non-key category emissions in 2C based on expert judgment results in medium confidence in emissions estimates.

The time series is consistent.

#### **4.4.4. Source-Specific QA/QC and Verification**

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

#### **4.4.5. Source-Specific Recalculations**

2C1 Iron and Steel production activity data have been improved for the years 2003-2006 based on more precise industry data for 2006 and industry data for 2003-2005 that replace a previous interpolation. See also Chapter 9.

Emissions under source category 2C4 Use of SF<sub>6</sub> in Aluminium and Magnesium Foundries have been recalculated for the years 2004 to 2006 to include emissions from a second factory which became known to have used SF<sub>6</sub> in this period.

#### **4.4.6. Source-Specific Planned Improvements**

The report of the individual review of the GHG inventory submitted in 2005 (UNFCCC 2006) suggested under point 43 a more transparent reporting regarding technology changes which lead to reduction of emission factors that have reduced PFC emissions from Aluminium production. Due to closing down of aluminium production in Switzerland in April 2006 and subsequent unavailability of technical informants, it is no longer possible to obtain more specific information on emission factors.

### **4.5. Source Category 2D – Other Production**

Source category 2D “Other Production” is **not a key category**. It comprises non-energy emissions from the production of Pulp and Paper as well as Food and Drink production –.

Table 4-10 Specification of source category 2D "Other Production".

2D	Source	Specification	Data Source
2D	Other Production	Pulp and Paper, Food and Drink	AD, EF: EMIS 2009/2D

#### 4.5.1. Methodological Issues

##### Methodology

For the sources in 2D, the only non-energy emissions occurring are NMVOC and CO. A country specific approach is used to calculate these emissions. The emissions are calculated by multiplying the annual production output (level of activity) by emission factors. Emissions of biogenic CO<sub>2</sub> are not reported in the CRF and emissions of non-biogenic CO<sub>2</sub> are not occurring.

##### Emission Factors

The emission factors for NMVOC and CO per ton of product produced are country specific. They are based on measurements and data from industry, literature and expert estimates, documented in the EMIS database (EMIS 2009/2D, see Section 1.4.3).

##### Activity Data

Activity data on production of products in category 2D is based on data from industry and expert estimates, documented in the EMIS database (EMIS 2009/2D, see Section 1.4.3).

#### 4.5.2. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

The time series is consistent.

#### 4.5.3. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

#### 4.5.4. Source-Specific Recalculations

No source-specific recalculations have been carried out.

#### 4.5.5. Source-Specific Planned Improvements

There are no planned improvements.

### 4.6. Source Category 2E – Production of Halocarbons and SF<sub>6</sub>

No emissions occurring in this sector within Switzerland. There is no production of HFC, PFC or SF<sub>6</sub> in Switzerland.

## 4.7. Source Category 2F – Consumption of Halocarbons and SF<sub>6</sub>

### 4.7.1. Source Category Description

#### Key category 2F

PFC emissions from Consumption of Halocarbons and SF<sub>6</sub> (trend)

#### Key category 2F1

HFC emissions from Consumption of Halocarbons and SF<sub>6</sub>; Refrigeration and Air Conditioning Equipment (level and trend)

Source category 2F comprises HFC, PFC and SF<sub>6</sub> emissions from consumption of the applications listed below.

Table 4-11 Specification of source category 2F "Consumption of Halocarbons and SF<sub>6</sub>". Data source "import statistics": Carbotech (2009).

2F	Source	Specification	Data Source
2F1	Refrigeration and Air Conditioning Equipment	Emissions from Refrigeration and Air Conditioning Equipment	AD: Various national statistics <sup>15</sup> and industry data EF: Industry data
2F2	Foam Blowing	Emissions from Foam Blowing, incl. Polyurethane Spray	AD: Industry data EF: Expert estimates
2F3	Fire Extinguishers	Not occurring in Switzerland	
2F4	Aerosol / Metered Dose Inhalers	Emissions from use as aerosols, incl. metered dose inhalers	AD: Import statistics EF: IPCC default values
2F5	Solvents	Emissions from use as solvents	AD: Import statistics EF: IPCC default values
2F6	Other applications using ODS substitutes	Not occurring in Switzerland	
2F7	Semiconductor Manufacturing	Emissions from use in semiconductor manufacturing	AD: Import statistics EF: IPCC default values
2F8	Electrical Equipment	Emissions from use in electrical equipment	AD: Industry data EF: Industry data
2F9	Other	Emissions of SF <sub>6</sub> which are not yet accounted under 2F8	AD: Industry data EF: Industry data

The following graph shows emissions in source category 2F by sub-sector and by different groups of gases. Refrigeration and air conditioning equipment account by far for the highest emissions in this source category with a share of 70% of the total emissions in the source category 2F.

<sup>15</sup> e.g. statistics on registration of cars and trucks, import statistics on synthetic gases (Carbotech 2007)

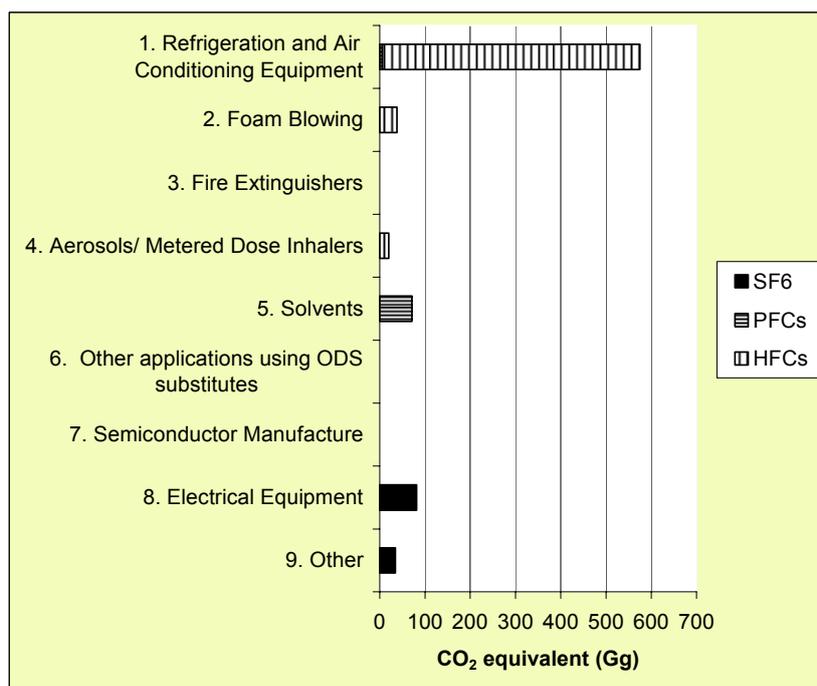


Figure 4-3 Distribution of emissions under source category 2F "Consumption of Halocarbons and SF<sub>6</sub>" (2008 data).

## 4.7.2. Methodological Issues

The data models used for source category 2F are complex and therefore a comprehensive documentation of all relevant model parameters is not possible in the framework of the NIR. Annex A3.2 shows an illustrative example of the model structure and parameters used for calculating emissions from mobile air-conditioning in cars. Where possible, the most important assumptions for the data model are documented (e.g. Table 4-12). Detailed documentation of the individual data models is available from Carbotech (2009) and related background documents. This information is FOEN internal due to confidentiality of data, but is open for consultation by reviewers.

### 2F1 Refrigeration and Air Conditioning Equipment

#### Methodology

The inventory under this sub-source category includes the following types of equipment: domestic refrigeration, commercial and industrial refrigeration, transport refrigeration, stationary air conditioning, mobile air conditioning, and heat pumps. For each of these types of equipment individual emission models are used for calculating actual emissions as per IPCC GPG Tier 2. In order to obtain the most reliable data for the calculations, two different approaches are applied to get the stock data needed for the model calculations: 'top down' using available statistics or estimations on the Swiss market from experts and associations and 'bottom up' through questionnaires sent to companies active in importation, production and service of appliances.

#### Emission Factors

Emission factors for manufacturing, product life and disposal as well as average product life times are established on the basis of expert judgement. Table 4-12 displays the detailed model parameters used. For product life emission factors a dynamic model is applied which implies that emission losses improve linearly between 1995 and 2010 due to better

production technologies. The start/end values are based on expert statements and Schwarz 2001.

Table 4-12 Typical values on life time, charge and emission factors used in model calculations for Refrigeration and Air Conditioning Equipment. Where values in brackets are provided, the first value shows the assumption for 1995 while the second value (in brackets) shows the assumption for 2010. Data between 1995 and 2010 is linearly interpolated.

Equipment type	Product life time [a]	Initial charge of new product [kg]	Manufacturing emission factor [% of initial charge]	Product life emission factor [% per annum]	Charge at end of life [% of initial charge of new product] *)	Disposal loss emission factor [% of remaining charge]
Domestic Refrigeration	12	0.1	NO	0.5	94	19 **)
Commercial and Industrial Refrigeration	10	NR	1	10 (5)	100	10
Transport Refrigeration / Trucks	10	1.8 ... 7.8	1	15	100	20
Transport Refrigeration / Railway	NA	NR	NO	10	100	20
Stationary Air Conditioning (direct / indirect cooling system)	15	1.6 ... 3.1 / 18.5	1	10 (3) / 6 (4)	100	28 / 19
Heat Pumps	15	4.7 ...7.5 till 1999 Going down to 2.8 ...4.5 in 2010	1	0.65	100	10
Mobile Air Conditioning / Cars	12	0.7 (0.83) ***)	NO	8.5	64	100 until year 2000 30 since 2001
Mobile Air Conditioning / Trucks	10	1.1	NO	10 until year 2000 (8.5)	35	100 until year 2000 30 since 2001
Mobile Air Conditioning / Buses	10	7.5	NO	10 until year 2000 (8.5)	35	100 until year 2000 30 since 2001
Mobile Air Conditioning / Railway	12	20	NO	4	100	10

\*) takes into account refill of losses during product life where applicable.

\*\*\*) takes into account R134a content in foams, based on information from the national recycling organisation SENS.

\*\*\*) Assumed constant since 2002. 0.83 kg in 1990. Linear interpolation between 1990 and 2002.

NA = not available

NR = not relevant as only aggregate data is used

NO = Not occurring (only import of charged units)

## Activity Data

Activity data is taken from industry information and national statistics such as for admission of new cars and trucks. Stock data is modelled dynamically. Due to the large number of sub-models used for modelling the total emissions for sub-source category 2F1, no table on time series of activity data is provided here, despite 2F1 being a key category. For illustration, the detailed calculation model for car air-conditioning including the time series for the activity

data for this particular sub-model can be seen from Annex A3.2. Car air-conditioning accounts for approx. 28% of the total emissions (CO<sub>2</sub> eq) of sub-source category 2F1 Refrigeration and Air Conditioning Equipment.

## 2F2 Foam Blowing

### Methodology

In Switzerland no production of open cell foam based on HFCs is reported by the industry. Therefore only closed cell PU and XPS foams, PU spray applications and sandwich elements are relevant under this source category.

The emission model (Tier 2) for foam blowing has been developed 'top down' based on import statistics for products and expert assumptions for market volumes and emission factors. Emissions for sandwich elements have been calculated as residual balance between SAEFL import statistics and consumption in PU spray, PU and XPS foams.

### Emission Factors

For emission factors and lifetime of XPS and PU foam, general default values according to IPCC are being used (IPCC 2000: p. 3.95). For PU spray, specific default values according to IPCC are being used (IPCC 2000: p. 3.96).

Table 4-13 Typical values on life time, charge and emission factors used in model calculations for foam blowing.

Application	Product life time years	Charge of new product % of product weight	Manufacturing emission factor % per annum	Product life emission factor % per annum	Charge at end of life % charge of new product
PU foam	50	4.5	NR	NR	NR
XPS foam	50	6.5	NO	10 / 0.7**	35%
HFC 134a HFC 152a				100 / 0**	0%
PU spray	50	10.6 / 0.8 *	0.03	95 / 2.5 **	0
Sandwich Elements	50	3	10/100 ***	0.5 / 0 ***	65 / 0 ***

\* Data for 1990 / 2007

\*\* Data for 1<sup>st</sup> year / following years

\*\*\* First value for R134a, R227ea, R365mfc and second value for R152a

NR Not relevant, because no substances according to this protocol has been used, all emissions occur outside Switzerland during production

NO Not occurring, because XPS not produced in Switzerland

### Activity Data

The export rate of PU spray from Swiss production is 92% of total production volume. For PU rigid foams no HFCs are used as foam blowing agent (only Pentane and CO<sub>2</sub>). From 2000 onwards there is no production of XPS in Switzerland. XPS foams are 100% imported.

Detailed activity data for this sub-source category is available at FOEN but not reported due to confidentiality.

### **2F3 Fire Extinguishers**

No emissions occurring in this sector within Switzerland. The application of HFC, PFC and SF<sub>6</sub> in fire extinguishers is prohibited by law.

### **2F4 Aerosol / Metered Dose Inhalers**

#### **Methodology**

The Tier 2 emission model for Aerosol / MDI is based on a 'top down' approach using import statistics for HFCs.

#### **Emission Factors**

An emission factor of 50% in the first and in the second year, respectively, is applied in line with IPCC GPG.

#### **Activity Data**

In most aerosol applications, HFC has been replaced already in the past years. According to the information of companies filling aerosol bottles for use in households, e.g. cosmetics, cloth care and paint, no HFC is being used. For special technical applications - especially metered dose inhalers (MDI) - HFC is still in use. Compared to the total amount of aerosol applied, the HFC use for MDI is considered to be irrelevant.

Activity data is based on import statistics. Detailed activity data for this sub-source category is available at FOEN but not reported due to confidentiality.

### **2F5 Solvents**

#### **Methodology**

The use of HFC as solvent is not occurring in Switzerland. PFC emissions are calculated according to Tier 1 method according to IPCC GPG on basis of a 'top down' approach using import statistics.

#### **Emission Factors**

An emission factor of 50% in the first and in the second year, respectively, is applied in line with IPCC GPG.

#### **Activity Data**

Activity data is based on import statistics. Detailed activity data for this sub-source category is available at SAEFL but not reported due to confidentiality.

### **2F6 Other applications using ODS substitutes**

No emissions occurring in this sector within Switzerland.

### **2F7 Semiconductor Manufacturing**

#### **Methodology**

No HFC, PFC and SF<sub>6</sub> emissions were considered for semiconductor manufacturing in 2007. The import of substances by firms delivering to semiconductor industry has mostly been declared as being used for "Syntheses / Laboratory" and "Other" and is reported under sub-source category 2F9. Until 2002 a small amount of PFC's (C<sub>2</sub>F<sub>6</sub>, CF<sub>4</sub> and only for 2002 C<sub>3</sub>F<sub>8</sub>) and SF<sub>6</sub> was used for semiconductor manufacturing. Since 2003 no more semiconductor manufacturing in Switzerland has been reported. Any left over amount which might still be

used for semiconductor manufacturing is considered not to be relevant and is reported under sub-source category 2F9.

## **2F8 Electrical Equipment**

### **Methodology**

Under an agreement with FOEN, the industry association SWISSMEM is reporting actual emissions of SF<sub>6</sub> on basis of a mass balance approach (Tier 3a), including data for production of electrical equipment, installation, operation and disposal.

### **Emission Factors**

Emission factors for this sub-source category are based on industry information and are calculated values based on the mass balance data. The calculated product life emission factor is varying between 0.77%/a (2005) and 0.24%/a (2006). For 2007 the calculated product life emission factor is 0.27%. The discontinuity in emission factor from 2005 to 2006 data is not yet fully understood, but could not be further verified for the present submission due to change of personal at the data supplier.

### **Activity Data**

Activity data is based on industry information. The wide annual fluctuation of SF<sub>6</sub> emissions from electrical equipment is related to the annual fluctuation of market volumes for such equipment.

## **2F9 Other**

### **Methodology**

The emissions reported under 2F9 relate to a small amount of unallocated SF<sub>6</sub> from the FOEN import statistics and since 2003 to further applications such as laboratory and syntheses use. The unallocated difference for SF<sub>6</sub> between the FOEN import statistics and the SWISSMEM mass balance (see 2F8) have been assigned to windows, cables and electrical control systems using a Tier 2 approach. Some imports of R134a were declared for medical use, and small import amount of HFC 23 was declared for electronics and refrigeration technology.

### **Emission Factors**

For windows a production emission factor of 33% and an operation emission factor of 1% per annum are applied with 100% of the remaining charge being emitted at time of disposal. Emission at time of disposal is however not yet relevant for emissions until 2008 due to the long lifetime of the windows of 25 years.

For cables and electrical control systems the production emission factor is assumed at 4% and the operation emission factor at 1%. 100% of the remaining charge is emitted at time of disposal after 40 years lifetime.

According to the IPCC guidelines (IPCC 2000) the emission factors for HFC 134a (medical use) and for HFC 23 (electronics and refrigeration technology) were chosen as 50% in the first year and 50% in the second year.

### **Activity Data**

Activity data is based on industry information. 80% of the production of cables and electrical control systems is exported.

### 4.7.3. Uncertainties and Time-Series Consistency

For refrigeration equipment, air-conditioning equipment as well as for the foam blowing source category, a Monte Carlo analysis according to IPCC Good Practice Guidance for the evaluation of uncertainties of model calculations according to Tier 2 has been carried out. The Monte Carlo Analysis was performed on the inventory data of the current GHG inventory (April 2009). For the purpose of the Monte Carlo Analysis, uncertainty of all relevant parameters (e.g. initial appliance charge, operation emission factor, import and export volumes, etc.) used in the emission models for the applications as per Table 4-15 below has been characterised by a statistical distribution. Frequently a triangular distribution was chosen, defined by the three parameters: minimum, maximum and most likely value. Some uniform distributions were chosen where the spectrum was assumed to have the same probability. In the other cases normal or Log normal distribution has been chosen. The analysis was carried out with 1000 cycles. Details on the distributions of parameters used (i.e. type of distribution, minimum, maximum, likeliest value) are documented in Carbotech 2009.

For the submission of 12 April 2006 (FOEN 2006a) the uncertainty for the import statistic data had been estimated for the first time. Discussions with the persons responsible for data collection in the years 1997–2006 led to the estimations given in Table 4-14.

Table 4-14 Estimated uncertainty for the data of the imported substances

Year	Minimal	Maximal	remarks
Up to 1999	- 10%	+30%	assumed that the data are not complete
2000 – 2003	-10%	+15%	data can be incomplete or possible double declaration
2004 – 2007	-10%	+10%	

The following table summarises the results for the application-specific emission models. The “value 2007” represents the actual emissions in Gg CO<sub>2</sub> equivalent for the specific application as used for calculating the 2007 CRF tables. The average, median, uncertainty, minimum and maximum values are output values of the Monte Carlo Analysis.

Uncertainties of more than 20% have been calculated for the following applications:

- Commercial/ Industrial Refrigeration
- Foam blowing
- Transport refrigeration
- Others
- Aerosols.

Medium uncertainties of 14% to 20% have been calculated for the following applications:.

- Stationary Air Conditioning
- Electrical Equipment

For the model calculations of stocks, uncertainties result with a maximum of 30% for R134a in Commercial/ Industrial Refrigeration. For the model calculations of stocks in domestic refrigeration no uncertainties value is given due to very asymmetric distribution. Calculation of stocks is not reported in detail here because the uncertainties for stock and new filled refrigerant related to the split of refrigerant on different applications is of less relevance for the overall emissions. This is because different applications show similar characteristics for the building of stocks and related emissions. Detailed data is available with FOEN.

Relevant parameters for the building of stock in PU-foam are the PU-foam export rate and the PU-Spray first year emission factor. The data base for PU-Sprays has been significantly improved with effect from the 2007 submission (FOEN 2007). This is attributed to improved models which are elaborated by the main producer and its blowing agent import firm. However, the high export rate of PU-Spray and the high emission factor of the first year lead to a small amount remaining in the stock with a relative high uncertainty.

Table 4-15 Summary of results for model parameter "emissions" from Monte Carlo Analysis for 2006 data on selected emission sources.

Application	Model parameter	value 2007 Gg CO <sub>2</sub> eq.	Average Gg CO <sub>2</sub> eq.	Median Gg CO <sub>2</sub> eq.	min. Gg CO <sub>2</sub> eq.	max. Gg CO <sub>2</sub> eq.	Uncertainty %
Commercial / Industrial Refrigeration	Emissions in Gg CO <sub>2</sub> eq.	282.6	342.1	338.2	170.7	570.2	30.2
Mobile Air-Conditioning		171.3	175.9	175.4	149.7	208.3	10.2
Stationary Air-Conditioning		82.7	110.4	110.1	76.9	152.6	19.8
Transport Refrigeration		22.2	20.9	20.8	14.1	28.8	22.0
Domestic Refrigeration		15.7	10.6	6.8	1.1	37.8	*)
<b>Total HFC from 2F1</b>		<b>574.5</b>	<b>659.8</b>	<b>655.9</b>	<b>495.6</b>	<b>901.9</b>	<b>16.4</b>
2F2 Foam Blowing		37.9	42.4	41.2	22.2	102.3	40.6
2F4 Aerosol		20.0	20.0	19.9	7.8	34.6	42.0
2F5 Solvents		71.2	71.6	71.6	60.8	79.9	7.0
2F8 Electric equipment		81.6	81.5	81.5	63.4	99.4	15.0
2F9 Other		34.7	41.3	36.4	27.5	180.2	65.8
<b>Total HFC from 2F_o</b>		<b>55.0</b>	<b>57.8</b>	<b>56.9</b>	<b>31.9</b>	<b>119.3</b>	<b>33.6</b>
<b>Total HFC from 2F</b>		<b>629.5</b>	<b>717.6</b>	<b>714.1</b>	<b>548.5</b>	<b>969.6</b>	<b>15.0</b>
<b>Total PFC from 2F</b>		<b>77.1</b>	<b>78.4</b>	<b>78.3</b>	<b>66.4</b>	<b>88.5</b>	<b>6.8</b>
<b>Total SF<sub>6</sub> from 2F</b>	<b>113.3</b>	<b>119.8</b>	<b>116.7</b>	<b>94.1</b>	<b>252.7</b>	<b>25.0</b>	

\*) very asymmetric distribution, therefore no indication of a standard deviation.

The significant improvement in uncertainty for Mobile Air-Conditioning as compared to the previous year (FOEN 2008) is due to correction of a wrong assumption for the Monte Carlo Analysis of synthetic gases.

The time series is consistent for all source categories, with exception of the sub-source category "Electrical Equipment" (2F8) where from 2000 onwards the data is based on a Tier 3a approach instead of model calculations according to Tier 2 as applied for data before 2000. Due to lack of basic information it is not possible to provide a consistent time series for category Electrical Equipment (2F8) retroactively.

#### 4.7.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### 4.7.5. Source-Specific Recalculations

Table 4-16 Summary of recalculations in source category 2F.

Category	Remarks
Metal production	Changes in the amount of used SF <sub>6</sub> in the magnesium foundries from 2004-2007 due to new information.
Foam blowing	R152a, R227ea and R365mfc was added in the modelling of Sandwich Elements and Boards. Stocks for these categories were also modelled.
Transport refrigeration	The lifetime of trucks was increased from 8 to 10 years
Domestic refrigeration	Decrease of the stock emissions because of an improvement in the modelling
Commercial refrigeration	The import of HFC23 in 2006 was changed according to the import statistic 2006, which led to a small increase
Stationary air-conditioning	According to information from the declaration of equipment with more than 3 kg refrigerant it was possible, to do a better modelling of the distribution of the gases to the different application
Mobile air-condition	Due to new information we reduced the filling of Air conditioning devices in cars to 0.7 kg.
Solvents	Like in previous years the PFC in the category "others" of the year 2006 were also modelled as solvents.
Electrical equipment	After 2001 the emission rate for the disposal was increased to 2% and the amount of disposed electrical equipment was changed for the years 2003 to 2006.
Others	A correction led to a decrease of SF <sub>6</sub> in the category others (2005, 2006). The inclusion of small amounts of R134a and HFC23 leads to a small change in the years 2004-2007.

All these changes have no influence on the early years 1990 till 1992. See also Chapter 9.

### 4.7.6. Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry is ongoing. As in the past years, methodologies and emission models will be updated during the yearly process of F-gas inquiry. The focus will be on improvements of HFC-emission calculations from refrigeration and air-conditioning equipment.

The emission factors of SF<sub>6</sub> in source category 2F8 Electrical Equipment shows a discontinuity from 2005 to 2006. It is intended to verify the emission factors for the next submission. Due to change of personal at the data supplier it was still not possible to verify this for the present submission.

## 4.8. Source Category 2G – Other

### 4.8.1. Source Category Description

Source category 2G "Other" is **not a key category**. It comprises non-energy emissions from the production in other industries.

Table 4-17 Specification of source category 2G "Other".

2G	Source	Specification	Data Source
2G	Other	Emissions from the production of charcoal, chipboard, from the use of explosives in the production of gypsum, blasting and shooting, and from Claus-units in refineries.	AD, EF: EMIS 2009/2G

## 4.8.2. Methodological Issues

### Methodology

In Switzerland source category 2G "Other" represents a comprehensive set of industrial processes: the production of charcoal, chipboard, and the use of explosives in the production of gypsum, blasting and shooting, as well as the use of Claus-units in refineries (sulphur extraction process).

For the sources in 2G a country specific approach is used to calculate CO<sub>2</sub>, CH<sub>4</sub>, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> emissions. The emissions are calculated by multiplying the annual production output (level of activity) by emission factors.

### Emission Factors

The emission factor for CO<sub>2</sub>, CH<sub>4</sub>, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub> emissions per ton of product produced are country specific. They are based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2009/2G, see Section 1.4.3).

### Activity Data

Activity data on production of products in category 2G is based on data from industry and expert estimates, documented in the EMIS database (EMIS 2009/2G, see Section 1.4.3).

## 4.8.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

The time series is consistent.

## 4.8.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

## 4.8.5. Source-Specific Recalculations

Emissions have been recalculated since 1991 due to updated data for blasting and shooting.

## 4.8.6. Source-Specific Planned Improvements

There are no planned improvements.

## 5. Solvent and Other Product Use

### 5.1. Overview

This chapter provides information on the estimation of the greenhouse gas emissions from solvent and other product use. Emissions contain NMVOC emissions from the use of solvents and other related compounds. It also includes indirect CO<sub>2</sub> emissions from the atmospheric decomposition of NMVOC. Further included are evaporative emissions of N<sub>2</sub>O, NO<sub>x</sub>, CO and SO<sub>2</sub> arising from other types of product use (firework, impregnation of mineral wool) and N<sub>2</sub>O emissions from medical use. The disposal of solvents is reported in the waste sector (in Chapter 8). Emissions from the use of halocarbons and sulphur hexafluoride are reported in the Industrial Processes Chapter under 2F. Other non-energy emissions not included under Industrial Processes are reported in this chapter.

#### Key category 3

CO<sub>2</sub> emissions from Solvent and Other Product Use (trend and level).

N<sub>2</sub>O emissions from Solvent and Other Product Use (trend).

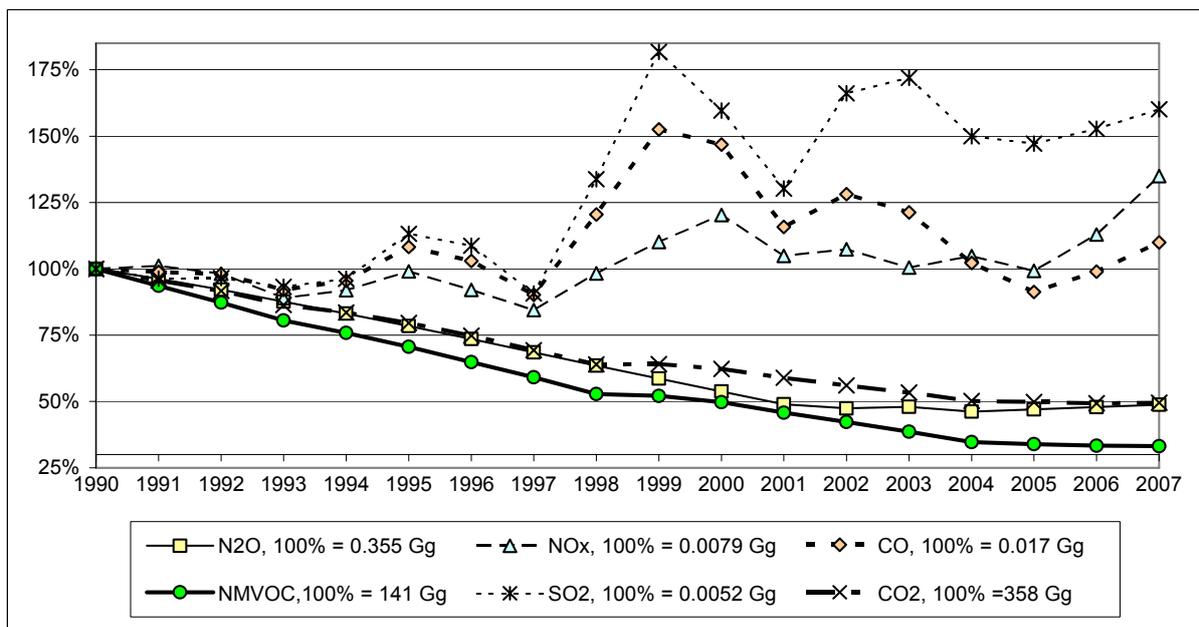


Figure 5-1 Overview over emissions in category 3 Solvent and Other Product Use in Switzerland. Note that NMVOC and N<sub>2</sub>O evolve highly correlated with CO<sub>2</sub> emissions.

Table 5-1 Emissions of source category 3 Solvent and Other Product Use.

Gas	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO <sub>2</sub>	Gg	358	342	328	309	299	285	267	248	229	229
N <sub>2</sub> O	t	355	342	327	311	295	279	261	243	226	208
NO <sub>x</sub>	t	7.9	8.0	7.8	7.0	7.3	7.8	7.3	6.7	7.8	8.7
CO	t	17	17	17	16	16	18	17	15	20	26
NMVOG	Gg	141	132	123	113	107	99	91	83	74	73
SO <sub>2</sub>	t	5.2	5.0	5.0	4.8	5.0	5.9	5.6	4.7	6.9	9.4

Gas	Unit	2000	2001	2002	2003	2004	2005	2006	2007
CO <sub>2</sub>	Gg	223	211	200	191	180	178	176	177
N <sub>2</sub> O	t	191	174	168	170	164	167	170	173
NO <sub>x</sub>	t	9.5	8.3	8.5	7.9	8.3	7.8	8.9	10.7
CO	t	25	20	22	21	17	15	17	19
NMVOG	Gg	70	64	59	54	49	48	47	47
SO <sub>2</sub>	t	8.3	6.7	8.6	8.9	7.8	7.6	7.9	8.3

NMVOG emissions have diminished since 1990 by -67% until 2007 mainly due to two reduction efforts: The limitation of the application of NMVOG brought by the ordinance on Air Pollution Control (Swiss Confederation 1985) and the introduction of the VOC-tax in 2000 (Swiss Confederation 1997). Also CO<sub>2</sub> and N<sub>2</sub>O emissions decreased significantly (-50% and -51% respectively). The other emissions have increased since 1990.

CO, NO<sub>x</sub> and SO<sub>2</sub> emissions mainly stem from burning of fireworks. Imports of fireworks were significantly fluctuating in the period 1993–2004 causing the variation of the emissions during that time. The time series of NO<sub>x</sub> emissions differ from CO and SO<sub>2</sub>: They are not only dependent on fireworks consumption but on the impregnation of mineral wool too, which is less varying.

## 5.2. Source Category 3A – Paint Application

### 5.2.1. Source Category Description

Source category 3A “Paint Application” comprises NMVOG emissions from paints, lacquers, thinners and related materials used in coatings in industrial, commercial and household applications. Also, it includes indirect CO<sub>2</sub> emissions resulting from post-combustion of NMVOG to reduce NMVOG in exhaust gases.

Table 5-2 Specification of source category 3A “Paint Application”.

	Source	Specification	Data Source
3A	Paint Application	Paint application in households, industry and construction	AD, EF: EMIS 2009/3A

## 5.2.2. Methodological Issues

### Methodology

For paint application (3A) a bottom-up country specific method based on the consumption of paint and its solvent content is used.

The indirect CO<sub>2</sub> emissions from NMVOC are calculated from the average carbon contents of NMVOC emissions for the subcategory 3A based on methodology and data from the Netherlands (RIVM 2005: p. 5-2ff.), assuming that the type and characteristics of solvents used in Switzerland are roughly similar.

Also, several industrial plants use facilities and equipment to reduce NMVOC in exhaust gases and room ventilation output. Often, this implies the feeding of air with high NMVOC content into the burning chamber of boilers, or other facilities to incinerate NMVOC. This leads to additional indirect CO<sub>2</sub> emissions resulting from post-combustion of NMVOC. They are estimated based on industry data and expert estimates.

### Emission Factors

Emission factors for NMVOC are country specific based on data from industry, documented in the EMIS database (EMIS 2009/3A).

For paint application in construction, as the most important source, the emission factor of 60 kg NMVOC/t paint for the year 2007 is based on expert estimates (EMIS 2009/3A).

The emission factor for the indirect CO<sub>2</sub>-emissions from NMVOC for 3A is 2.35 Gg CO<sub>2</sub>/Gg NMVOC (RIVM 2005: p. 5-2ff.).

### Activity Data

The activity data correspond to the annual consumption of paints. They are based on data from industry, documented in the EMIS database.

For paint application in construction, as the most important source, the activity data equals the consumption of 45'000 t paint in 2007 (EMIS 2009/3A).

## 5.2.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (EMIS) results in medium confidence in emissions estimates.

The uncertainty of total CO<sub>2</sub> emissions from the entire category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate). The uncertainty of N<sub>2</sub>O emissions from the entire category 3 is estimated to be 80% (expert estimate).

Time series is consistent.

## 5.2.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### 5.2.5. Source-Specific Recalculations

CO<sub>2</sub> and NMVOC emissions have been recalculated for 2005 and 2006 based on new industry data and expert estimates on NMVOC emissions in these years, replacing a previous extrapolation.

### 5.2.6. Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry is ongoing.

## 5.3. Source Category 3B – Degreasing and Dry Cleaning

### 5.3.1. Source Category Description

Source category 3B “Degreasing and Dry Cleaning” comprises NMVOC emissions from degreasing, dry cleaning and cleaning in electronic industry. Also, it includes indirect CO<sub>2</sub> emissions resulting from post-combustion of NMVOC to reduce NMVOC in exhaust gases.

Table 5-3 Specification of source category 3B “Degreasing and Dry Cleaning”.

	Source	Specification	Data Source
3B	Degreasing and Dry Cleaning	Degreasing, Dry Cleaning, Cleaning of electronic components, cleaning of parts in metal processing, other industrial cleaning.	AD, EF: industry data, EMIS 2009/3B

### 5.3.2. Methodological Issues

#### Methodology

For degreasing and dry cleaning (3B) a country specific method based on the consumption of solvents and the resulting emissions is used.

The indirect CO<sub>2</sub> emissions from NMVOC are calculated from the average carbon contents of NMVOC emissions for the subcategory 3B based on methodology and data from the Netherlands (RIVM 2005: p. 5-2ff.), assuming that the type and characteristics of solvents used in Switzerland are roughly similar.

Also, several industrial plants use facilities and equipment to reduce NMVOC in exhaust gases and room ventilation output. Often, this implies the feeding of air with high NMVOC content into the burning chamber of boilers, or other facilities to incinerate NMVOC. This leads to additional indirect CO<sub>2</sub> emissions resulting from post-combustion of NMVOC. They are estimated based on industry data and expert estimates.

#### Emission Factors

Emission factors for NMVOC are country specific based on data from industry and expert estimates, documented in the EMIS database (EMIS 2009/3B).

Degreasing of metal is the most important source in 3B. Its emission factor of 270 kg NMVOC per ton of solvent for 2007 is based on an industry survey (EMIS 2009/3B).

The emission factor for the indirect CO<sub>2</sub>-emissions from NMVOC for 3B is 2.24 Gg CO<sub>2</sub> per Gg NMVOC (RIVM 2005<sup>16</sup>: p. 5-2ff.).

### **Activity Data**

The activity data are based on data from industry and expert estimates, documented in the EMIS database.

The activity data for degreasing of metal (3'800 t solvent in 2007), as the most important source, is based on an industry survey (EMIS 2009/3B).

### **5.3.3. Uncertainties and Time-Series Consistency**

The uncertainty assessment (EMIS 2009/3B) results in medium confidence in emissions estimates.

The uncertainty of total CO<sub>2</sub> emissions from the entire category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate). The uncertainty of N<sub>2</sub>O emissions from the entire category 3 is estimated to be 80% (expert estimate).

The time series is consistent.

### **5.3.4. Source-Specific QA/QC and Verification**

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### **5.3.5. Source-Specific Recalculations**

CO<sub>2</sub> and NMVOC emissions have been recalculated for the whole time series based on new industry data and expert estimates for these years.

### **5.3.6. Source-Specific Planned Improvements**

Gradual improvement of the data quality in co-operation with industry is ongoing.

## **5.4. Source Category 3C – Chemical Products, Manufacture and Processing**

### **5.4.1. Source Category Description**

Source category 3C “Chemical Products, Manufacture and Processing” comprises NMVOC emissions from manufacturing and processing chemical products. Also, it includes indirect CO<sub>2</sub> emissions resulting from post-combustion of NMVOC to reduce NMVOC in exhaust gases.

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<sup>16</sup> There seems to be a typo in the relevant section of the RIVM 2005 regarding the Emission Factor for the indirect CO<sub>2</sub>-emissions from NMVOC for 3B.

Table 5-4 Specification of source category 3C "Chemical Products, Manufacture and Processing".

	Source	Specification	Data Source
3C	Chemical Products, Manufacture and Processing	Handling and storage of solvents; fine chemical production; production of pharmaceuticals; manufacturing of paint, inks, glues, adhesive tape, rubber; processing of PVC, polystyrene foam, polyurethane and polyester,.	AD, EF: industry data, EMIS 2009/3C

## 5.4.2. Methodological Issues

### Methodology

For category 3C country specific methods are used. The emissions of fine chemical and pharmaceutical production are based on production and expert estimates. The emissions of handling and storage of solvents are calculated based on the imported quantities. The emissions from manufacturing paint, glues, inks, adhesive tape, rubber and polyurethane as well as the processing of PVC are calculated based on production numbers. The emissions from processing of polystyrene foam and polyester are calculated based on consumption.

The indirect CO<sub>2</sub> emissions from NMVOC are calculated from the average carbon contents of NMVOC emissions for the subcategory 3C based on methodology and data from the Netherlands (RIVM 2005: p. 5-2ff.), assuming that the type and characteristics of solvents used in Switzerland are roughly similar.

Also, several industrial plants use facilities and equipment to reduce NMVOC in exhaust gases and room ventilation output. Often, this implies the feeding of air with high NMVOC content into the burning chamber of boilers, or other facilities to incinerate NMVOC. This leads to additional indirect CO<sub>2</sub> emissions resulting from post-combustion of NMVOC. They are estimated based on industry data and expert estimates. .

### Emission Factors

Emission factors for NMVOC are country specific based on data from industry and expert estimates and are documented in the EMIS database. Emission factors for handling and storage of solvents are estimated according to the solvent vapor pressure.

The emission factor for the indirect CO<sub>2</sub> emissions from NMVOC for 3C is 2.31 Gg CO<sub>2</sub> per Gg NMVOC (RIVM 2005: p. 5-2ff.).

### Activity Data

The activity data correspond to the annual consumption of solvents. They are based on data from industry and expert estimates, documented in the EMIS database (EMIS 2009/3C).

Fine chemical production is the most important source category in 3C (emissions 1'200 t NMVOC in 2007). Data for this source provided by industry refers directly to the emissions for this category without distinction between activity data and emission factors (EMIS 2009/3C). It is planned to evaluate whether the methodology to determine emissions from this source can be improved.

## 5.4.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (EMIS) results in medium confidence in emissions estimates.

The uncertainty of total CO<sub>2</sub> emissions from the entire category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate). The uncertainty of N<sub>2</sub>O emissions from the entire category 3 is estimated to be 80% (expert estimate)

Time series is consistent.

#### 5.4.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

#### 5.4.5. Source-Specific Recalculations

CO<sub>2</sub> and NMVOC emissions have been recalculated for the whole time series based on new industry data and expert estimates for these years.

#### 5.4.6. Source-Specific Planned Improvements

Gradual improvement of the data quality in co-operation with industry is ongoing.

### 5.5. Source Category 3D – Other

#### 5.5.1. Source Category Description

Source category 3D “Other” comprises emissions from many different solvent applications. Besides NMVOC also emissions of N<sub>2</sub>O, NO<sub>x</sub>, CO and SO<sub>2</sub> are relevant. Also, 3D includes indirect CO<sub>2</sub> emissions resulting from post-combustion of NMVOC to reduce NMVOC in exhaust gases.

The application of N<sub>2</sub>O in households and hospitals and CO<sub>2</sub> from the impregnation of mineral wool and the use of fireworks are the only direct greenhouse gas emission considered in this category.

Table 5-5 Specification of source category 3D “Other”.

	Source	Specification	Data Source
3D	Other	Use of spray cans in industry and households; domestic solvent use; print industry; application of glues and adhesives; use of concrete additives; removal of paint and lacquer; car underbody sealant; de-icing of airplanes; tanning of leather; impregnating of glass and mineral wool; use of cooling and other lubricants; extraction of oils and fats; use of pesticides; use of pharmaceutical products in households; house cleaning industry/craft/services; hairdressers; scientific laboratories; textile production; paper and paper board production; clothing production; cosmetic institutions; production and use of tobacco products; vehicles dewaxing; wood preservation; medical practitioners; other health care institutions; not attributable solvent emissions; use of N <sub>2</sub> O in households and in hospitals; other use of gases; production of perfume /aroma and cosmetics; use of fireworks.	AD, EF: industry data, EMIS 2009/3D

## 5.5.2. Methodological Issues

### Methodology

For category 3D a country specific method based on the production/consumption of the different solvent applications is used.

The emissions from house cleaning, the most important source, is calculated proportional to the population.

The indirect CO<sub>2</sub> emissions from NMVOC are calculated from the average carbon contents of NMVOC emissions for the subcategory 3D based on methodology and data from the Netherlands (RIVM 2005: p. 5-2ff.), assuming that the type and characteristics of solvents used in Switzerland are roughly similar.

Also, several industrial plants use facilities and equipment to reduce NMVOC in exhaust gases and room ventilation output. Often, this implies the feeding of air with high NMVOC content into the burning chamber of boilers, or other facilities to incinerate NMVOC. This leads to additional indirect CO<sub>2</sub> emissions resulting from post-combustion of NMVOC. They are estimated based on industry data and expert estimates. .

### Emission Factors

Emission factors for NMVOC are country specific based on data from industry and expert estimates, documented in the EMIS database (EMIS 2009/3D). The NMVOC emissions from the production of cosmetics, perfume and aroma are calculated per employee, documented in the EMIS database.

Emission factors for N<sub>2</sub>O, NO<sub>x</sub>, CO and SO<sub>2</sub> are country specific based on data from industry and expert estimates, documented in the EMIS database (EMIS 2009/3D).

The emission factor for the indirect CO<sub>2</sub>-emissions from NMVOC for 3D is 2.53 Gg CO<sub>2</sub>/Gg NMVOC (RIVM 2005: p. 5-2ff.).

The emission factor for house cleaning, the most important source, is 900 g/inhabitant in 2007, based on Theloke et al. (2000), documented in EMIS (EMIS 2009/3D).

### Activity Data

For the calculation of NMVOC emissions, the activity data correspond to the annual production/consumption of solvents. They are based on data from industry and expert estimates, documented in the EMIS database.

For other emissions, data from EMIS is used.

The activity data for house cleaning, as the most important source, is the number of inhabitants (7.617 million in 2007).

## 5.5.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (EMIS) results in medium confidence in emissions estimates.

The uncertainty of total CO<sub>2</sub> emissions from the entire category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate). The uncertainty of N<sub>2</sub>O emissions from the entire category 3 is estimated to be 80% (expert estimate)

Time series is consistent.

## 5.5.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### **5.5.5. Source-Specific Recalculations**

N<sub>2</sub>O emissions were recalculated for 2006. The number of inhabitants for 2006 was slightly modified, as the number for this year was updated in the Swiss overall energy statistics (SFOE 2008). Since the number of inhabitants is used as activity data for the modelling of the emissions of 3D Other, they had to be recalculated accordingly.

In addition to that, CO<sub>2</sub> and NMVOC emissions have been recalculated for the whole time series based on new industry data and expert estimates for these years.

### **5.5.6. Source-Specific Planned Improvements**

Gradual improvement of the data quality in co-operation with industry is ongoing.



## 6. Agriculture

### 6.1. Overview

This chapter provides information on the estimation of the greenhouse gas emissions from the sector Agriculture. The following source categories are reported:

- 4A Enteric Fermentation, CH<sub>4</sub> emissions from domestic livestock,
- 4B Manure Management, emissions of CH<sub>4</sub> and N<sub>2</sub>O
- 4D Agricultural Soils, emissions of N<sub>2</sub>O, NO<sub>x</sub> and NMVOC ,
- 4F Field Burning of Agricultural Residues, emissions of CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>x</sub>, CO, NMVOC and SO<sub>2</sub>.
- Categories 4C Rice Cultivation and 4E Burning of Savannas are not occurring in Switzerland

Total greenhouse gas emissions from agriculture in 2007 were 5'346 Gg CO<sub>2</sub> equivalents in total which is a contribution of 10.4% to the total of Swiss greenhouse gas emissions. Main agricultural sources of greenhouse gases in 2007 were enteric fermentation emitting 2'319 Gg CO<sub>2</sub> equivalents, followed by agricultural soils with 2'104 Gg CO<sub>2</sub> equivalents.

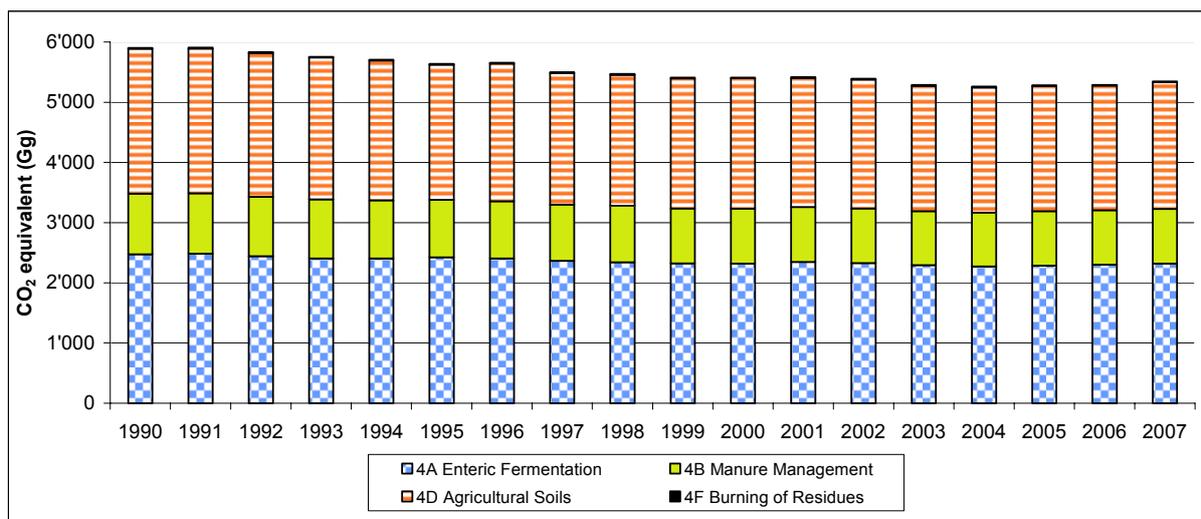


Figure 6-1 Greenhouse gas emissions in Gg CO<sub>2</sub> equivalents of agriculture 1990-2007.

Main greenhouse gases are CH<sub>4</sub> and N<sub>2</sub>O. No CO<sub>2</sub> emissions are reported in the agricultural sector. CO<sub>2</sub> emissions from soils are reported under Land Use, Land-use Change and Forestry. CO<sub>2</sub> emissions from energy use in agriculture are reported under 1A4c Energy; Others Sectors, Agriculture/Forestry/Fishing.

Table 6-1 Greenhouse gas emissions in Gg CO<sub>2</sub> equivalents from agriculture 1990-2007.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO <sub>2</sub> equivalent (Gg)									
CO <sub>2</sub>	0	0	0	0	0	0	0	0	0	0
CH <sub>4</sub>	3'042	3'048	2'999	2'957	2'950	2'961	2'938	2'890	2'873	2'838
N <sub>2</sub> O	2'861	2'859	2'833	2'798	2'756	2'678	2'718	2'609	2'595	2'572
Sum	5'903	5'907	5'833	5'755	5'706	5'638	5'655	5'499	5'468	5'410

Gas	2000	2001	2002	2003	2004	2005	2006	2007
	CO <sub>2</sub> equivalent (Gg)							
CO <sub>2</sub>	0	0	0	0	0	0	0	0
CH <sub>4</sub>	2'835	2'867	2'846	2'803	2'775	2'797	2'811	2'829
N <sub>2</sub> O	2'577	2'549	2'545	2'481	2'483	2'485	2'476	2'516
Sum	5'411	5'416	5'391	5'285	5'259	5'282	5'287	5'346

CH<sub>4</sub> and N<sub>2</sub>O emissions are declining since 1990. This general trend can be explained by a reduction of the number of cattle and a reduced input of mineral fertilisers. Only in the last three years CH<sub>4</sub> emissions increased again due to slightly higher livestock numbers (mainly cattle). Emission factors did not change significantly.

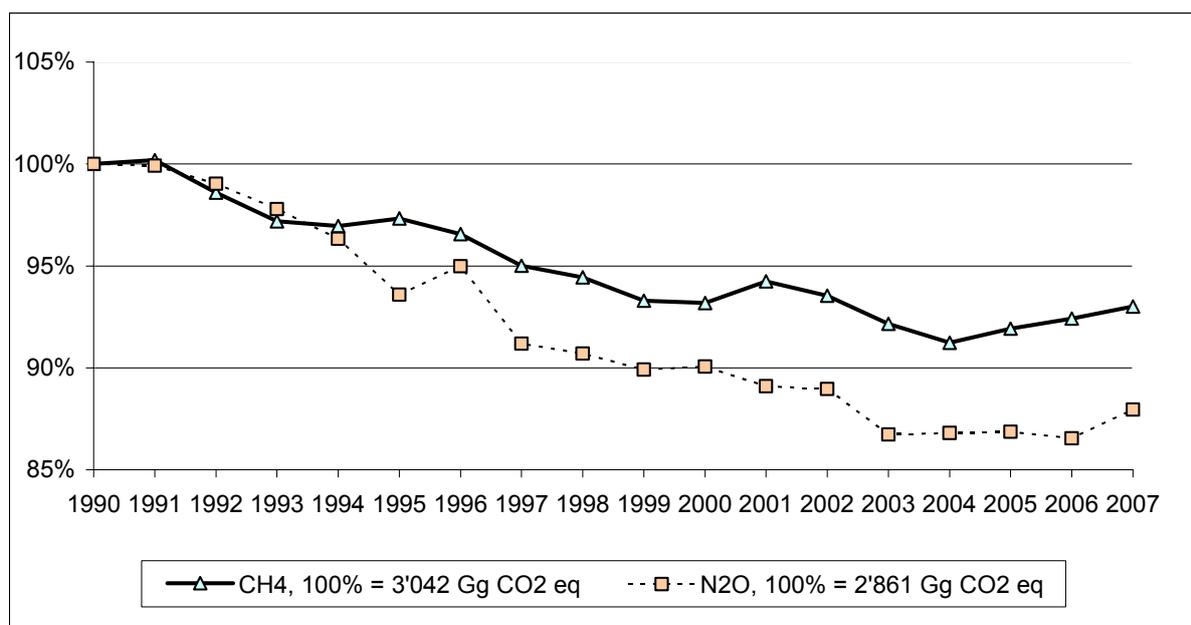


Figure 6-2 Trend of the greenhouse gases of the agricultural sector 1990-2007. The base year 1990 represents 100%.

Among the key categories of the Swiss inventory, five are out of the agricultural sector:

**Key category 4A**

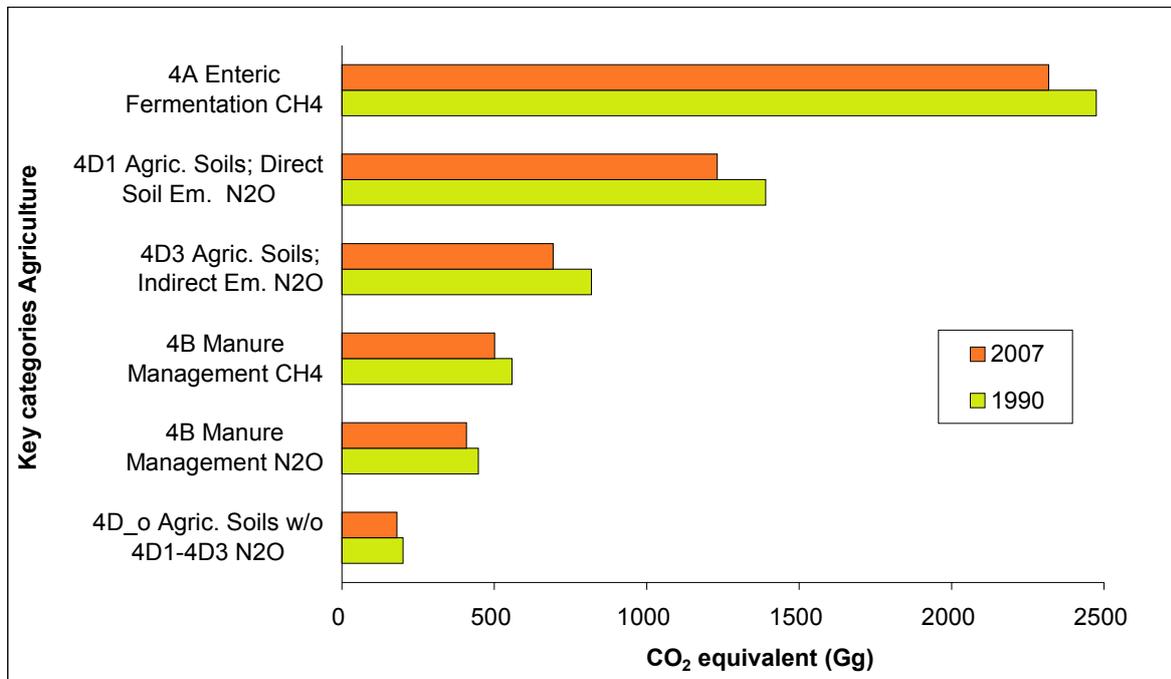
CH<sub>4</sub> emissions from Enteric Fermentation (level and trend)

**Key categories 4B**

CH<sub>4</sub> and N<sub>2</sub>O emissions from Manure Management (both level)

**Key category 4D1**

N<sub>2</sub>O emissions from Agricultural Soils; Direct Soil Emissions (level and trend)

**Key category 4D3**N<sub>2</sub>O emissions from Agricultural Soils; Indirect Soil Emissions (level and trend)**Key Category 4D without 4D1-N<sub>2</sub>O & 4D3-N<sub>2</sub>O**Sum of N<sub>2</sub>O emissions from 4D2 Pasture, Range and Paddock Manure and of 4D4 Other (sewage and compost used for fertilising) (trend)Figure 6-3 Key sources (Tier 1 and Tier 2) in Agriculture, emissions 1990 and 2007 in CO<sub>2</sub> equivalents (Gg).**6.2. Source Category 4A – Enteric Fermentation****6.2.1. Source Category Description****Key category 4A**CH<sub>4</sub> emissions from Enteric Fermentation (level and trend)

The emission source is the domestic livestock population broken down into 3 cattle categories (mature dairy cattle, mature non-dairy cattle, young cattle), sheep, goats, horses, mules and asses, swine and poultry. Emissions from enteric fermentation are declining since 1990, mainly due to a reduction of the number of cattle. Only in the last three years cattle livestock numbers were slightly increasing (mainly cattle). Emissions from cattle contribute to almost 92% of the emissions from enteric fermentation.

Table 6-2 Specification of source category 4A "Enteric Fermentation". (AD: Activity data; EF: Emission factors).

4A	Source	Specification	Data Source
4A1	Cattle	Mature dairy cattle	AD: Livestock data from SBV 2008
		Mature non-dairy cattle	Net energy and metabolisable energy (calves) from RAP 1999
		Young cattle (calves on milk, pre-weaned calves, breeding calves, breeding cattle 1 (4-12 months), breeding cattle 2 (more than one year), fattening calves, fattening cattle)	EF: Soliva 2006
4A3 4A4	Sheep Goats		AD: Livestock data, net energy, and feed intake losses from SBV 2008 EF: Soliva 2006
4A6 4A7 4A8	Horses Mules and asses Swine		AD: Livestock data, digestible energy and feed intake losses from SBV 2008 EF: Soliva 2006
4A9	Poultry		AD: Livestock data; metabolisable energy and feed intake losses from SBV 2008 EF: Hadorn and Wenk 1996 cited in Soliva 2006

## 6.2.2. Methodological Issues

### Methodology

The calculation is based on methods described in the IPCC Good Practice Guidance (IPCC 2000, equation 4.14). CH<sub>4</sub> emissions from enteric fermentation of the livestock population have been estimated using Tier 2 methodology. This means that detailed country specific data on nutrient requirements, feed intake and CH<sub>4</sub> conversion rates for specific feed types are required.

For calculating the **gross energy intake** a country specific method based on available data on net energy (lactation, growth), digestible energy and metabolisable energy has been applied. Data on energy intakes are taken from SBV (2008) and from RAP (1999). The method is described in detail in Soliva (2006) and is realised in ART (2008).

Different energy levels (Figure 6-4) are used to express the energy conversion from energy intake to the energy required for maintenance and performance.

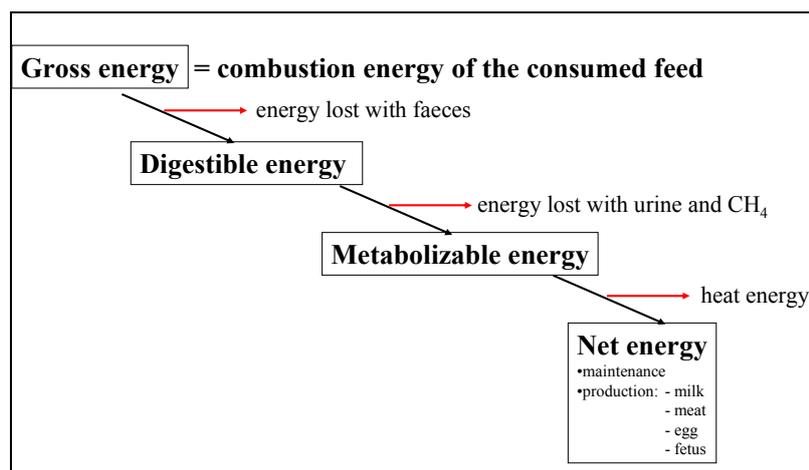


Figure 6-4 Levels of feed energy conversion. Reference: Soliva 2006.

Net energy (NE) is used to express the energy required by the ruminants such as cattle, sheep and goats. NE in cattle feeding is further sub-divided into NE for lactation (NEL) and NE for growth (NEV). For some of the young cattle categories NEL is used rather than NEV what would seem natural. However, cattle raising is often coupled with dairy cattle activities and therefore the same energy unit (NEL) is used in these cases (RAP 1999). Exceptions are the milk-fed calves, whose requirements for energy are expressed as metabolisable energy (ME). Horses, mules, asses and swine are fed on the basis of digestible energy (DE), whereas poultry are fed according to metabolisable energy (ME).

In the energy estimation also some feed energy losses are integrated. Feed losses are defined as the feed not eaten by the animal and therefore represent a loss of net energy.

For the livestock category cattle detailed estimations for NE are necessary. As the Swiss Farmers Union does not calculate the NE for detailed cattle sub-categories, NE data for each cattle sub-category was calculated individually according to the animal's requirements following the feeding recommendations of RAP (1999). These RAP recommendations are also used by the Swiss farmers as basis for their cattle feeding regime and for filling in application forms for subsidies for ecological services, and are therefore highly appropriate. In the calculation of the NE data, the animal's weight, daily growth rate, daily feed intake (DM), daily feed energy intake, and energy required for milk production for the respective sub-categories were considered.

For estimating the gross energy intake out of the available data on net energy, metabolisable energy and digestible energy, the following conversion factors were applied:

Table 6-3 Conversion factors used for calculation of energy requirements of individual livestock categories.  
Reference: Soliva 2006: p.3. GE: Gross energy; DE: Digestible Energy; ME: Metabolisable Energy;  
NEL: Net energy for lactation; NEV: Net energy for growth.

Livestock Category		Conversion Factors	
Mature dairy cattle		NEL to GE	0.318
Mature non-dairy cattle		NEL to GE	0.275
Young cattle	Milk-fed calf	ME to GE	0.930
	Suckler cow calf	NEL to GE	0.291
	Breeding calf	NEL to GE	0.341
	Breeding cattle 1 (4-12 months)	NEL to GE	0.322
	Breeding cattle 2 (more than one year)	NEL to GE	0.313
	Fattening calf	NEV to GE	0.350
	Fattening cattle	NEV to GE	0.401
Sheep	Sheep (breeding)	NEL to GE	0.287
	Sheep (fattening)	NEV to GE	0.350
Goats		NEL to GE	0.283
Horses, mules, asses		DE to GE	0.560
Swine		DE to GE	0.682
Poultry		ME to GE	0.700

For the **methane conversion rate  $Y_m$**  (%) only few country specific data exist. Therefore mainly default values recommended by the IPCC for developed countries in Western Europe were used (IPCC 1997b: Reference Manual: p. 4.32–4.35 and IPCC 2000: p. 4.27). For poultry a country specific value ( $Y_{\text{poultry}} = 0.1631$ ) was used since no default value is given by the IPCC. This value was evaluated in an in vivo trial with broilers (Hadorn and Wenk 1996).

### Emission factors

All emission factors for enteric fermentation are country specific, based on IPCC equation 4.14 IPCC 2000: p. 4.26.

$$EF = \frac{GE * Y_m * 365 \text{ days} / y}{55.65 \text{ MJ} / \text{kg} \text{ CH}_4}$$

$GE$  = Gross energy intake (MJ/head/day)

$Y_m$  = Methane conversion rate, which is the fraction of gross energy in feed converted to methane

55.65 MJ/kg = energy content of methane.

The following input data are used:

Table 6-4 Gross energy intake per head of different livestock groups. Calculation is based on the above mentioned parameters net energy, digestible energy, metabolisable energy according to the method described in Soliva (2006). Input data on net energy, digestible energy and metabolisable energy is taken from SBV (2008) and RAP (1999). All sub-categories displayed in italic.

Gross Energy intake		1990-1999									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		MJ/head/day									
<b>Cattle</b>											
Mature dairy cattle		259.1	261.2	261.8	264.2	263.7	264.7	263.9	267.7	270.2	271.2
Mature non-dairy cattle		205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1
Young cattle	Young cattle average	87.5	88.2	88.3	88.4	88.7	90.1	90.4	91.2	90.4	95.9
	<i>Calves on milk</i>	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6
	<i>Pre-weaned calves</i>	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7
	<i>Breeding calves</i>	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9
	<i>Breeding cattle 1 (4-12 months)</i>	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2
	<i>Breeding cattle 2 (&gt; 1 year)</i>	129.1	129.1	129.1	129.1	129.1	129.1	129.1	129.1	129.1	129.1
	<i>Fattening calves</i>	55.6	55.6	55.6	55.6	55.6	55.6	55.6	55.6	55.6	55.6
	<i>Fattening cattle</i>	124.6	124.6	124.6	124.6	124.6	124.6	124.6	124.6	124.6	124.6
<b>Sheep</b>		20.8	21.4	21.7	21.1	23.2	24.3	21.4	21.8	21.6	22.8
<b>Goats</b>		31.7	32.0	32.3	32.5	33.2	34.8	32.4	29.3	29.2	28.9
<b>Horses</b>		145.3	135.1	133.4	134.8	153.3	176.8	131.9	133.9	134.1	136.0
<b>Mules and Asses</b>		162.0	158.1	159.7	164.7	161.0	156.1	118.3	115.0	110.3	103.1
<b>Swine</b>		35.2	36.0	36.2	35.9	36.8	40.4	37.2	37.0	36.5	36.4
<b>Poultry</b>		1.8	1.9	1.9	1.6	1.7	1.8	1.7	1.8	1.7	1.7

Gross Energy intake		2000-2007							
		2000	2001	2002	2003	2004	2005	2006	2007
		MJ/head/day							
<b>Cattle</b>									
Mature dairy cattle		273.4	275.0	275.6	276.6	279.1	279.4	279.4	281.5
Mature non-dairy cattle		205.1	205.1	205.1	205.1	205.1	205.1	205.1	205.1
Young cattle	Young cattle average	96.2	95.4	95.0	94.7	94.7	94.2	94.3	94.2
	<i>Calves on milk</i>	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6
	<i>Pre-weaned calves</i>	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7
	<i>Breeding calves</i>	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9
	<i>Breeding cattle 1 (4-12 months)</i>	89.2	89.2	89.2	89.2	89.2	89.2	89.2	89.2
	<i>Breeding cattle 2 (&gt; 1 year)</i>	129.1	129.1	129.1	129.1	129.1	129.1	129.1	129.1
	<i>Fattening calves</i>	55.6	55.6	55.6	55.6	55.6	55.6	55.6	55.6
	<i>Fattening cattle</i>	124.6	124.6	124.6	124.6	124.6	124.6	124.6	124.6
<b>Sheep</b>		22.1	22.8	22.6	22.3	23.0	22.5	21.7	22.6
<b>Goats</b>		31.9	31.9	30.9	31.4	30.9	30.8	30.6	30.5
<b>Horses</b>		137.5	139.4	138.1	138.9	139.7	141.3	141.8	142.6
<b>Mules and Asses</b>		103.5	98.9	94.5	91.5	89.2	86.1	85.6	84.6
<b>Swine</b>		35.2	35.2	35.0	35.0	35.0	34.3	34.2	35.5
<b>Poultry</b>		1.7	1.7	1.7	1.7	1.6	1.6	1.6	1.5

The gross energy intake per head for some animal categories revealed some fluctuations during the inventory period. The value for mature dairy cattle increased which is mainly a result of higher milk production (4'940 kg per head and year in 1990 compared to 5'770 kg per year in 2007). The gross energy intake for mature non-dairy cattle is significantly higher than IPCC default values, since this category only comprehends mature cows to produce offspring for meat. The gross energy intake of young cattle was calculated separately for all sub-categories displayed in Table 6-4 (in italics) and subsequently averaged. The values for all the 7 sub-categories summarized under young cattle are constant over time. Since the composition of the young cattle category is changing over time (e.g. more pre-weaned calves, less fattening calves, see Table 6-5) the average gross energy intake for young cattle is also slightly changing over time. The gross energy intake for the horse categories showed higher values for 1994 and 1995. According to the Swiss Farmers Union data comparison of these years can be made only partially due to changes in livestock survey methods (SBV 2000).

### Activity data

The activity data input has been obtained from statistics published by the Swiss Farmers Union (SBV 2008). The following data were used:

Table 6-5 Activity for calculating methane emissions from enteric fermentation (SBV 2008).

Population Size	1990-1999									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	in 1'000 heads									
<b>Cattle</b>	1'855	1'829	1'783	1'745	1'747	1'748	1'747	1'673	1'641	1'609
Mature dairy cattle	795	795	781	762	763	763	764	744	737	684
Mature non-dairy cattle	i.e	i.e	i.e	i.e	i.e	i.e	i.e	i.e	i.e	41
Young cattle	1'060	1'034	1'002	983	984	986	983	929	904	884
<i>Calves on milk</i>	122	123	123	125	123	120	134	132	137	116
<i>Pre-weaned calves</i>	i.e	i.e	i.e	i.e	i.e	i.e	i.e	i.e	i.e	33
<i>Breeding calves</i>	214	204	197	184	183	166	155	139	136	72
<i>Breeding cattle 1 (4-12 months)</i>	132	133	127	125	118	129	131	121	118	147
<i>Breeding cattle 2 (&gt; 1 year)</i>	404	400	397	381	379	378	383	372	350	305
<i>Fattening calves</i>	88	79	71	76	79	82	75	68	66	48
<i>Fattening cattle</i>	100	96	87	92	101	110	105	97	97	162
<b>Sheep</b>	395	409	415	424	405	387	419	420	422	424
<b>Goats</b>	68	65	58	57	55	53	57	58	60	62
<b>Horses</b>	45	49	52	54	48	41	43	46	46	49
<b>Mules and Asses</b>	7	7	8	8	8	8	8	9	10	11
<b>Swine</b>	1'787	1'723	1'706	1'692	1'569	1'446	1'379	1'395	1'487	1'453
<b>Poultry</b>	5'932	5'642	5'499	6'410	6'431	6'241	6'425	6'537	6'724	6'886

Population Size	2000-2007							
	2000	2001	2002	2003	2004	2005	2006	2007
	in 1'000 heads							
<b>Cattle</b>	1'588	1'611	1'594	1'570	1'545	1'555	1'567	1'572
Mature dairy cattle	669	669	658	638	621	621	618	615
Mature non-dairy cattle	45	51	58	65	70	78	87	94
Young cattle	874	891	878	867	854	856	861	863
<i>Calves on milk</i>	103	115	114	114	111	106	101	100
<i>Pre-weaned calves</i>	36	40	47	52	57	62	67	72
<i>Breeding calves</i>	76	78	76	73	71	75	77	76
<i>Breeding cattle 1 (4-12 months)</i>	161	160	154	147	143	147	147	147
<i>Breeding cattle 2 (&gt; 1 year)</i>	352	350	345	337	326	318	320	320
<i>Fattening calves</i>	43	40	38	39	36	35	35	34
<i>Fattening cattle</i>	105	109	104	105	109	112	114	114
<b>Sheep</b>	421	420	430	445	441	446	451	444
<b>Goats</b>	62	63	66	67	71	74	76	79
<b>Horses</b>	50	50	51	53	54	55	56	58
<b>Mules and Asses</b>	12	12	13	14	15	16	16	17
<b>Swine</b>	1'498	1'548	1'557	1'529	1'538	1'609	1'635	1'573
<b>Poultry</b>	6'983	6'939	7'339	7'585	8'061	8'256	7'648	8'221

The Swiss Farmers Union collects livestock data for cattle at a more disaggregated level than the one displayed in the CRF. The category "Mature non-dairy cattle" only includes mature cows used to produce offspring for meat. The CRF livestock category "Young cattle" sums up the sub-categories calves on milk, pre-weaned calves, breeding calves, breeding cattle 1 (4-12 months), breeding cattle 2 (more than one year), fattening calves and fattening cattle. This regrouping of the cattle category enhances the consistency and transparency of the emissions from livestock activities (also refer to chapter 6.3). For mature non-dairy cattle (mature cows used to produce offspring for meat) and pre-weaned calves no activity data was collected before 1999 (included in the sub-categories mature dairy cattle and calves on milk respectively).

The number of cattle was slightly declining during the last 17 years, which is a result of an ongoing process to a less intensive form of animal husbandry due to ecological and economical reasons. Between 1998 and 1999 some changes in the allocation to the various sub-categories can be observed. This is a result of a modification of the questionnaire for the collection of livestock population data. Only in the last three years cattle livestock numbers were slightly increasing.

The numbers of sheep, goats and horses were increasing since 1990. The number of swine was increasing again until 2006 after a decrease until 1996 – a process that could be observed also in many other European countries (SBV 2004: p.69). Nevertheless the number of swine decreased between 2006 and 2007 by 4% and the years to come will show whether this is a new trend or statistical variability. After a rapid increase the number of poultry decreased between 2005 and 2006 by approximately 7% but increased again by 7% between 2006 and 2007. Most likely, this was a consequence of changed consumption patterns as a result of the avian flu in 2006.

### 6.2.3. Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from ART was used (ART 2008a):

Table 6-6 Input data for the uncertainty analysis of the source category 4A "Enteric Fermentation" (ART 2008a).

Input data for uncertainty analysis 4A	Lower bound (2.5 Percentile) (Tier 2)	Upper bound (97.5 Percentile) (Tier 2)	Mean uncertainty (Tier 1)
Activity data (head)	-6.4%	+6.4%	± 6.4%
Emission factor (kg CH <sub>4</sub> /head/yr)	-14.7%	+19.6%	± 17.2%

To apply for the Tier 1 uncertainty analysis, the arithmetic mean of lower and upper bound is used for activity data and for emission factors. For further results see Section 1.7.

The time series between 1990 and 2007 are consistent.

### 6.2.4. Source-Specific QA/QC and Verification

The documentation about the data set and calculation method assures transparency and traceability of the calculation methods (Soliva 2006). Additionally a document in German lists all the methodological differences between the former calculations and the current methodology (Soliva 2006a).

Quality with regard to the methodology is assured by a countercheck done by ART which was responsible for a major recalculation of the whole time series in the year 2007.

Livestock data was compared with the livestock data provided to the FAO and checked for plausibility (FAO 2007). No major inconsistencies could be observed during this quality control process.

IPCC tables with data for estimating emission factors for cattle (such as weight, weight gain, milk production) were filled in, checked for consistency and confidence and compared with IPCC default values (refer to Table A - 36 in Annex A3.3). Methane conversion ( $Y_m$ ) rates and feed digestibilities were compared to literature values representative for Swiss conditions.

Cross checks with data provided in the "Synthesis and Assessment Report" were conducted where possible.

All QA/QC activities will be further described in a separate document that will be published this year. Therein eventual differences between national and (IPCC) standard values are being analysed and discussed.

Additionally a quality control was done by INFRAS by a countercheck of the calculation sheets.

### 6.2.5. Source-Specific Recalculations

A recalculation was carried out for the year 2005 and 2006 due to some data updates from the Swiss Farmers Union (SBV 2008).

## 6.2.6. Source-Specific Planned Improvements

There are no source-specific planned improvement.

## 6.3. Source Category 4B – Manure Management

### 6.3.1. Source Category Description

#### Key categories 4B

CH<sub>4</sub> and N<sub>2</sub>O emissions from Manure Management (both level)

CH<sub>4</sub> and N<sub>2</sub>O emissions from manure management are reported. The total emissions from manure management are declining since 1990, mainly due to a reduction of the cattle population.

Table 6-7 Specification of source category 4B “Manure Management (CH<sub>4</sub>)”. (AD: Activity data; EF: Emission factors).

4B	Source	Specification	Data Source
4B1	Cattle	Mature dairy cattle	AD: SBV 2008 EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006
		Mature non-dairy cattle	
		Young cattle	
4B3 4B4 4B6 4B8	Sheep Goats Horses Swine		AD: SBV 2008 EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006
4B7	Mules and Asses		AD: SBV 2008 EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006
4B9	Poultry		AD: SBV 2008 EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006

Table 6-8 Specification of source category 4B “Manure Management (N<sub>2</sub>O)”.

4B	Source	Specification	Data Source
4B11 4B12	Liquid Systems Solid storage and dry lot		AD: SBV 2008; FAL/RAC 2001; Menzi et al. 1997; Schmid et al. 2000 EF: IPCC 1997c; IPCC 2000

### 6.3.2. Methodological Issues

For calculation of CH<sub>4</sub> and N<sub>2</sub>O emissions slightly different livestock sub-categories are used. The livestock categories reported in the CRF tables are the same, but the respective sub-categories as a basis for the calculation are slightly different. Nevertheless there is no inconsistency in the total number of animals as they are the same both for CH<sub>4</sub> and N<sub>2</sub>O emissions. The calculation of CH<sub>4</sub> and N<sub>2</sub>O emissions is realised in ART (2008).

Calculation of CH<sub>4</sub> emissions is based on the domestic livestock populations mature dairy cattle, mature non-dairy cattle, young cattle (calves on milk, pre-weaned calves, breeding

calves, breeding cattle (4-12 months), breeding cattle (more than one year), fattening calves, fattening cattle), sheep, goats, horses, mules and asses, swine and poultry as reported for enteric fermentation.

Calculation of N<sub>2</sub>O emissions are based on a slightly different livestock population break down:

- Cattle: Mature dairy cattle/mature non-dairy cattle and young cattle (calves on milk/pre-weaned calves, breeding cattle 1st year, breeding cattle 2nd year, breeding cattle 3rd year, fattening calves, fattening cattle)
- Sheep: sheep places
- Goats: goat places
- Horses: pre-weaned foals, foals < 3 years (foals 1 year, foals 2 years) and other horses (horses 3 years, horses more than 4 years, breeding mares and studs).
- Mules and asses: Mules and asses < 1 year, mules and asses more than 1 year
- Swine: fattening pig places, breeding pig places
- Poultry: young hens, laying hens, broilers, other poultry

This calculation is chosen because more detailed data on N excretion for the particular animal categories are available (FAL/RAC 2001). The nitrogen excretion rates per animal place includes excretions not only from the mature animals but also from their corresponding offsprings and other associated animals (e.g. boars). The categories for sheep, swine and goats as provided by FAL/RAC (2001) (i.e. animal places) do not correspond to the categories of the Swiss Farmers Union (SBV 2008). The conversion from the FAL/RAC (2001) classification to the available livestock categories according to SBV is done as follows (Schmid et al. 2000):

- One fattening pig place corresponds to one fattening pig over 25 kg, 1/6 fattening pig place to one young pig below 30 kg.
- One breeding pig place corresponds to one sow, 1/2 breeding pig place to one boar.
- One sheep place corresponds to one ewe over one year.
- One goat place corresponds to one (female) goat older 1.5 years.<sup>17</sup>

## a) CH<sub>4</sub> Emissions

### Methodology

Calculation of CH<sub>4</sub> emissions from manure management is based on IPCC Tier 2 (IPCC 2000: equation 4.17).

$$EF_i = VS_i \cdot 365 \text{ days / year} \cdot Bo_i \cdot 0.67 \text{ kg / m}^3 \cdot \sum_{ijk} MCF_{jk} \cdot MS_{ijk}$$

EF<sub>i</sub>: annual emission factor for livestock population i

VS<sub>i</sub>: daily VS excreted for an animal within population i

Bo<sub>i</sub>: maximum CH<sub>4</sub> producing capacity for manure produced by an animal within population i

MCF<sub>jk</sub>: CH<sub>4</sub> conversion factors for each manure management system j by climate region k

<sup>17</sup> Since the number of (female) goats older than 1.5 years are not known, the following approximation is used: GP = DG + 0.6492\*OFG. GP: goat places, DG: dairy goats, OFG: other female goats older than 1 year.

$MS_{ijk}$ : fraction of animal species / category  $i$ 's manure handled using manure system  $j$  in climate region  $k$

### Emission factor

Calculation of the emission factor is based on the parameters volatile substance excreted (VS), the maximum  $CH_4$  producing capacity for manure ( $B_o$ ) and the  $CH_4$  conversion factors for each manure management system (MCF).

The **daily excretions of VS** for cattle sub-categories were estimated according to IPCC (2000: equation 4.16: p. 4.31). For the livestock categories swine, sheep, goats, horses, mules and asses, and poultry default values from IPCC (1997c: Reference Manual: p. 4.39 to 4.47) were taken.

The **ash content** of cattle manure is assumed to amount to 8% on average (IPCC 1997c: Reference Manual: p. 4.47). The digestible energy of the feed for cattle is assumed to be 60% on average, except for calves with 65% (IPCC 1997c: Reference Manual: p. 4.39). The calculation of gross energy intake per head is described in detail in chapter 6.2.2.

For the Methane Producing Potential ( $B_o$ ) default values are used (IPCC 1997c: Reference Manual: p. 4.39 to 4.47).

For the Methane Conversion Factor (**MCF**) IPCC default values are used (IPCC 2000, p. 4.36 and IPCC 1997c: Reference Manual: p. 4.25). In Switzerland mainly two manure management systems exist, solid storage and liquid/slurry storage. Calves are mainly kept in deep litter systems and there are also specific MCF values for pasture and poultry systems: The following MCF's were used:

Table 6-9 Manure management systems and Methane conversion factors (MCFs). References: IPCC 2000, p. 4.36 and IPCC 1997b: p. 4.25 (for liquid/slurry).

Manure management system	Description	MCF
Solid manure	Dung and urine are excreted in a barn. The solids (with and without litter) are collected and stored in bulk for a long time (months) before disposal.	1%
Liquid/slurry	Combined storage of dung and urine under animal confinements for longer than 1 month.	10%
Pasture	Manure is allowed to lie as it is, and is not managed (distributed, etc.).	1%
Deep litter	Dung and urine is excreted in a barn with lots of litter and is not removed for a long time (months). This is applied for the cattle sub-categories of milk-fed calves and fattening calves, and for sheep and goats.	3.9%
Poultry system	Manure is excreted on the floor with or without bedding.	1.5%

The fraction of animal's manure handled using different manure management systems (**MS**) was separately calculated for each livestock category and the respective manure management systems. The information about the percentage of a livestock category kept in a specific housing system is based on FAL/RAC (2001). The percentages of solid manure or slurry produced by different animals within specific housing systems were obtained from Menzi et al. (1997), as were the percentages of the grazing time for each livestock category.

## Activity data

Activity data on all livestock categories is taken from SBV (2008) (refer to chapter 6.2.2 for details).

### b) N<sub>2</sub>O Emissions

#### Methodology

For the calculation of N<sub>2</sub>O emissions the country specific method IULIA is applied. IULIA is an IPCC-derived method for the calculation of N<sub>2</sub>O emissions from agriculture that basically uses the same emission factors, but adjusts the activity data to the particular situation of Switzerland. Further information is provided under the chapter 6.5.2. IULIA is described in detail in Schmid et al. (2000).

For calculation of emissions from manure management IULIA applies other values for the nitrogen excretion per animal category than IPCC (refer to information about activity data) and differentiates the animal waste management systems Liquid systems and Solid storage. The combined systems (liquid/slurry) are split up into Liquid systems or Solid storage. N<sub>2</sub>O emissions from pasture, range and paddock appear under the category „D Agricultural soils, subcategory 2 animal production“. IPCC categories „daily spread“ and „other systems“ are not occurring. The basic animal waste management systems included in IULIA are defined in Menzi et al. (1997).

#### Emission factors

IPCC default emission factors are used for the two animal waste management systems (IPCC 1997c: Reference Manual: p. 4.104).

Table 6-10 Emission factors for calculating N<sub>2</sub>O emissions from manure management (IPCC 1997c: p. 4.104).

Source	Emission factor per animal waste management system (kg N <sub>2</sub> O-N / kg N)
Liquid systems	0.001
Solid storage	0.020

## Activity data

Input data on all livestock categories are taken from the Swiss Farmers Union (SBV 2008). These input data are converted into the following livestock categories (Walther et al. 1994, FAL/RAC 2001).

Table 6-11 Activity data for calculating N<sub>2</sub>O emissions from manure management (SBV 2008).

Population Size	1990-1999									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	in 1'000 heads									
<b>Cattle</b>										
Mature dairy and mature non-dairy cattle	795	795	781	762	763	763	764	744	737	725
Young cattle	1'060	1'034	1'002	983	984	986	983	929	904	884
<i>Calves on milk and pre-weaned calves</i>	122	123	123	125	123	120	134	132	137	150
<i>Breeding cattle 1st year</i>	346	337	324	308	302	295	286	260	254	219
<i>Breeding cattle 2nd year</i>	253	252	251	239	239	239	243	233	217	188
<i>Breeding cattle 3rd year</i>	151	148	147	142	141	139	140	139	133	118
<i>Fattening calves</i>	88	79	71	76	79	82	75	68	66	48
<i>Fattening cattle</i>	100	96	87	92	101	110	105	97	97	162
<b>Sheep</b>	395	409	415	424	405	387	419	420	422	424
<i>Sheep places</i>	191	201	201	211	201	191	208	208	209	222
<b>Goats</b>	68	65	58	57	55	53	57	58	60	62
<i>Goat places</i>	40	38	34	33	32	31	33	34	35	37
<b>Horses</b>	45	49	52	54	48	41	43	46	46	49
<i>Pre-weaned foals</i>	4	4	5	5	5	5	4	4	4	4
<i>Foals 1 year</i>	3	3	3	4	4	3	3	3	3	IE
<i>Foals 2 years</i>	3	3	3	3	3	3	3	3	3	IE
<i>Foals &lt; 3 years</i>	5	6	6	7	7	6	6	6	6	7
<i>Horses 3 years</i>	2	3	3	3	3	3	3	3	3	IE
<i>Horses more than 4 years</i>	24	26	28	28	23	18	20	24	25	IE
<i>Breeding mares and studs</i>	9	9	10	11	10	9	9	9	9	IE
<i>Other horses</i>	36	39	41	43	36	30	32	36	36	38
<b>Mules and Asses</b>	7	7	8	8	8	8	8	9	10	11
<i>Mules and asses &lt; 1 year</i>	1	1	1	1	1	1	1	1	1	IE
<i>Mules and asses &gt; 1 year</i>	6	7	7	7	7	7	7	8	9	IE
<b>Swine</b>	1'787	1'723	1'706	1'692	1'569	1'446	1'379	1'395	1'487	1'453
<i>Fattening pig places</i>	1'012	977	960	931	844	757	769	769	827	830
<i>Breeding pig places</i>	184	179	178	179	168	156	142	148	156	139
<b>Poultry</b>	5'932	5'642	5'499	6'410	6'431	6'241	6'425	6'537	6'724	6'886
<i>Young hens</i>	719	664	710	719	732	714	732	733	793	761
<i>Laying hens</i>	3'083	2'645	2'536	2'518	2'226	2'118	2'226	2'278	2'270	2'223
<i>Broilers</i>	2'020	2'199	2'096	2'990	3'293	3'231	3'293	3'342	3'502	3'747
<i>Other poultry</i>	110	134	158	183	180	177	174	184	158	155

continued on next page

Population Size	2000-2007							
	2000	2001	2002	2003	2004	2005	2006	2007
	in '000 heads							
<b>Cattle</b>								
Mature dairy and mature non-dairy cattle	714	720	716	703	691	699	705	708
Young cattle	874	891	878	867	854	856	861	863
<i>Calves on milk and pre-weaned calves</i>	139	155	161	166	168	168	169	173
<i>Breeding cattle 1st year</i>	236	238	230	220	215	222	223	223
<i>Breeding cattle 2nd year</i>	222	219	219	213	205	205	210	210
<i>Breeding cattle 3rd year</i>	130	130	126	124	121	113	110	109
<i>Fattening calves</i>	43	40	38	39	36	35	35	34
<i>Fattening cattle</i>	105	109	104	105	109	112	114	114
<b>Sheep</b>	421	420	430	445	441	446	451	444
<i>Sheep places</i>	217	217	220	229	227	229	231	230
<b>Goats</b>	62	63	66	67	71	74	76	79
<i>Goat places</i>	37	38	39	40	42	44	45	46
<b>Horses</b>	50	50	51	53	54	55	56	58
<i>Pre-weaned foals</i>	4	4	3	3	3	3	3	3
<i>Foals 1 year</i>	IE	IE	IE	IE	IE	IE	IE	IE
<i>Foals 2 years</i>	IE	IE	IE	IE	IE	IE	IE	IE
<i>Foals &lt; 3 years</i>	6	6	6	6	6	6	6	7
<i>Horses 3 years</i>	IE	IE	IE	IE	IE	IE	IE	IE
<i>Horses more than 4 years</i>	IE	IE	IE	IE	IE	IE	IE	IE
<i>Breeding mares and studs</i>	IE	IE	IE	IE	IE	IE	IE	IE
<i>Other horses</i>	40	40	42	43	44	46	47	48
<b>Mules and Asses</b>	12	12	13	14	15	16	16	17
<i>Mules and asses &lt; 1 year</i>	IE	IE	IE	IE	IE	IE	IE	IE
<i>Mules and asses &gt; 1 year</i>	IE	IE	IE	IE	IE	IE	IE	IE
<b>Swine</b>	1'498	1'548	1'557	1'529	1'538	1'609	1'635	1'573
<i>Fattening pig places</i>	851	868	874	857	859	907	901	877
<i>Breeding pig places</i>	145	149	148	144	146	151	154	143
<b>Poultry</b>	6'983	6'939	7'339	7'585	8'061	8'256	7'648	8'221
<i>Young hens</i>	832	745	754	809	853	868	888	902
<i>Laying hens</i>	2'150	2'069	2'154	2'117	2'089	2'189	2'147	2'198
<i>Broilers</i>	3'808	3'993	4'298	4'518	4'971	5'060	4'481	5'002
<i>Other poultry</i>	193	132	132	140	148	139	131	120

Data on nitrogen excretion per animal category (kg N/head/year) is taken from FAL/RAC (2001: p. 48/49), Walther et al. (1994) and Schmid et al. (2000) (see Table A - 35 in Annex A3.3). These data are calculated according to the method IULIA. Unlike IPCC, IULIA distinguishes the age structure of the animals and the different use of the animals (e.g. fattening and breeding). This consideration of adopted nitrogen excretion values is one of the major advantages of the method IULIA in the Swiss context. Calculation of nitrogen excretion of dairy cattle is based on milk production reported. This more disaggregated approach leads to 30% lower calculated nitrogen excretion rates compared to IPCC, which therefore also implies to lower total N<sub>2</sub>O emissions from manure management.

The nitrogen excretion per sheep place has been changed from 16 in 1994 to 12 kg N/head/year in 2001 according to the revised standard values of N excretion (FAL/RAC 2001). The values for the years 1995 to 2000 were calculated by linear interpolation. The value currently used is based on a feeding regime mainly based on roughage from extensive pasture, range and paddock. Still it seems low compared to IPCC default values and therefore will be revised during the next recalculation.

The split of nitrogen flows into the different animal waste management systems including ammonia emissions are taken from Menzi et al. (1997).

### 6.3.3. Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from ART was used (ART 2008a):

Table 6-12 Input data for the uncertainty analysis of the source category 4B "Manure Management" (ART 2008a).

Input data for uncertainty analysis 4B	Lower bound (2.5 Percentile) (Tier 2)	Upper bound (97.5 Percentile) (Tier 2)	Mean uncertainty (Tier 1)
Activity data CH <sub>4</sub> (head)	-6.4%	+6.4%	±6.4%
Activity data N <sub>2</sub> O (liquid systems, kg N)	-29.9%	+29.2%	±29.5%
Activity data N <sub>2</sub> O (solid storage, kg N)	-29.9%	+29.2%	±29.5%
Emission factor CH <sub>4</sub> (kg CH <sub>4</sub> /head/yr)	-54.7%	+53.5%	±54.1%
Emission factor N <sub>2</sub> O (liquid systems, kg N <sub>2</sub> O-N / kg N)	-100%	+0%	±50%
Emission factor N <sub>2</sub> O (solid storage, kg N <sub>2</sub> O-N / kg N)	-75%	+50%	±62.5%

To apply for the Tier 1 uncertainty analysis, the arithmetic mean of lower and upper bound is used for activity data and for emission factors. To aggregate liquid systems and solid storage (as required for input into Tier 1 analysis 4B/N<sub>2</sub>O), the combined uncertainty of the emissions is determined by using Tier 1 error propagation for the sub-systems. For further results see Section 1.7.

The time series 1990–2007 is consistent.

#### 6.3.4. Source-Specific QA/QC and Verification

For CH<sub>4</sub> the documentation about the data set and calculation method assures transparency and traceability of the calculation methods (Soliva 2006). Additionally a document in German lists all the methodological differences between the former calculations and the current methodology regarding CH<sub>4</sub> estimations (Soliva 2006a). For N<sub>2</sub>O estimations an internal documentation of the Agroscope Reckenholz-Tänikon Research Station (ART) is available (Berthoud 2004).

IPCC tables with data for estimating emission factors for all livestock categories (such as weight, digestibility, maximum CH<sub>4</sub> producing capacity (B<sub>0</sub>) or daily excretion of volatile solids) were filled in, checked for consistency and confidence and compared with IPCC default values (refer to Table A - 37 in Annex A3.3). Factors for methane conversion (MCF) and manure management distribution (MS) were analysed considering the Swiss national agricultural context.

All relevant data needed for the calculation of N<sub>2</sub>O emissions such as nitrogen excretion, manure management system distribution and N<sub>2</sub>O emission factors have been checked for consistency and have been compared to IPCC default as well as literature values.

Cross checks with data provided in the "Synthesis and Assessment Report" were conducted where possible.

Furthermore, quality is assured by the same procedures as mentioned in chapter 6.2.4. All QA/QC activities will be further described in a separate document that will be published this year. Therein eventual differences between national and (IPCC) standard values are being analysed and discussed.

A quality control was done by INFRAS by a countercheck of the calculation sheets.

#### 6.3.5. Source-Specific Recalculations

A recalculation was carried out for the year 2005 and 2006 due to some data updates from the Swiss Farmers Union (SBV 2008).

### 6.3.6. Source-Specific Planned Improvements

There are no source-specific planned improvements.

## 6.4. Source Category 4C – Rice Cultivation

Rice Cultivation is of minor importance in Switzerland. The agricultural land used for rice cultivation and the annual yield of rice are not estimated by the Swiss Farmers Union (SBV 2008). There is only some insignificant upland rice cultivation. Emissions are assumed to be zero. They are therefore not considered in the emission calculation.

## 6.5. Source Category 4D – Agricultural Soils

### 6.5.1. Source Category Description

**Key category 4D1**

N<sub>2</sub>O emissions from Agricultural Soils; Direct Soil Emissions (level and trend).

**Key category 4D3**

N<sub>2</sub>O emissions from Agricultural Soils; Indirect Soil Emissions (level and trend).

**Key Category 4D without 4D1-N<sub>2</sub>O & 4D3-N<sub>2</sub>O**

Sum of N<sub>2</sub>O emissions from 4D2 Pasture, Range and Paddock Manure and of 4D4 Other (sewage and compost used for fertilising) (level)

The source category 4D includes the following emissions: Direct N<sub>2</sub>O emissions from soils and from animal production (emission from pasture, range and paddock), indirect N<sub>2</sub>O emissions, NO<sub>x</sub> emissions from soils and NMVOC emissions.

Direct and indirect N<sub>2</sub>O emissions as well as NO<sub>x</sub> emissions are decreasing since 1990 in almost all sub-categories.

Table 6-13 Specification of source category 4D "Agricultural Soils". (AD: Activity data; EF: Emission factors).

4D	Source	Specification	Data Source
4D1	Direct soil emissions	Includes emissions from synthetic fertilizer, animal manure, crop residue, N-fixing crops, organic soils, residues from meadows and pasture, N-fixing meadows and pasture	AD: SBV 2008; FAL/RAC 2001; Leifeld et al. 2003; Menzi et al. 1997; Schmid et al. 2000; Walther et al. 1994; EF: IPCC 1997c (N <sub>2</sub> O); IPCC 2000
4D2	Animal production	Only emissions from pasture, range and paddock	AD: SBV 2008; FAL/RAC 2001; Menzi et al. 1997; Schmid et al. 2000; Walther et al. 1994 EF: IPCC 1997c
4D3	Indirect emissions	Leaching and run-off, N deposition air to soil	AD: SBV 2008; FAL/RAC 2001; Prasuhn and Braun 1994; Braun et al. 1994; Menzi et al. 1997; Schmid et al. 2000; Walther et al. 1994 EF: IPCC 2000
4D4	Other (sewage sludge and compost used for fertilizing)		AD: SBV 2008 EF: IPCC 1997c

## 6.5.2. Methodological Issues

### Methodology

For calculation of N<sub>2</sub>O emissions from agricultural soils the national method IULIA is applied. IULIA is an IPCC-derived method for the calculation of N<sub>2</sub>O emissions from agriculture that basically uses the same emission factors, but adjusts the activity data to the particular situation of Switzerland (Schmid et al. 2000). According to Schmid et al. (2000) IULIA is better adapted to the conditions of Swiss agriculture, compared to the IPCC method. There is no indication that the adoption of the IPCC method would lead to a better estimation of the N<sub>2</sub>O emissions in Switzerland.

The modelling of the N<sub>2</sub>O emissions is realised in ART (2008). The model structure is displayed in the following figure.

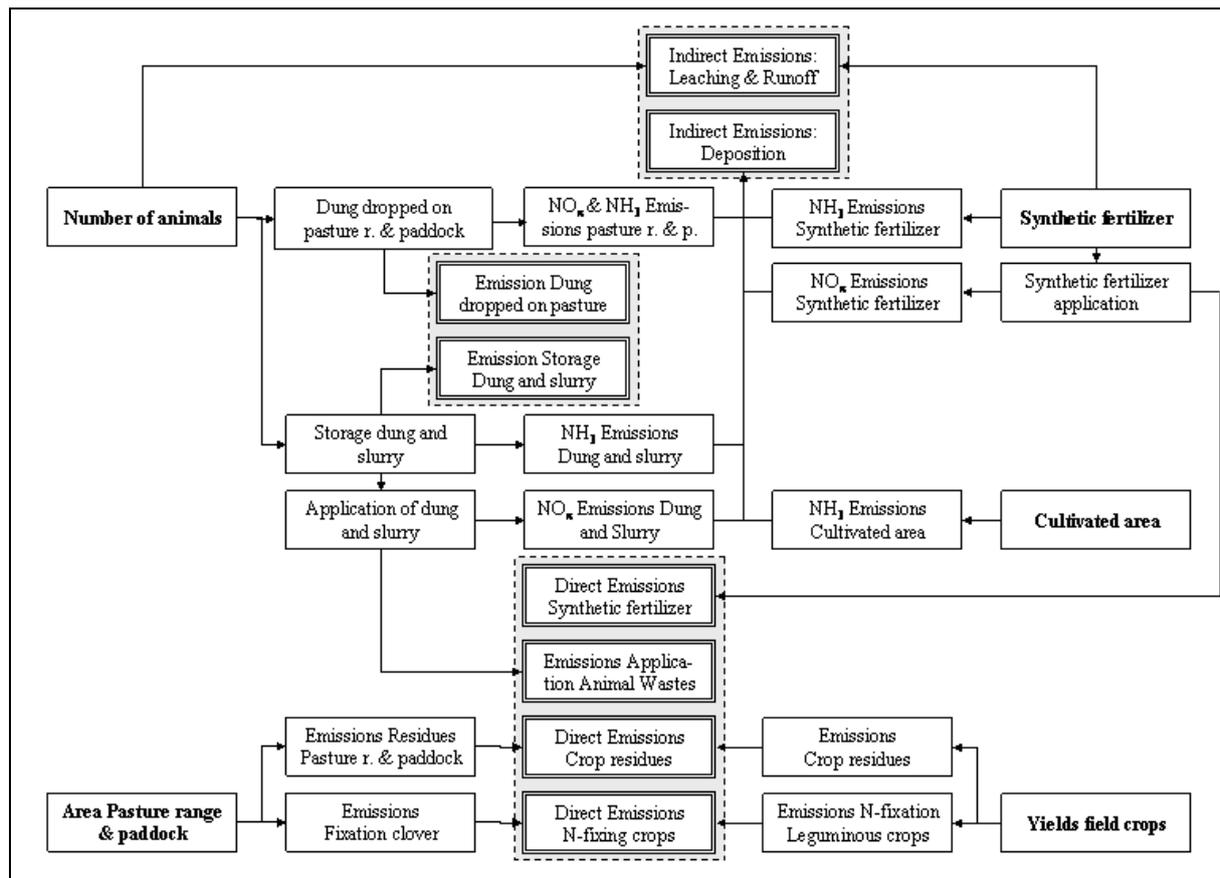


Figure 6-5 Diagram of the N<sub>2</sub>O emissions in Agriculture (Berthoud 2004).

Main differences between the IULIA method and IPCC are (Schmid et al. 2000: p. 74):

- IULIA estimates lower nitrogen excretion per animal category, especially due to the lower excretions of cattle (refer to chapter 6.3.2).
- The amount of losses to the atmosphere from the excreted nitrogen is more than 50% higher compared to IPCC.
- The amount of leaching (of nitrogen excreted and of synthetic fertilizers) is lower by 1/3 compared to IPCC.
- The share of solid storage out of the total manure is more than twofold; the share of excretion on pasture, range and paddock is lower by 1/3.
- The nitrogen inputs from biological fixation are higher by a factor of 30 since fixation on meadows and pastures are also considered. The consideration of nitrogen fixation from grassland is one of the major advantages of the method IULIA as the grassland accounts for the majority of nitrogen fixed in Swiss agricultural soils.
- The nitrogen inputs from crop residues are only 25% higher although emissions from plant residue on grasslands are considered. This is explained by the fact that the emissions from plant residues returned to soils on cropland are estimated 50% below the IPCC defaults.

Despite the different assumptions of the two methods, differences at the level of the N<sub>2</sub>O emissions are quite moderate. In total IULIA estimations of the N<sub>2</sub>O emissions from agriculture are 14% lower than the IPCC estimations (Schmid et al. 2000: p. 75).

**Direct emissions from soil (4D1)**

Calculation of direct N<sub>2</sub>O emissions from soil is based on IPCC 2000 Tier 1b.

- Emissions from **synthetic fertilizer** include mineral fertilizer. The amount of nitrogen in fertilizer is taken from SBV (2008). From the amount of nitrogen in fertilizer losses to the atmosphere in form of NH<sub>3</sub> are subtracted and the rest is multiplied with the corresponding emission factor. NO<sub>x</sub> emissions are not subtracted since they occur mainly after the fertilizer application. The basis for N<sub>2</sub>O-emissions is the mineral fertilizer including the nitrogen that will be lost as NO<sub>x</sub> later (Berthoud 2004).
- According to the method IULIA losses to the atmosphere are set to 6% (NH<sub>3</sub>) instead of the IPCC value of 10% for NH<sub>3</sub> and NO<sub>x</sub> (Schmid et al. 2000: p. 63 and IPCC 1997c: p. 4.94).
- To model the emissions of **animal wastes applied to soils**, nitrogen input from manure applied to soils is calculated. This is calculated by the total N excretion minus N excreted on pasture, range and paddock minus ammonia volatilization from solid and liquid manure. The losses (to the atmosphere) as ammonia are specified for each animal category separately instead of using a fixed ratio of 20% (Schmid et al. 2000: p. 66). NO<sub>x</sub> emissions are not subtracted since they occur after the application of animal wastes. For details regarding the volatilized N refer to Table 6-15.
- Emissions from **crop residues** are based on the amount of nitrogen in crop residues returned to soil. According to IULIA (Schmid et al. 2000: p. 68 and p. 100) the calculation of nitrogen in crop residues is based on data reported on crop yields (SBV 2008), the standard values for arable crop yields (FAL/RAC 2001 and Walther et al. 1994) and standard amounts of nitrogen in crop residues returned to soils (FAL/RAC 2001 and Walther et al. 1994). The calculation of the amount of nitrogen in crop residues returned to soil according to IULIA is as follows (Schmid et al. 2000: p. 101):

$$F_{CR} = \sum_{Cr} (E_{Cr} * \frac{NR_{Cr}}{Y_{Cr}})$$

F<sub>CR</sub>: Amount of nitrogen in crop residues returned to soils (t N)

E<sub>Cr</sub>: Amount of crop yields for culture Cr (t)

Y<sub>Cr</sub>: Standard values for arable crop yields for culture Cr (t/ha)

NR<sub>Cr</sub>: Standard amount of nitrogen in crop residues returned to soils (t/ha)

From 2001 on updated standard values and amounts of nitrogen returned to soil are used. In addition to the N transfer from crop residues, IULIA also takes into account the plant residue returned to soils on meadows and pastures (Schmid et al.: 2000). Three quarters of the agricultural land use consists of grassland which underscores the importance of the source for Switzerland. Input data on the managed area of meadows and pastures are taken from SBV (2008).

- For calculation of emissions from **N-fixing crops**, IULIA assumes that 60% of the nitrogen in crops is caused by biological nitrogen fixation (Schmid et al. 2000: p. 70). This is in line with IPCC, assuming that biological nitrogen fixation supplies 50-60 per cent of the nitrogen in grain legumes (IPCC 1997c, p. 4.89). The total amount of nitrogen is calculated according to the calculation of nitrogen in crop residues. In addition, IULIA takes biological nitrogen fixation on meadows and pastures into account, assuming a nitrogen concentration of 3.5% in the dry matter from which 80% derives from biological nitrogen fixation. For the dry matter production of clover on pastures and meadows statistical data were used (Schmid et al. 2000: p. 70). The following table gives an overview of the calculation of emissions from N-fixing crops.

Table 6-14 Input values for calculation of emissions from N-fixing crops according to IULIA (Schmid et al. 2000: p. 70).

Fixation	Share of N caused by fixation	Share of N in Dry matter
Leguminous (N-fixing crops)	0.6	
Clover (Fixation on meadows and pastures)	0.8	0.035

- Emissions from **cultivated organic soils** are based on estimations on the area of cultivated organic soils (Leifeld et al. 2003) and the IPCC default emission factor for N<sub>2</sub>O emissions from cultivated organic soils (IPCC 1997b).

Estimation of NMVOC emissions of meadows and arable land is based on Spirig and Neftel (2002). VOC flows are estimated in Warneke et al. (2002) (for meadows) and König et al. (1995) (for arable land). Emissions were measured in a field trial in Austria (Karl et al. 2001).

### **Emissions from animal production (4D2)**

Calculation of emissions from animal production is based on IULIA (Schmid et al. 2000). This equation is similar to equation 4.18, IPCC 2000: p. 4.42, but applies national N excretion rates. For calculation of the N excretion per animal category, refer to chapter 6.3.2.

Only emissions of pasture, range and paddock are to be reported under agricultural soils. Other emissions from animal production are reported under Manure Management. The relevant input data are taken from FAL/RAC (2001: p. 48/49), Schmid et al. (2000), Walther et al. 1994 (nitrogen excretion in kg N/head/yr) and Menzi et al. (1997; fraction of animal waste management system).

### **Indirect emissions (4D3)**

Calculation of the indirect emissions is based on IPCC 2000 Tier 1b.

- For calculation of N<sub>2</sub>O emissions from **leaching and run-off**, N from fertilizers and animal wastes has to be estimated. The relevant input data (cultivated area, information on leaching and run-off) is taken from FAL/RAC (2001), Prasuhn and Braun (1994) and Braun et al. (1994).  $Frac_{Leach}$  is set as 0.2 instead of the IPCC default of 0.3 (Prasuhn and Mohni 2003). This value is extrapolated from long-term monitoring and modelling studies from the canton of Berne. According to Schmid et al. (2000: p. 71), the default value of IPCC leads to an overestimation of the emissions from leaching and run-off. The default value is based on a model which assumes that 30% of nitrogen from synthetic fertilizer and deposition is reaching water bodies. According to Schmid et al. (2000) this amount cannot be applied to the N-excretion of animals for production.
- N<sub>2</sub>O emissions from **deposition** are based on NH<sub>3</sub> and NO<sub>x</sub> emissions. Losses to the atmosphere are calculated according to Menzi et al. (1997) and Schmid et al. (2000). For NH<sub>3</sub> emissions specific losses for all livestock categories are assumed. Furthermore, it is estimated that 6% of nitrogen in mineral fertilizer, sewage sludge and compost is emitted as NH<sub>3</sub> and 1.5 kg NH<sub>3</sub> -N/ha agricultural soil is produced during decomposition of organic material. 0.7% of nitrogen excretion from livestock and mineral fertilizer is emitted as NO<sub>x</sub> (Schmid et al. 2000: p. 66, EEA 2007). Details about the amount of volatilized N (NH<sub>3</sub> and NO<sub>x</sub>) are provided in the following table.

Table 6-15 Overview of the volatilized N (NH<sub>3</sub>- and NO<sub>x</sub>-) from animal wastes and fertilizer for 2007. The total amount of volatilized N appears under the indirect emissions (atmospheric deposition) in the CRF, table 4D. Sources: SBV 2008; FAL/RAC 2001; Schmid et al. 2000; Menzi et al. 1997.

	N excretion (t N) / N content 2007	Losses NH <sub>3</sub> (%)	Emissions NH <sub>3</sub> (t N) 2007	Losses NO <sub>x</sub> (%)	Emissions NO <sub>x</sub> (t N) 2007	Volatilized N total (NH <sub>3</sub> , NO <sub>x</sub> in t) 2007
<b>Cattle</b>						
Mature dairy and mature non-dairy cattle	76'125	32	24'360	0.7	533	24'893
Young cattle	26'280	26	6'724	0.7	184	6'908
<i>Calves on milk and pre-weaned calves</i>	2'244	37	830	0.7	16	846
<i>Breeding cattle 1st year</i>	5'582	22	1'228	0.7	39	1'267
<i>Breeding cattle 2nd year</i>	8'420	22	1'852	0.7	59	1'911
<i>Breeding cattle 3rd year</i>	5'999	22	1'320	0.7	42	1'362
<i>Fattening calves</i>	271	37	100	0.7	2	102
<i>Fattening cattle</i>	3'765	37	1'393	0.7	26	1'419
<b>Sheep</b>						
<i>Sheep places</i>	2'760	14	386	0.7	19	406
<b>Goats</b>						
<i>Goats places</i>	741	29	215	0.7	5	220
<b>Horses</b>	2'446	32	783	0.7	17	800
<i>Pre-weaned foals</i>	50	32	16	0.7	0	16
<i>Foals 1 year</i>	IE	32	IE	0.7	IE	IE
<i>Foals 2 years</i>	IE	32	IE	0.7	IE	IE
<i>Foals &lt; 3 years</i>	281	32	90	0.7	2	92
<i>Horses 3 years</i>	IE	32	IE	0.7	IE	IE
<i>Horses more than 4 years</i>	IE	32	IE	0.7	IE	IE
<i>Breeding mares and studs</i>	IE	32	IE	0.7	IE	IE
<i>Other horses</i>	2'115	32	677	0.7	15	692
<b>Mules and Asses</b>	429	32	137	0.7	3	140
<i>Mules and asses &lt; 1 year</i>	IE	32	IE	0.7	IE	IE
<i>Mules and asses &gt; 1 year</i>	IE	32	IE	0.7	IE	IE
<b>Swine</b>	16'395	46	7'542	0.7	115	7'657
<i>Fattening pig places</i>	11'403	46	5'245	0.7	80	5'325
<i>Breeding pig places</i>	4'992	46	2'296	0.7	35	2'331
<b>Poultry</b>	4'035	51	2'049	0.7	28	2'077
<i>Young hens</i>	307	54	166	0.7	2	168
<i>Laying hens</i>	1'560	54	842	0.7	11	853
<i>Broilers</i>	2'001	48	960	0.7	14	974
<i>Other poultry</i>	167	48	80	0.7	1	81
<b>Total animals</b>			42'196		904	43'100
<b>Mineral fertilizer, compost and sewage sludge (t N)</b>	57'900	6.0	3'474	0.7	405	3'879
<b>NH<sub>3</sub> emissions from cropland (ha)</b>	1'060'278	1.5	1'590			1'590
<b>Total</b>			47'260		1'310	48'570

The estimations of the ammonia emissions is based on a Swiss study, which takes into account the specific farming and manure systems (Menzi et al. 1997: p. 37). Emission factors are lower for cattle, sheep, goats and horses due to the grazing regime. Higher emission factors are estimated under stall feeding conditions.

#### **Other (sewage sludge and compost used for fertilizing) (4D4)**

This source category covers N<sub>2</sub>O emissions from sewage sludge and from compost used for fertilizing. The calculation of the emissions corresponds to the one for synthetic fertilizer.

Until 1995 the categories sewage sludge and compost were not disclosed separately but included under synthetic fertilizer. From 1995 onwards these categories are reported separately.

#### **NO<sub>x</sub> emissions**

NO<sub>x</sub> emissions are estimated to be 0.7% of total nitrogen from animal manure and mineral fertilizer, sewage sludge and compost. This factor is based on the CORINAIR Emission Inventory Guidebook 2003 (EEA 2007). Data on N-excretion (kg N/head/yr) is taken from FAL/RAC (2001), Schmid et al. (2000) and Walther et al. (1994). The amount of nitrogen from mineral fertilizer, sewage sludge and compost is taken from SBV (2008).

#### **Emission factors**

The following IPCC default emission factors for calculating N<sub>2</sub>O emissions from agricultural soils are used.

Table 6-16 Emission factors for calculating N<sub>2</sub>O emissions from agricultural soils (IPCC 1997c: tables 4.18 (direct emissions), 4.22 (pasture, range and paddock) and 4.23 (indirect emissions); IPCC 2000: table 4.17 (organic soils)).

Emission source	Emission factor
<b>Direct emissions</b>	
Synthetic fertilizer	0.0125 kg N <sub>2</sub> O -N/kg N
Animal excreta nitrogen used as fertilizer	0.0125 kg N <sub>2</sub> O -N/kg N
Crop residue	0.0125 kg N <sub>2</sub> O -N/kg N
N-fixing crops	0.0125 kg N <sub>2</sub> O -N/kg N
Organic soils	8 kg N <sub>2</sub> O-N/ha/year
Residues meadows and pasture	0.0125 kg N <sub>2</sub> O -N/kg N
N-fixing meadows and pasture	0.0125 kg N <sub>2</sub> O -N/kg N
<b>Indirect emissions</b>	
Leaching and run-off	0.025 kg N <sub>2</sub> O -N/kg N
Deposition	0.01 kg N <sub>2</sub> O -N/kg N
<b>Animal production</b>	
Pasture, range and paddock	0.02 kg N <sub>2</sub> O -N/kg N/a
<b>Other</b> (sewage sludge and compost used for fertilizing)	0.0125 kg N <sub>2</sub> O -N/kg N

### Activity data

Activity data for calculation of direct soil emissions has been provided by SBV (2008; use of synthetic fertilizer, sewage sludge, compost, crops produced, area of pasture, range and paddock), FAL/RAC (2001: p. 48/49), Schmid et al. (2000), Walther et al. (1994; nitrogen excretion), Menzi et al. (1997; NH<sub>3</sub>) and Leifeld et al. (2003) (revised area of cultivated organic soils).

The relevant activity data for calculating N<sub>2</sub>O emissions from soils is displayed in the following table. Additional information is given in Table A - 38 in Annex A3.3.

Table 6-17 Activity data for calculating N<sub>2</sub>O emissions from agricultural soils. Comment: Animal manure: Ammonia volatilization is already subtracted.

Related activity data		1990-1999									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		Value									
<b>Direct emissions</b>											
Fertilizers (t N/yr)		75'200	75'800	75'400	70'200	66'500	63'400	65'900	58'000	58'400	60'800
	Mineral fertilizer (t N/yr)	IE	IE	IE	IE	IE	56'300	58'800	50'900	51'100	53'500
	Sewage sludge (t N/yr)	IE	IE	IE	IE	IE	4'600	4'400	4'200	4'200	4'200
	Compost (t N/yr)	IE	IE	IE	IE	IE	2'500	2'700	2'900	3'100	3'100
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	81'387	81'138	79'777	78'839	77'607	76'505	76'518	74'675	74'373	73'479
N-fixing crops	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	654	736	857	763	779	830	895	1'073	1'070	1'014
Crop residue	N from crop residues (t N/yr)	14'150	14'057	13'761	14'171	13'321	13'826	15'596	14'896	14'806	13'172
Organic soils	Area of cultivated organic soils (ha)	17'000	17'000	17'000	17'000	17'000	17'000	17'000	17'000	17'000	17'000
N-fixing meadows and pasture	Area of meadows and pasture (ha)	784'867	788'089	792'338	791'387	785'006	798'550	802'514	803'722	798'295	805'131
	N fixation meadows and pasture (t N/yr)	29'027	28'886	29'728	32'316	34'168	31'574	31'933	32'144	31'838	32'094
Residues meadows and pasture	Area of meadows and pasture (ha)	784'867	788'089	792'338	791'387	785'006	798'550	802'514	803'722	798'295	805'131
	N from residues meadows and pasture (t N/yr)	21'473	21'433	21'713	23'217	25'129	22'974	23'090	23'132	22'954	23'090
<b>Indirect emissions</b>											
Leaching and run-off	N excretion of all animals (t N/yr)	149'146	148'535	146'067	144'215	141'766	139'472	139'568	136'101	135'224	132'637
	Fertilizer (t N/yr)	75'200	75'800	75'400	70'200	66'500	63'400	65'900	58'000	58'400	60'800
Deposition	N from fertilizers and animal wastes that is lost through leaching and run off (t N/yr)	44'869	44'867	44'293	42'883	41'653	40'574	41'094	38'820	38'725	38'687
	Emissions NH <sub>3</sub> from fertilizers and animal wastes	54'358	54'054	53'217	52'418	51'220	50'116	50'277	48'850	48'885	48'552
	Emissions NO <sub>x</sub> from fertilizers and animal wastes	1'570	1'570	1'560	1'501	1'458	1'420	1'438	1'359	1'355	1'354
	Sum volatilized N (NH <sub>3</sub> and NO <sub>x</sub> ) from fertilizers, animal wastes and cropland (t N/yr)	55'928	55'624	54'767	53'919	52'678	51'536	51'715	50'209	50'240	49'906
<b>Animal production</b>											
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	20'548	20'521	20'214	19'764	19'508	19'209	19'317	18'606	17'968	16'697

Related activity data		2000-2007							
		2000	2001	2002	2003	2004	2005	2006	2007
		Value							
<b>Direct emissions</b>									
Fertilizers (t N/yr)		60'100	64'200	62'800	58'400	57'800	56'600	55'500	57'900
	Mineral fertilizer (t N/yr)	53'000	57'100	55'700	53'200	53'600	52'400	51'400	53'900
	Sewage sludge (t N/yr)	4'000	4'000	4'000	2'000	1'000	1'000	900	800
	Compost (t N/yr)	3'100	3'100	3'100	3'200	3'200	3'200	3'200	3'200
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	72'713	71'259	71'085	70'140	69'796	70'900	71'320	71'687
N-fixing crops	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	797	722	1'119	1'224	1'294	1'147	1'072	1'077
Crop residue	N from crop residues (t N/yr)	14'911	12'893	14'225	12'250	14'532	14'040	13'041	14'020
Organic soils	Area of cultivated organic soils (ha)	17'000	17'000	17'000	17'000	17'000	17'000	17'000	17'000
N-fixing meadows and pasture	Area of meadows and pasture (ha)	806'369	809'441	809'597	812'624	812'370	807'793	805'905	809'187
	N fixation meadows and pasture (t N/yr)	32'060	31'120	31'143	31'485	31'623	31'089	31'130	31'639
Residues meadows and pasture	Area of meadows and pasture (ha)	806'369	809'441	809'597	812'624	812'370	807'793	805'905	809'187
	N from residues meadows and pasture (t N/yr)	23'075	22'217	22'220	22'321	22'334	22'174	22'139	22'267
<b>Indirect emissions</b>									
Leaching and run-off	N excretion of all animals (t N/yr)	132'267	128'988	128'606	126'880	126'137	127'985	128'674	129'213
	Fertilizer (t N/yr)	60'100	64'200	62'800	58'400	57'800	56'600	55'500	57'900
Deposition	N from fertilizers and animal wastes that is lost through leaching and run off (t N/yr)	38'473	38'638	38'281	37'056	36'787	36'917	36'835	37'423
	Emissions NH <sub>3</sub> from fertilizers and animal wastes	48'129	47'328	47'194	46'379	46'217	46'897	47'005	47'261
	Emissions NO <sub>x</sub> from fertilizers and animal wastes	1'347	1'352	1'340	1'297	1'288	1'292	1'289	1'310
	Sum volatilized N (NH <sub>3</sub> and NO <sub>x</sub> ) from fertilizers, animal wastes and cropland (t N/yr)	49'476	48'680	48'534	47'676	47'505	48'189	48'294	48'571
<b>Animal production</b>									
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	17'515	16'695	16'525	16'274	15'988	15'980	16'081	16'137

The following table gives an overview on the different N amounts in 2007 that form the basis of N<sub>2</sub>O emissions in the CRF tables.

Table 6-18 Overview on the N amounts in the subcategories of Agricultural Soils that end up in N<sub>2</sub>O emissions. The N excretion is multiplied with the emission factors from Table 6-16 and the factor 44/28 for the conversion into N<sub>2</sub>O. The data for N excretion of synthetic fertilizers already considers losses to the atmosphere in form of ammonia and is therefore not identical with the data in Table 6-17.

Summary of N <sub>2</sub> O emissions from agricultural soils 2007	N excretion & emission (kg N a <sup>-1</sup> )	Emission factors	Emissions (t N)	Emissions (t N <sub>2</sub> O)	Emissions (Gg N <sub>2</sub> O)
<b>Direct emissions</b>	<b>191'354'966</b>		<b>2'528</b>	<b>3'972</b>	<b>3.97</b>
Synthetic fertilizers	50'666'000	0.0125	633	995	1.00
Animal wastes applied to soils	71'687'029	0.0125	896	1'408	1.41
N-fixing crops	32'715'571	0.0125	409	643	0.64
Fixation cropland	1'077'000	0.0125	13	21	0.02
Fixation meadows and pasture	31'639'000	0.0125	395	621	0.62
Crop residues	36'286'367	0.0125	454	713	0.71
Crop residues cropland	14'020'000	0.0125	175	275	0.28
Crop residues meadows and pasture	22'267'000	0.0125	278	437	0.44
Cultivation of histosol (ha)	17'000	8	136	214	0.21
<b>Animal Production (pasture range and paddock)</b>	<b>16'136'656</b>	<b>0.02</b>	<b>323</b>	<b>507</b>	<b>0.51</b>
<b>Indirect emissions</b>	<b>85'992'952</b>		<b>1'421</b>	<b>2'233</b>	<b>2.23</b>
Deposition	48'570'353	0.0100	486	763	0.76
Leaching and run-off	37'422'599	0.0250	936	1'470	1.47
<b>Other (fertilization with compost and sewage sludge)</b>	<b>3'760'000</b>	<b>0.0125</b>	<b>47</b>	<b>74</b>	<b>0.07</b>
<b>Total</b>	<b>297'244'574</b>		<b>4'319</b>	<b>6'787</b>	<b>6.79</b>

### 6.5.3. Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from ART was used (ART 2008a):

Table 6-19 Input data for the uncertainty analysis of the source category 4D "Agricultural Soils". (ART 2008a).

Input data for uncertainty analysis 4D	Lower bound (2.5 Percentile (Tier 2))	Upper bound (97.5 Percentile (Tier 2))	mean uncertainty (Tier 1)
Activity data 4D1 (fertilizer, kg N)	-12.4%	+10.3%	±11.3%
Activity data 4D1 (organic soils, hectares)	-29.4%	+29.4%	±29.4%
Activity data 4D2 (kg N)	-54.2%	+60.5%	±57.3%
Activity data 4D3 (deposition, kg N)	-34.6%	+48.3%	±41.4%
Activity data 4D3 (leaching and run-off, kg N)	-22.2%	+22.0%	±22.1%
Activity data 4D4 (sewage sludge and compost)	-8.1%	+8.1%	± 8.1%
Emission factor 4D1 (fertilizer, kg N <sub>2</sub> O-N / kg N)	-80%	+80%	±80%
Emission factor 4D1 (organic soils, kg N <sub>2</sub> O-N / kg N)	-75%	+87.5%	±81.3%
Emission factor 4D2 (kg N <sub>2</sub> O-N / kg N)	-75%	+50%	±62.5%
Emission factor 4D3 (deposition, kg N <sub>2</sub> O-N / kg N)	-80%	+100%	±90%
Emission factor 4D3 (leaching and run-off, kg N <sub>2</sub> O-N / kg N)	-92%	+380%	±236%
Emission factor 4D4 (sewage sludge and compost, kg N <sub>2</sub> O-N / kg N)	-80%	+80%	±80%

To apply for the Tier 1 uncertainty analysis, the arithmetic mean of lower and upper bound is used for activity data and for emission factors. To aggregate fertilizer and organic soils to a single category 4D1 and deposition, leaching and run-off to 4D3 (as required for input into Tier 1 analysis), the combined uncertainty of the emissions is determined by using Tier 1 error propagation for the sub-systems. For further results see Section 1.7.

The time series between 1990 and 2007 are consistent.

#### 6.5.4. Source-Specific QA/QC and Verification

An internal documentation of the Agroscope Reckenholz-Tänikon Research Station (ART) about the calculation of the greenhouse gas emissions in agriculture assures transparency and traceability of the calculation methods (Berthoud 2004).

All relevant data needed for the calculation of direct and indirect nitrogen inputs to agricultural soils (e.g.  $F_{SN}$ ,  $Frac_{GASF}$ ,  $N_{ex}$ ,  $Frac_{GASM}$ ,  $F_{BN}$ ,  $F_{CR}$ ) have been checked for consistency and confidence and have been compared (where possible) to IPCC default as well as literature values. N<sub>2</sub>O emission factors have been compared to literature values to assure plausibility. Furthermore cross checks with data provided in the "Synthesis and Assessment Report" were conducted where possible.

All QA/QC activities will be further described in a separate document that will be published this year. Therein eventual differences between national and (IPCC) standard values are being analysed and discussed.

Quality is assured by the same procedures as mentioned in chapter 6.2.4. A quality control was done by INFRAS by a countercheck of the calculation sheets.

### 6.5.5. Source-Specific Recalculations

A recalculation was carried out for the year 2005 and 2006 due to some data updates from the Swiss Farmers Union (SBV 2008).

### 6.5.6. Source-Specific Planned Improvements

There are no source-specific planned improvements.

## 6.6. Source Category 4E – Burning of savannas

Burning of savannas does not occur (NO) in Switzerland.

## 6.7. Source Category 4F – Field Burning of Agricultural Residues

### 6.7.1. Source Category Description

Source category 4F “Field Burning of Agricultural Residues” is **not a key category**. Emissions from this source occur from open burning of branches in agriculture and forestry. The source category includes CH<sub>4</sub>, N<sub>2</sub>O, NO<sub>x</sub>, CO and NMVOC emissions. Burning of other residues than branches is not occurring. Therefore, emissions from field burning of agricultural residues are of minor importance in Switzerland.

### 6.7.2. Methodological Issues

#### Methodology

The emissions are calculated by multiplying the annual estimate of branches burned (in Gg of wood equivalent) by emission factors (IPCC default method).

#### Emissions factors

The emission factors are taken from EMEP/CORINAIR (EEA 2007). See also EMIS 2005/4F.

Table 6-20 Emission factors for calculating emissions from burning of branches in agriculture and forestry (EEA 2007).

Emissions from burning of branches in agriculture and forestry	Emission factor kg/t dry matter
CH <sub>4</sub>	6.8
N <sub>2</sub> O	0.18
NO <sub>x</sub>	3.6
CO	104.0
NMVOC	9.5
SO <sub>2</sub>	0.7

## Activity data

Activity data is taken from the SFSO (2003).

Table 6-21 Activity data for calculating emissions from burning of branches in agriculture and forestry (EMIS 2009/4F). Estimations remained unchanged since 1990.

Amount of Residues burned	Activity data (in Gg dry matter)
Amount of branches burned in agriculture and forestry	70

### 6.7.3. Uncertainties and Time-Series Consistency

No uncertainty assessment has been carried out. Uncertainty is high (especially regarding activity data).

The time series are consistent.

### 6.7.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### 6.7.5. Source-Specific Recalculations

No recalculation has been carried out.

### 6.7.6. Source-Specific Planned Improvements

There are no planned improvements.



## 7. Land Use, Land-Use Change and Forestry

### 7.1. Overview

#### a) Methodology

This chapter includes information about the estimation of greenhouse gas emissions by sources and removals by sinks from land use, land-use change and forestry (LULUCF). Data acquisition and calculations are based on the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003) and are completed by country specific methodologies.

The land areas in the period 1990-2007 are represented by geographically explicit land-use data with a resolution of one hectare (following approach 3 for representing land areas; IPCC 2003). Direct and repeated assessment of land use with full spatial coverage also enables to calculate spatially explicit land-use change matrices. In 2004 the new Swiss land-use statistics has been launched (referred to as AREA). AREA operates with a newly designed set of land-use and land-cover categories (SFSO 2006a). Simultaneously, aerial photos from two earlier Swiss land-use statistics (1979/85 and 1992/97) are being re-evaluated according to the new approach. At the moment the interpretation of 35% of the Swiss territory is completed for all three time slices. A full coverage can be expected in 2013. To estimate the land use and land-use change for each year in the period 1990-2007, a spatial extrapolation based on the presently available AREA data in combination with both earlier land-use statistics had to be performed.

Country specific emission factors and carbon stock values for forests and partially for agricultural land and grassland are derived from surveys and measurements. For other land use categories, IPCC default values or expert estimates are used. Forest growth factors depend on climate conditions; their annual variation is therefore modelled against climatic parameters.

The six main land categories required by IPCC (2003) are: A. Forest Land, B. Cropland, C. Grassland, D. Wetlands, E. Settlements and F. Other Land. These categories were further divided in 18 sub-divisions of land use. A further spatial stratification reflects the criteria 'altitude' (3 zones), 'geomorphologic and climatic conditions' (adopting the five regions of the National Forest Inventory) and 'soil type' (mineral, organic).

#### b) CO<sub>2</sub> emissions

Table 7-1 and Figure 7-1 summarize the CO<sub>2</sub> emissions and removals in consequence of carbon losses and gains for the years 1990-2007. The total net emissions and removals of CO<sub>2</sub> from 1990 to 2007 vary between -5'518 Gg (1994) and 1'070 Gg (2006).

In Table 7-1 and Figure 7-2, four components of the CO<sub>2</sub> balance are differentiated:

- Increase of living biomass on forest land (three-year average): growth of biomass on forest land remaining forest land; it represents the largest sink of carbon.
- Decrease of living biomass on forest land (three-year average): decrease of carbon in living biomass (by harvest and mortality) on forest land remaining forest land; it represents the largest source of carbon.
- Net carbon stock changes in dead organic matter (DOM) on forest land remaining forest land (three-year average): it represents a small sink of carbon in most years.
- Land-use change and soil: balance of carbon emissions and removals due to land-use changes, due to the use of soils (especially of organic soils), and due to

agricultural lime application. In the period under investigation this accumulative component persistently represents a source of carbon.

In forests, growth of biomass and net changes in dead organic matter exceed the harvesting and mortality rate in most years. Compared to CO<sub>2</sub> fluxes involved in forest biomass dynamics, the net CO<sub>2</sub> emissions arising from all land-use changes, from the use of soils, and from agricultural lime application are relatively small (see Figure 7-2). As a result, the LULUCF sector was a sink of -1'557 Gg CO<sub>2</sub> on the average between 1990 and 2007. However, the forestal carbon sink seems to diminish since the mid-nineties.

Table 7-1 Switzerland's CO<sub>2</sub> emissions and removals (Gg) of source category 5 „Land Use, Land-Use Change and Forestry” 1990-2007. Positive values refer to emissions; negative values refer to removals. In this table, emissions of CH<sub>4</sub> and N<sub>2</sub>O are not included.

LULUCF	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Gg CO <sub>2</sub>									
Total Sector 5: LULUCF	-2'360	-1'676	-1'157	-3'222	-5'518	-5'306	-4'530	-2'515	-1'687	-1'380
Increase of living biomass in forest	-12'252	-11'770	-11'998	-12'205	-13'326	-13'840	-13'108	-12'457	-11'795	-12'833
Decrease of living biomass in forest	9'782	9'880	9'887	8'789	8'791	10'062	9'840	9'698	9'900	10'426
Net change in dead organic matter in forest	-838	-760	-27	-707	-1'854	-2'413	-2'160	-667	-729	105
Land-use change and soils	949	974	981	901	871	885	898	910	937	923

LULUCF	2000	2001	2002	2003	2004	2005	2006	2007	Mean 1990-2007
	Gg CO <sub>2</sub>								
Total Sector 5: LULUCF	745	212	375	-1'584	295	859	1'070	-655	-1'557
Increase of living biomass in forest	-12'644	-13'623	-13'190	-12'330	-11'497	-10'669	-11'993	-13'158	-12'483
Decrease of living biomass in forest	13'567	14'036	13'892	11'223	10'855	11'331	11'795	12'289	10'891
Net change in dead organic matter in forest	-1'148	-1'148	-1'289	-1'429	-32	-859	260	-726	-912
Land-use change and soils	970	948	962	953	968	1'056	1'008	940	946

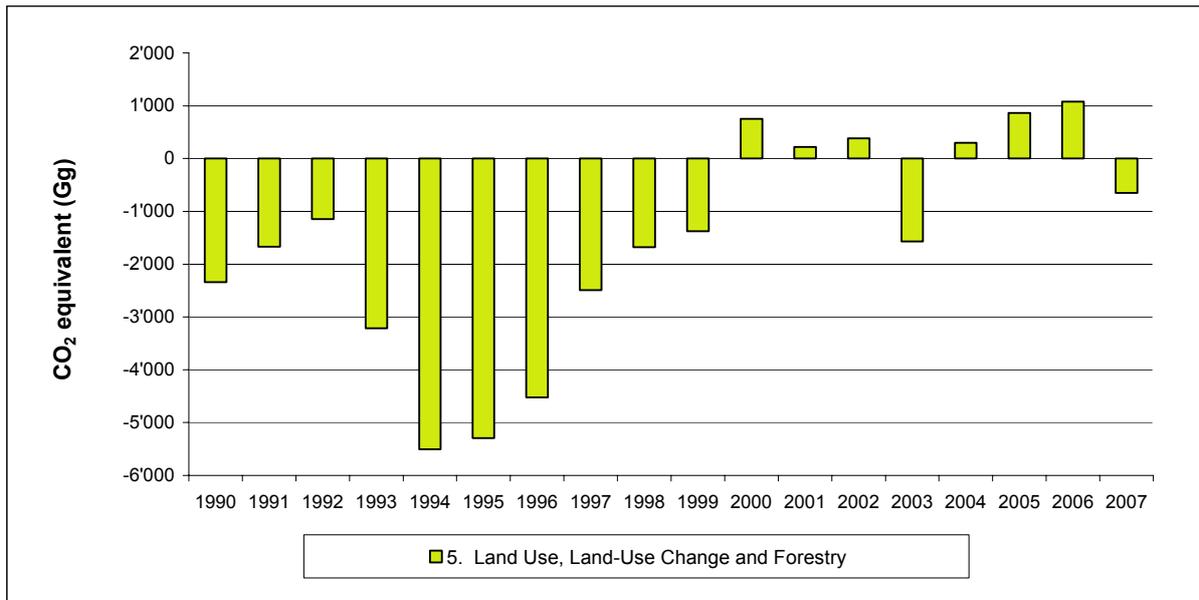


Figure 7-1 Switzerland's net CO<sub>2</sub> balance of source category 5 "Land Use, Land-Use Change and Forestry" 1990–2007 (in Gg CO<sub>2</sub> eq). Positive values refer to emissions, negative values refer to removals.

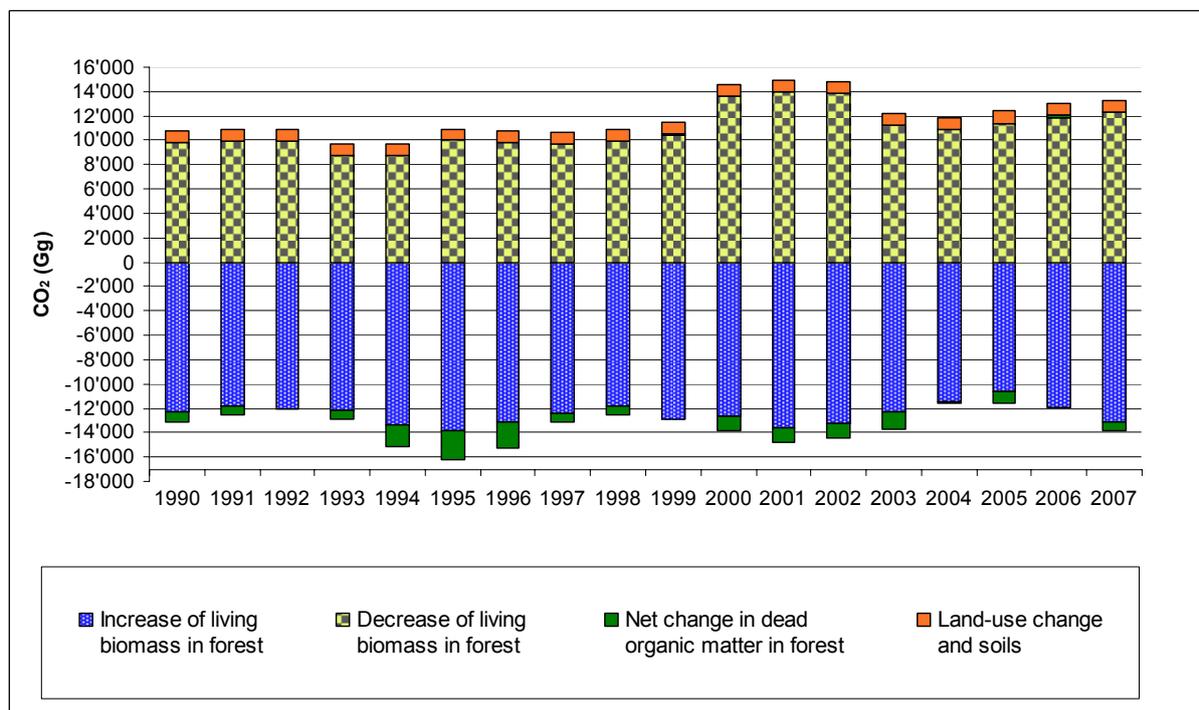


Figure 7-2 (i) CO<sub>2</sub> removals due to the increase (growth) of living biomass on forest land, (ii) CO<sub>2</sub> emissions due to the decrease (harvest and mortality) of living biomass on forest land, (iii) net CO<sub>2</sub> emissions and removals due to changes in dead organic matter on forest land, and (iv) net CO<sub>2</sub> emissions due to land-use changes, use of soils, and agricultural lime application, 1990–2007. Note that except for 1999 and 2006 net changes in dead organic matter are a sink of carbon.

### c) **Non-CO<sub>2</sub> emissions**

The non-CO<sub>2</sub> emissions associated with land use, land-use change and forestry are very small. Between 1990 and 2007 annual CH<sub>4</sub> emissions add up to less than 0.53 Gg, and N<sub>2</sub>O emissions equal at maximum 0.04 Gg. Those emissions arise from soil disturbance associated with land-conversion to cropland (N<sub>2</sub>O; CRF Table 5 III) and wildfires on forest land (CH<sub>4</sub> and N<sub>2</sub>O; CRF Table 5 V). The calculation methods are based on default procedures of IPCC (2003; chapter 3) and summarized in chapters 7.3 and 7.4, respectively.

The next chapter (7.2) gives an overview of the methodical approach including the calculation of the activity data (land-use data) and carbon emissions. The following chapters (7.3-7.8) describe the details of the CO<sub>2</sub> equivalent emission/removal calculations for each main land-use category.

## **7.2. Methodical Approach and Activity Data**

### **7.2.1. General Approach for Calculating Carbon Emissions and Removals**

#### **a) Work Steps**

The selected procedure for calculating carbon emissions and removals in the LULUCF sector corresponds to a Tier 2 approach as described in IPCC (2003; chapter 3). It can be summarised as follows:

- Define land use categories and sub-divisions with respect to available land-use data (see Table 7-2). For the present study, so-called combination categories (CC) were defined on the basis of the AREA land-use and land-cover categories (FOEN 2007f; SFSO 2006a).
- Define criteria and collect data for the spatial stratification of the land-use categories.
- Measure or estimate the carbon stocks and carbon stock changes for each spatial stratum of the land-use categories.
- Calculate the land use and the land-use change matrix in each spatial stratum.
- Calculate the carbon stock changes in living biomass ( $\Delta C_l$ ), in dead organic matter ( $\Delta C_d$ ) and in soil ( $\Delta C_s$ ) for all cells of the land-use change matrix.
- Finally, aggregate the results by summarising the carbon stock changes over land-use categories and strata according to the level of disaggregation displayed in the CRF tables.

Table 7-2 Land-use categories used in this report (so-called combination categories CC): 6 main land-use categories and the 18 sub-divisions. Additionally, descriptive remarks, abbreviations used in the CRF tables, and CC codes are given. For a detailed definition of the CC categories see FOEN (2007f) and SFSO (2006a).

CC Main category	CC Sub-division	Remarks	Terminology in CRF tables	CC code
A. Forest Land	Afforestations	areas converted to forest by active measures, e.g. planting	afforestation	11
	Productive Forest	dense and open forest meeting the criteria of forest land	productive	12
	Unproductive Forest	brush forest and forest on unproductive areas meeting the criteria of forest land	unproductive	13
B. Cropland		arable and tillage land (annual crops and leys in arable rotations)		21
C. Grassland	Permanent Grassland	meadows, pastures (low-land and alpine)	permanent	31
	Shrub Vegetation	agricultural and unproductive areas predominantly covered by shrubs	woody, shrub	32
	Vineyards, Low-Stem Orchards, Tree Nurseries	perennial agricultural plants with woody biomass (no trees)	woody, vine	33
	Copse	agricultural and unproductive areas covered by perennial woody biomass including trees	woody, copse	34
	Orchards	permanent grassland with fruit trees	woody, orchard	35
	Stony Grassland	grass, herbs and shrubs on stony surfaces	unproductive, stony	36
	Unproductive Grassland	unmanaged grass vegetation	unproductive	37
D. Wetlands	Surface Waters	lakes and rivers	surface	41
	Unproductive Wetland	reed, unmanaged wetland	unproductive	42
E. Settlements	Buildings and Constructions	areas without vegetation such as houses, roads, construction sites, dumps	building	51
	Herbaceous Biomass in Settlements	areas with low vegetation, e.g. lawns	herb	52
	Shrubs in Settlements	areas with perennial woody biomass (no trees)	shrub	53
	Trees in Settlements	areas with perennial woody biomass including trees	tree	54
F. Other Land		areas without soil and vegetation: rocks, sand, screes, glaciers		61

## b) Calculating Carbon Stock Changes

For calculating carbon stock changes, the following input parameters (mean values per hectare) must be quantified for all land-use categories (CC) and spatial strata (i):

$stockC_{l,i,CC}$	carbon stock in living biomass
$stockC_{d,i,CC}$	carbon stock in dead organic matter
$stockC_{s,i,CC}$	carbon stock in soil
$increaseC_{l,i,CC}$	annual increase (growth) of carbon in living biomass
$decreaseC_{l,i,CC}$	annual decrease (harvesting and mortality) of carbon in living biomass
$changeC_{d,i,CC}$	annual net carbon stock change in dead organic matter
$changeC_{s,i,CC}$	annual net carbon stock change in soil

On this basis, the carbon stock changes in living biomass ( $\Delta C_l$ ), in dead organic matter ( $\Delta C_d$ ) and in soil ( $\Delta C_s$ ) are calculated for all cells of the land-use change matrix. Each cell is characterized by a land-use category before the conversion (b), a land-use category after the conversion (a), and the area of converted land within the spatial stratum (i). Equations 7.2.1.-7.2.3 show the general approach of calculating C emissions and removals

taking into account the net carbon stock changes in living biomass, dead organic matter and soils as well as the stock changes due to conversion of land use (difference of the stocks before and after the conversion):

$$\Delta C_{l,i,ba} = [ \text{increase}C_{l,i,a} - \text{decrease}C_{l,i,a} + W_l * (\text{stock}C_{l,i,a} - \text{stock}C_{l,i,b} ) ] * A_{i,ba} \quad (7.2.1)$$

$$\Delta C_{d,i,ba} = [ \text{change}C_{d,i,a} + W_d * (\text{stock}C_{d,i,a} - \text{stock}C_{d,i,b} ) ] * A_{i,ba} \quad (7.2.2)$$

$$\Delta C_{s,i,ba} = [ \text{change}C_{s,i,a} + W_s * (\text{stock}C_{s,i,a} - \text{stock}C_{s,i,b} ) ] * A_{i,ba} \quad (7.2.3)$$

where:

- a: land-use category after conversion (CC = a)
- b: land-use category before conversion (CC = b)
- ba: land use conversion from b to a
- i: spatial stratum
- $A_{i,ba}$ : area of land converted from b to a in the spatial stratum i (activity data from the land-use change matrix)
- $W_l, W_d, W_s$ : weighting factors for living biomass, dead organic matter and soil, respectively.

The following values for W were chosen:

$W_l = W_d = W_s = 0$  if land use after the conversion is 'Forest Land' (a = 11, 12, or 13)

$W_s = 0.5$  if a or b is 'Buildings and Constructions' (a = 51 or b = 51)

$W_l = W_d = W_s = 1$  otherwise.

The difference of the stocks before and after the conversion are weighted with a factor ( $W_l, W_d, W_s$ ) accounting for the effectiveness of the land-use change in some special cases. For example, the succession from grassland to forest land is quite frequent in mountainous regions in Switzerland. Immediately after the conversion young forests have lower carbon stocks than the mean carbon stock values determined for 'productive forest'. Therefore, the weighting factors for the conversion 'to forest land' was set to zero in order to avoid an overestimation of C-sinks (see also Chapter 7.3.2.1). In the case of land-use changes involving 'buildings and constructions' it is assumed that only 50% of the soil carbon is emitted as the humus layer is re-used on construction sites (see also Chapter 7.7.2b).

For all land-use categories applies: If a equals b, there is no change in land use and the difference in carbon stocks becomes zero.

### c) Displaying Results in the Common Reporting Format (CRF)

In the CRF tables 5A to 5F, a part of the land-use categories (CC) and associated spatial strata are shown at an aggregated level for optimal documentation and overview. The values of  $\Delta C$  are accordingly summarised. Positive values of  $\Delta C_{l,i,ba}$  are inserted in the column "Gains" and negative values in the column "Losses", respectively (besides  $\text{increase}C_{l,i,CC}$  and  $\text{decrease}C_{l,i,CC}$  if land use does not change).

The CRF tables 5A to 5F are subdivided in two parts: (1) X Land remaining X Land and (2) Land converted to X Land. Land-use changes taking place between the six main land-use categories are reported in the second part.

Unchanged areas as well as the land-use changes occurring among the sub-categories belonging to the same main land-use category are reported in the first part. For example, the area of 'shrub vegetation' (CC32) converted to 'permanent grassland' (CC31) is reported in CRF 5C1 in the sub-division 'permanent' in the respective altitude zone. As CC31 and CC32 do have different carbon stocks in soil and biomass, a carbon stock change is calculated according to the equations presented in Chapter 7.2.1b.

#### d) Considering the Conversion Delay Time

Changes in the soil carbon stock – this is also true for the increase of woody biomass – as a result of land-use changes are slow processes that might take decades. Therefore, IPCC (2003) suggests to implement a conversion time (T). Following the IPCC default value (T = 20 years), the carbon emission or removal due to a soil carbon stock difference (stock $C_{s,i,a}$  – stock $C_{s,i,b}$ ) does not occur in one year but is distributed evenly over the 20 years following the land-use conversion.

In this report, a conversion time of 20 years has been applied to soil carbon stock changes in the case of land converted to forest land, land converted to cropland, land converted to grassland and land converted to unproductive wetland. Accordingly, the CRF tables 5A2, 5B2, 5C2, and 5D2 now contain the cumulative area remaining in the respective category in the reporting year.

In addition, the default conversion time of 20 years has been assumed for carbon stock changes in biomass (living and dead) for land converted to forest land.

The land-use category CC11 (afforestations) is inherently a transitional category by definition in the land-use survey. Areas converted to afforestations are reported in the CRF Table 5A2 with the same conversion time as for other forest sub-categories (20 years). However, afforestations remaining afforestations (according to the land-use survey) are reported in CRF Table 5A1 and are merged with sub-category CC12 (productive forest).

Table 7-3 summarises the conversion times applied to carbon stock changes in living biomass, in dead organic matter, and in soils for all types of land-use transitions.

Table 7-3 Conversion time periods applied for different land-use transitions and carbon pools.

Land-Use Categories	Conversion time T [years]		
	living biomass	dead organic matter	soil
5A2. Land converted to Forest Land (including afforestations)	20	20	20
5B2. Land converted to Cropland	1	1	20
5C2. Land converted to Grassland	1	1	20
5D2. Land converted to Wetlands	1	1	20
5D2. Land converted to surface water	1	1	1
5E2. Land converted to Settlements	1	1	1
5F2. Land converted to Other Land	1	1	1

There is no consistent data on land-use changes before 1990, but it is well known (ARE/SAEFL 2001, FOEN 2009b) that the main trends of the Swiss land-use dynamics (e.g. increase of forests and settlements) did arise before 1970. Therefore, it was assumed that between 1971 and 1989 the annual rate of all land-use changes was the same as in 1990.

## 7.2.2. General Approach for Compiling Land-use Data

### a) Swiss Land Use Statistics (AREA)

Data of the Swiss Land Use Statistics (AREA) evaluated by the Swiss Federal Statistical Office (SFSO 2008) are the basis of activity data. In the course of the AREA survey, every hectare of Switzerland's territory (4'128 kha) will be assigned to one of 46 land-use categories and to one of 27 land-cover categories by means of stereographic interpretation of aerial photos (SFSO 2006a).

For the reconstruction of the land use conditions in Switzerland during the period 1990-2007 three data sets are used:

- Land Use Statistics “1979/85” (AREA1)
- Land Use Statistics “1992/97” (AREA2)
- Land Use Statistics “2004/09” (AREA3) (launched in 2004, ongoing)

The aerial photos for AREA1 and AREA2 were actually taken 1977-1986 and 1990-1998, respectively, in the course of two earlier Swiss land-use statistics (ASCH1 and ASCH2). They are now simultaneously being re-evaluated according to the newly designed AREA set of land-use and land-cover categories (SFSO 2006a). Presently, coherently interpreted data of 35% of the Swiss territory are available for all three time slices (AREA1-AREA2-AREA3; SFSO 2008). In the previous submission (FOEN 2008), coverage has been still restricted to 23%.

AREA3 was launched in 2004 and it is expected to be completed in 2013. As a direct consequence, the inter-survey period is (as it was in former surveys) not the same throughout the Swiss territory, but varies regionally. It averages approximately 12 years. This methodical characteristic needs to be considered when reconstructing the annual country-wide ‘status’ or when calculating annual rates of land-use change.

#### **b) Combination Categories (CC) as derived from AREA Land Use Statistics**

The 46 land-use categories and 27 land-cover categories of AREA were aggregated to 18 combination categories (CC; FOEN 2007f), thus implementing the main categories proposed by IPCC as well as country specific sub-divisions (see Table 7-2). The sub-divisions were defined with respect to optimal distinction of biomass densities, carbon turnover, and soil carbon contents.

The first digit of the CC-code represents the main category, whereas the second digit stands for the respective sub-division.

#### **c) Interpolation of the Status for each Year**

The exact dates of aerial photo shootings are known for each hectare. However, the exact occurrence date (year) of a land-use change on a specific hectare is unknown. The actual change can have taken place in any year between two AREA surveys. In this study, it is assumed that the probability of a land-use change from AREA1 to AREA2 and from AREA2 to AREA3 is uniformly distributed over the respective interim period between two surveys. Therefore, the land-use change of each hectare has to be equally distributed over its specific interim period.

Thus, the land-use status for the years between two data collection dates can be calculated by linear interpolation. Dates of aerial photo shootings (i.e. starting and ending year of the inter-survey period) and the land-use categories of AREA1, AREA2 and AREA3 for every hectare are used for these calculations. An example is shown in Figure 7-3: A hectare has been assigned to the land-use category “cropland” in AREA1 (aerial photo in 1980). A land-use change to “surrounding of buildings” has been discovered 10 years later (1990) in AREA2.

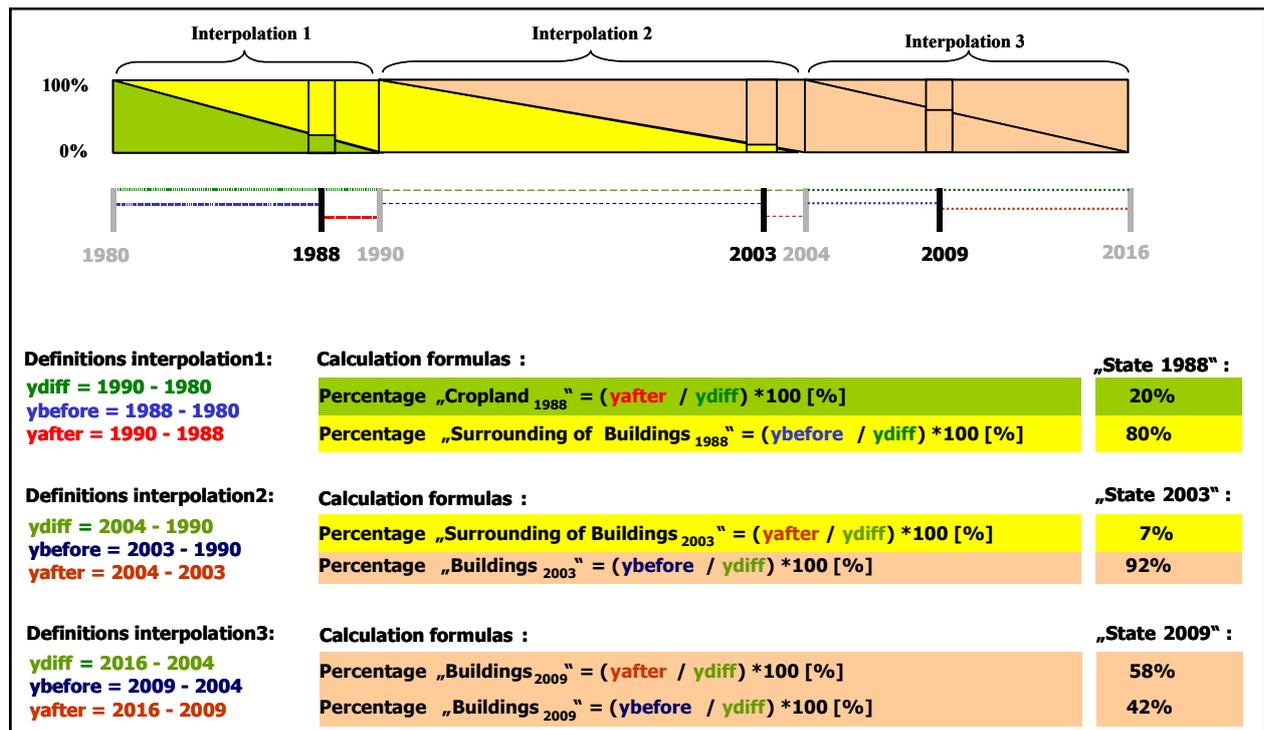


Figure 7-3 Hypothetical linear development of land-use changes between AREA1, AREA2 and AREA3 considering as example a hectare changing from “cropland” to “surrounding of buildings” and then from “surrounding of buildings” to “buildings”. For 2009, a linear interpolation has been carried out between AREA3 and a virtual fourth survey modelled for 2016.

The “status 1988” of that hectare is determined by calculating the fractions of the two land-use categories for the year 1988. A linear development from “cropland” to “surrounding of buildings” during the whole interim period is assumed. Thus, in 1988 the hectare is split up in two fractions: 80% is “surrounding of buildings” and 20% is “cropland”. The same procedure can be applied for two survey dates between AREA2 and AREA3 (here shown for the period 1990-2004, highlighting “status 2003”).

At present, AREA3 comprehends aerial photos from three years (2004-2006). More recent photos have not been interpreted yet. Therefore, the land-use changes occurring after AREA3 are calculated from the linear development detected between AREA3 and a virtual fourth survey, AREA4 (see Figure 7-3: example “status 2009”). AREA4 was modelled by randomly assigning a land-use type to each hectare, thereby maintaining the same transition probabilities as observed between AREA2 and AREA3 within each spatial stratum (Sigmaphan 2008).

The status for each individual year in the period 1990-2007 for the whole Swiss territory results from the summation of the fractions of all hectares per CC, additionally considering the spatial strata where appropriate. Results are subsumed in Table 7-5 and in Table 7-6.

### 7.2.3. Spatial Stratification

In order to quantify carbon stocks and GHG emissions by sources and removals by sinks in the LULUCF sector as accurately as possible, a further spatial stratification of Switzerland’s territory turned out to be useful.

For Forest Land, three different altitudinal belts and the five production regions of the National Forest Inventory (NFI; EAFV/BFL 1988; Brassel and Brändli 1999) were differentiated. Altitude data are available on a hectare-grid from the Swiss Federal Statistical Office (SFSO 1997). They were classified in belts <600 m a.s.l. (meters above sea level),

601-1200 m a.s.l., and >1200 m a.s.l. (Figure 7-4). The five NFI regions were adopted from EAFV/BFL (1988):

1. Jura
2. Central Plateau
3. Pre-Alps
4. Alps
5. Southern Alps.

For Cropland and Grassland under cultivation, it was a purposive approach to differentiate two soil types (organic and mineral soils) and also the above-mentioned altitudinal zones. For mapping the occurrence of organic soils, two appropriate categories of the digital soil map "BEK" (SFSO 2000a) were selected, as shown in Figure 7-4. The codes F1 and Q3 represent organic soils (Histosols) in the Central Plateau and in Alpine valleys, respectively.

The digital map does not allow to reliably distinguish organic and mineral soils under forest land.

Applying all spatial stratifications, 30 different strata (referred to as subscript *i* in Chapter 7.2.1.b) would be theoretically possible. Not all of them, but altogether 20 have been defined and used for the calculation of LULUCF-associated C emissions and removals.

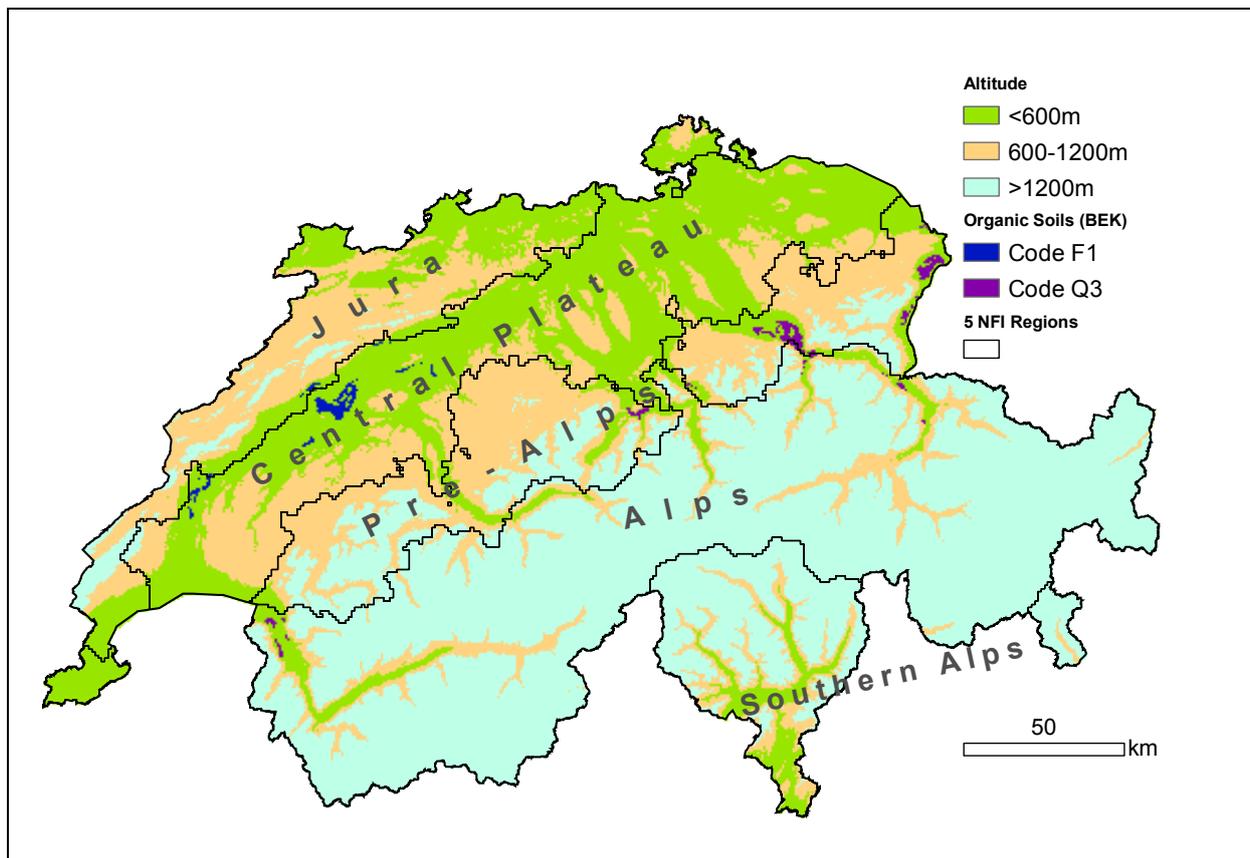


Figure 7-4 Map showing the spatial stratification according to NFI region, altitude, and soil type.

#### 7.2.4. Spatial Extrapolation of Land-Use Statistics

The land-use survey AREA3 has been launched in 2004. Presently, a sample region covering 35% of the Swiss territory has been evaluated (see Figure 7-5). In the same sample region, the old aerial photographs of two prior land-use statistics (ASCH1 and ASCH2) have

been simultaneously re-analysed using the new interpretation categories, thus providing additional datasets for AREA1 and AREA2. For the rest of the Swiss territory data availability is currently restricted to the LUcode classification (SFSO 2005), i.e. a land-use classification that has been developed on the basis of ASCH1 and ASCH2 data (Table 7-4; see FOEN 2006b for details).

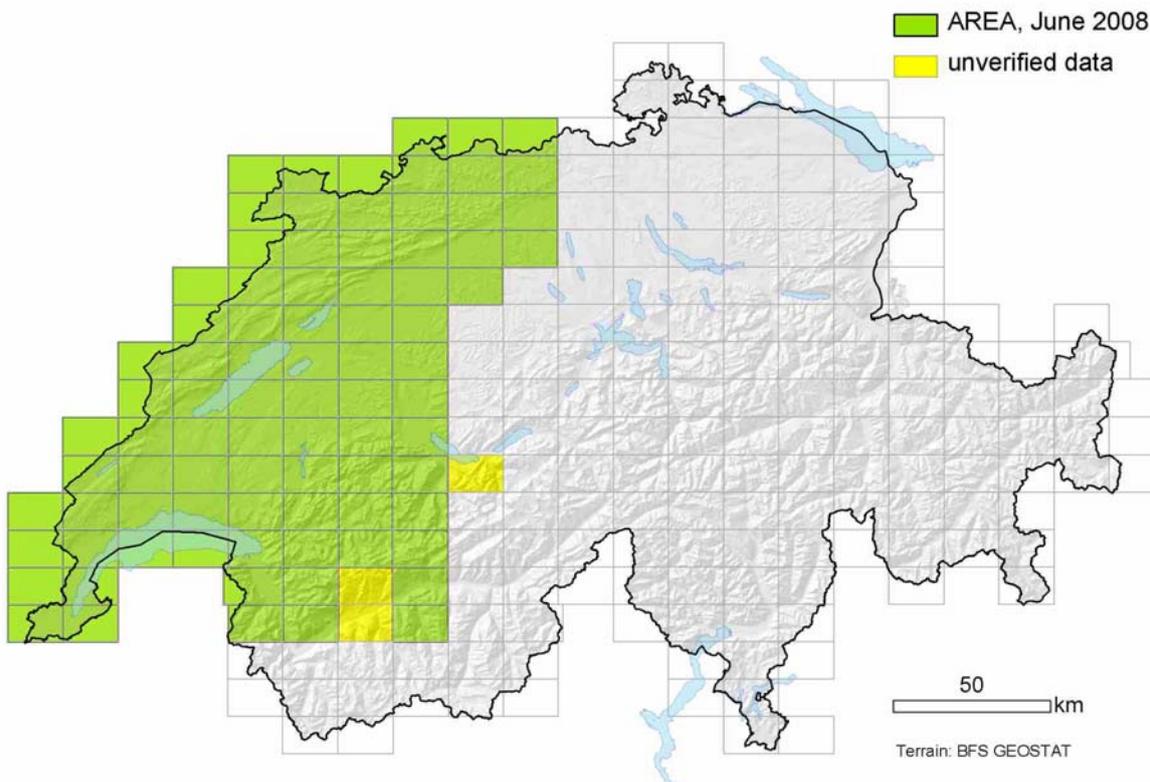


Figure 7-5 Map showing the regions that have already been evaluated in the land-use survey AREA3 (as of June 2008), including some unverified (provisional) data..

A spatial extrapolation of the AREA-derived CC data in the sample region (35%) to the total Swiss territory has been carried out, using ASCH2 as a reference basis. First, the CC data in the sample region ( $AREA_{\text{samp}}$ ) were interpolated in time for each year (see Figure 7-3), and then the spatial extrapolation of the respective land-use categories was calculated. In the same way the land-use changes detected in the sample region were extrapolated.

The LUcode classification included the 6 main categories and 13 sub-divisions (LUcode), which are an aggregation of the 74 ASCH-codes (FOEN 2006b). The CC classification is built of 6 main categories and 18 sub-divisions (Table 7-4). A direct correspondence of all LUcode and CC sub-divisions is not given. Therefore, an auxiliary categorisation, called 'excat' (extrapolation category) is introduced. Excat includes 11 sub-divisions. Each LUcode category and CC, respectively, can be definitely assigned to one excat code. The relation between LUcodes categories, CC and 'excat' is shown in Table 7-4.

Table 7-4 Relation between different land-use categorisations: IPCC main categories (IPCC 2003), LUcode sub-divisions, LUcode (aggregated ASCH code; FOEN 2006b), ASCH code and description (SFSO 2005), Excat code (extrapolation category; this report), combination category (CC), and CC code (FOEN 2007f).

Main Category	LUcode Sub-division	LUcode	ASCH-code	ASCH-description	Excat code	Combination Category (CC)	CC code		
Forest Land	Afforestations	11	9	Afforestations	11	Afforestations	11		
	Productive Forest		10	Damaged forest areas	12	Productive Forest	12		
			11	Normal dense forest	12				
			13	Open forest (on agricultural areas)	12				
			14	Forest stripes, edges	12				
	Unproductive Forest	13	12	Forest on unproductive areas	13	Unproductive Forest	13		
15			Brush forest	13					
Cropland		20	52	Garden allotments	21				
			71	Regular vineyards	30				
			72	"Pergola" vineyards	30				
			73	Extensive vines	30				
			78	Horticulture	21				
			81	Favourable arable land and meadows	21				
				21	Cropland	21			
Grassland	Permanent Grassland	31	32	Green motorway environs	31	Permanent Grassland	31		
			38	Airfields, green airport environs	31				
			54	Golf courses	50				
			67	Green railway environs	31				
			68	Green road environs	31				
			82	Other arable land and meadows	31				
			83	Farm pastures	31				
			85	Mountain meadows	31				
			87	Remote and steep alpine	31				
			88	Favourable alpine pastures	31				
			89	Rocky alpine pastures	31				
			Grass with Perennial Woody Biomass	32	16			Scrub vegetation	30
	17	Groves, hedges			30				
	18	Clusters of trees (on agricultural areas)			30				
	19	Other woods			30				
	75	Intensive orchards			30				
	76	Rows of fruit trees			30				
	77	Scattered fruit trees			30				
	84	Brush meadows and farm pastures			30				
	86	Brush alpine pastures			30				
					30				
	Unproductive Grassland	33	97	Unproductive grass and shrubs	30	Vineyards, Low-Stem Orchards, Tree nurseries	33		
					30			Copse	34
					30			Orchards	35
30					Stony Grassland			36	
30					Unproductive Grassland			37	
Wetlands	Surface Waters	41	91	Lakes	41	Surface Waters	41		
			92	Rivers	41				
	Unproductive Wetland	42	95	Wetlands	42	Unproductive Wetland	42		
				96	Water shore vegetation	42			
Settlements	Buildings/Constructions	51	20	Ruins	51	Buildings and Constructions	51		
			21	Industrial buildings	51				
			23	Buildings in recreational areas	51				
			24	Buildings in special urban areas	51				
			25	One- and two-family houses	51				
			26	Terraced houses	51				
			27	Blocks of flats	51				
			28	Agricultural buildings	51				
			29	Unspecified buildings	51				
			31	Motorways	51				
			33	Roads and paths	51				
			34	Parking areas	51				
			35	Railway station grounds	51				
			36	Railway lines	51				
			37	Airports	51				
			51	Sport grounds	51				
			53	Camping, caravan sites	51				
			61	Other supply or waste treatment plants	51				
			62	Energy supply plants	51				
			63	Waste water treatment plants	51				
	64	Quarries, mines	51						
	65	Dumps	51						
	66	Construction sites	51						
	Surrounding of Buildings	52	41	Industrial grounds	50	Herbaceous Biomass in Settlement	52		
			45	Surroundings of one- and two-family	50				
			46	Surroundings of terraced houses	50				
			47	Surroundings of blocks of flats	50				
			48	Surroundings of agricultural buildings	50				
	Parks	53	56	Cemeteries	50	Shrubs in Settlements	53		
			59	Public parks	50				
				50	Trees in Settlements	54			
Other Land		60	69	River shores	61				
			90	Glaciers, perpetual snow	61				
			93	Flood protection structures	61				
			98	Avalanche protection structures	61				
			99	Rocks, sand, screens	61				
				61	Other Land	61			

In this extrapolation approach the whole Swiss territory is divided into three main sub-regions (see Figure 7-6):

- Sample region (samp): CC data are available on hectare-basis for AREA1, AREA2 and AREA3. Coverage: 35% of Swiss territory.
- Extrapolation region (extrapol): Land use can be quantified by extrapolating CC data in the sample region using excat. Coverage: 91% of Swiss territory (including the sample region).
- Substitution region (subst): This is the remaining area for which no or too little CC data in the sample region are available. Extrapolation of CC data is impossible and land-use data from the ASCH1 and ASCH2 surveys (LUcode categories) is used instead. Coverage: 9% of Swiss territory. Changes in land-use after the ASCH2 survey are neglected in the substitution region.

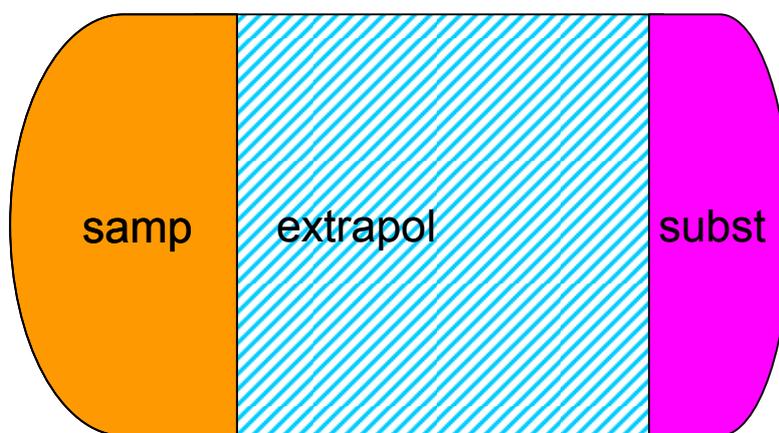


Figure 7-6 Scheme showing the three sub-regions of Switzerland used for the extrapolation: sampling region of AREA (samp), extrapolation region (extrapol, diagonal shading) and substitution region (subst).

As the spatial stratification is needed for the computation of CO<sub>2</sub> equivalent emissions/removals the land use and land-use changes must be quantified for each stratum. The basic idea is to extrapolate the CC data of a certain stratum by applying a stratum-specific area expansion factor (AEF). As CC datasets are not available in ASCH2, excat is used instead. The AEF for a certain excat in stratum  $i(z, nfi, soil)$  can be formulated as:

$$AEF(excat, i) = ASCH2_{extrapol}(excat, i) / ASCH2_{samp}(excat, i) \quad (7.2.4)$$

where:

$ASCH2_{extrapol}(excat, i)$ : Number of hectares in the ASCH2 dataset covered by land-use type excat situated in stratum  $i$  for the whole extrapolation region

$ASCH2_{sample}(excat, i)$ : Number of hectares in the ASCH2 dataset covered by land-use type excat situated in stratum  $i$  in the sample region

$i$ : Spatial strata defined by a combination of  $z$  (altitude zone),  $nfi$  (NFI region) and soil (organic, mineral);  $i = i(z, nfi, soil)$ .

To avoid arbitrary results caused by very small and unrepresentative areas in the sample region, a 'decision cascade' is introduced (see Figure 7-7). The idea is to apply a less differentiated AEF if the size of the sub-sample does not reach a specific threshold ( $T$ ). The threshold of the most differentiated case (level A in Figure 7-7) is calculated as follows:

$$T(excat, i) = 10\% * ASCH2_{extrapol}(excat, i) \quad (7.2.5)$$

In FOEN (2006), thresholds were empirically tested and it was decided to successively adjust the calculation of thresholds in later submissions to match approximately the half of the

relative size of the sample region. Now, as the sample region is larger than 20% the thresholds are calculated with a factor of 10%.

description	threshold	availability	number of categories
level A: excat, i	T (excat,i)	74%	208 (max. 330)
level B1: excat	T (excat)	75%	20 (max. 30)
level B2: i	T (i)	100%	11
level C: main category	T (main category)	100%	6
level D: general	-	100%	1

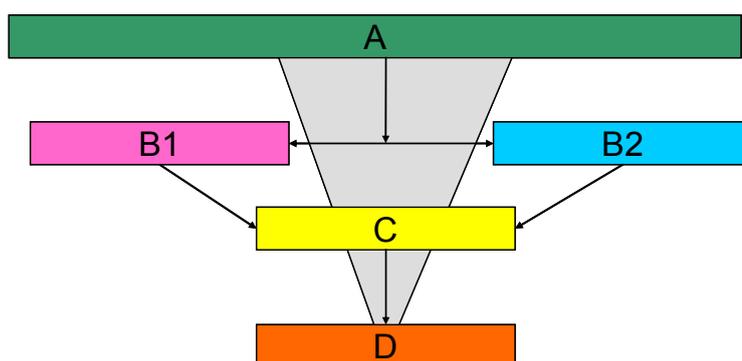


Figure 7-7 Extrapolation cascade for calculating area expansion factors (AEF) at different levels of differentiation.

If the size of the sub-sample  $AREA_{samp}(excat(CC),i,yr)$  is greater than the threshold  $T(excat,i)$ , then the extrapolated area  $AREA_{extrapol}(CC,i,yr)$  is calculated by the most differentiated AEF (see Equation 7.2.4). This corresponds to level A in Figure 7-7. With these AEF-values, the extrapolated area of the combination category CC in the stratum i in the year yr is calculated as follows:

$$AREA_{extrapol}(CC,i,yr) = AEF(excat(CC),i) * AREA_{samp}(CC,i,yr) \quad (7.2.6)$$

where:

$AREA_{samp}(CC,i,yr)$ : Number of all hectares in the AREA data sample (interpolated to the year yr) covered by land-use type CC situated in stratum i.

$excat(CC)$ : Stands for the excat to which the respective CC is assigned (see Table 7-4).

If the threshold is not reached at level A, then the threshold values of level B1 ( $T(excat)$ ) and B2 ( $T(i)$ ) are calculated (with an appropriately simplified version of Equation 7.2.5) and compared. The AEF of the level with the higher value for T is calculated (only if threshold is exceeded):

$$AEF(excat) = ASCH2_{extrapol}(excat) / ASCH2_{samp}(excat) \quad (7.2.7a)$$

$$AEF(i) = ASCH2_{extrapol}(i) / ASCH2_{samp}(i) \quad (7.2.7b)$$

where:

$ASCH2_{extrapol}(excat)$ : Number of all hectares in the ASCH2 dataset covered by land-use type excat within the extrapolation region, regardless of the stratum i.

$ASCH2_{samp}(excat)$ : Number of all hectares in the ASCH2 dataset covered by land-use type excat within the sample region, regardless of the stratum i.

$ASCH2_{extrapol}(i)$ : Number of all hectares in the ASCH2 dataset lying in the spatial stratum  $i$  within the extrapolation region, regardless of the land-use category.

$ASCH2_{samp}(i)$ : Number of all hectares in the ASCH2 dataset lying in the spatial stratum  $i$  within sample region, regardless of the land-use category.

If the size of the sub-sample size does not reach the thresholds  $T(excat)$  and  $T(i)$ , the threshold of the main category  $T(maincat)$  is evaluated and the  $AEF(maincat)$  is used (level C in Figure 7-7). 'Maincat' denotes the main land-use category according to Table 7-4:

$$AEF(maincat) = ASCH2_{extrapol}(maincat) / ASCH2_{samp}(maincat) \quad (7.2.8)$$

If also  $T(maincat)$  is not reached by the size of the generalised sub-sample, then the most general area expansion factor  $AEF(general)$  is used (level D in Figure 7-7), which is the ratio of the extrapolation region to the sample region:

$$AEF(general) = ASCH2_{extrapol} / ASCH2_{samp} \quad (7.2.9)$$

By applying area expansion factors of different accuracy levels, slight discrepancies in the total area result. Therefore, a calibration factor  $F$  is calculated *a posteriori* to adjust the sum of the calculated areas to the real total area of the extrapolation region:

$$F(yr) = ASCH2_{extrapol} / [ \sum AREA_{extrapol}(CC,i,yr) ] \quad (7.2.10)$$

With the presently available sample data, the values of  $F(yr)$  lie between 1.093 and 1.095.

In the substitution region only ASCH data are available (i.e.  $AREA_{samp}(CC,i,yr) = 0$ ). ASCH2 data are chosen as a surrogate for AREA. They are converted by means of the *excat* classification to the CC by the function 'part', which corresponds to the fraction of CC in *excat*:

$$AREA_{subst}(CC,i,yr) = ASCH2_{subst}(excat(CC),i) * part(CC,yr) \quad (7.2.11)$$

$$part(CC,yr) = AREA_{samp}(CC,yr) / AREA_{samp}(excat(CC),yr) \quad (7.2.12)$$

where:

$ASCH2_{subst}(excat(CC),i)$ : Number of all hectares in the ASCH dataset covered by land-use *excat* and situated in stratum  $i$  in the substitution region.

$AREA_{samp}(CC,yr)$ : Number of all hectares in the AREA dataset covered by land-use CC.

$AREA_{samp}(excat(CC),yr)$ : Number of all hectares in the AREA dataset covered by land-use *excat*.

The total stratified area of the CC in Switzerland is the sum of the calibrated area in the extrapolation region and of the area in the substitution region:

$$AREA_{Switzerland}(CC,i,yr) = F(yr) * AREA_{extrapol}(CC,i,yr) + AREA_{subst}(CC,i,yr) \quad (7.2.13)$$

As the size of the sample region will increase continuously during the next years, the results of this extrapolation approach will successively become more precise.

## 7.2.5. The Land-use Tables and Change Matrices

In Table 7-5 the land-use statistics resulting from interpolation in time (Chapter 7.2.2.c), spatial stratification (Chapter 7.2.3) and spatial extrapolation (Chapter 7.2.4) are exemplarily shown for the year 1990. This table gives also an overview of the size of the individual spatial strata.

Table 7-5 Land use (CC) by the end of 1990, stratified separately for altitude (3 zones), soil type (mineral or organic) and NFI-region (1-5), in kha.

CC:	11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	Sum
<b>Altitude</b>																			
<600	1.1	224.6	0.8	346.5	114.8	2.4	26.3	36.2	0.7	1.1	3.3	144.4	4.7	122.8	50.0	2.6	20.8	1.8	1104.9
601-1200	1.4	520.5	10.8	155.1	376.2	5.6	9.1	40.8	0.3	2.1	2.3	11.4	3.8	50.6	18.5	1.1	5.6	8.2	1223.4
>1200	1.2	379.9	98.2	0.2	464.6	95.9	11.9	55.8	0.1	122.9	77.2	6.3	21.4	12.7	3.3	0.2	1.3	447.1	1800.1
	3.8	1125.0	109.7	501.8	955.7	103.9	47.3	132.7	1.1	126.0	82.8	162.1	29.9	186.1	71.8	3.8	27.7	457.0	4128.4
<b>Soil</b>																			
mineral	3.8	1123.9	109.7	485.9	954.0	103.8	47.2	132.4	1.1	126.0	82.6	161.6	29.6	184.4	71.1	3.8	27.5	456.9	4105.2
organic	0.0	1.1	0.0	15.9	1.7	0.1	0.1	0.3	0.0	0.1	0.2	0.5	0.3	1.7	0.7	0.1	0.2	0.1	23.1
	3.8	1125.0	109.7	501.8	955.7	103.9	47.3	132.7	1.1	126.0	82.8	162.1	29.9	186.1	71.8	3.8	27.7	457.0	4128.4
<b>NFI-region</b>																			
1	0.8	207.6	5.6	79.7	128.8	1.0	4.5	15.7	0.3	0.3	0.6	24.8	1.3	28.9	11.6	0.5	5.0	0.6	517.6
2	0.8	237.5	0.4	346.9	142.6	1.1	12.0	31.7	0.4	0.3	1.8	73.0	4.1	90.2	36.6	1.5	14.1	0.8	995.8
3	1.0	218.7	9.9	53.4	259.5	9.1	1.7	22.2	0.1	7.7	8.4	32.1	13.6	29.3	9.6	0.7	3.5	15.7	696.2
4	1.0	338.4	59.3	17.4	386.8	82.3	15.0	41.0	0.3	107.5	61.7	18.8	10.5	29.5	9.6	0.9	3.1	380.0	1563.2
5	0.2	122.7	34.6	4.4	38.0	10.4	14.1	22.1	0.1	10.3	10.3	13.3	0.4	8.2	4.4	0.2	2.0	59.9	355.6
	3.8	1125.0	109.7	501.8	955.7	103.9	47.3	132.7	1.1	126.0	82.8	162.1	29.9	186.1	71.8	3.8	27.7	457.0	4128.4

Table 7-6 shows the overall trends of land-use changes between 1990 and 2007. For example, the area of afforestations (CC 11) decreased by 72% during this period, while the area of productive forests (CC 12) increased by 2%.

Table 7-6 Statistics of land use (CC) for the whole period 1990-2007 (in kha) and relative change (%) between 1990 and 2007.

CC:	11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	Sum
<b>Year:</b>																			
1990	3.8	1125.0	109.7	501.8	955.7	103.9	47.3	132.7	1.1	126.0	82.8	162.1	29.9	186.1	71.8	3.8	27.7	457.0	4128.4
1991	3.7	1126.8	110.2	500.8	954.0	103.6	47.4	131.6	1.0	125.7	82.8	162.1	29.9	187.9	72.4	3.9	28.0	456.6	4128.4
1992	3.7	1128.5	110.6	499.9	952.3	103.2	47.5	130.4	1.0	125.5	82.7	162.1	29.9	189.6	72.9	4.0	28.4	456.2	4128.4
1993	3.6	1129.9	110.8	499.0	951.2	103.0	47.5	129.3	0.9	125.4	82.5	162.1	29.9	191.2	73.4	4.0	28.7	456.0	4128.4
1994	3.4	1131.0	111.1	497.2	951.3	102.8	47.4	128.4	0.9	125.3	82.4	162.1	29.9	192.8	74.0	4.1	28.8	455.7	4128.4
1995	3.1	1132.0	111.3	495.0	952.0	102.7	47.3	127.5	0.9	125.2	82.3	162.1	29.9	194.3	74.7	4.1	28.7	455.3	4128.4
1996	2.9	1132.9	111.6	492.7	952.8	102.5	47.2	126.6	0.8	125.1	82.2	162.1	29.9	195.9	75.3	4.1	28.7	455.0	4128.4
1997	2.7	1133.9	111.8	490.5	953.5	102.3	47.1	125.7	0.8	125.1	82.1	162.2	29.9	197.5	76.0	4.1	28.6	454.6	4128.4
1998	2.5	1134.9	112.1	488.2	954.3	102.1	47.0	124.9	0.8	125.0	82.1	162.2	29.8	199.0	76.7	4.1	28.6	454.3	4128.4
1999	2.3	1135.9	112.4	486.0	955.0	101.9	46.9	124.0	0.8	124.9	82.0	162.2	29.8	200.6	77.4	4.1	28.5	453.9	4128.4
2000	2.0	1136.8	112.6	483.7	955.7	101.7	46.8	123.1	0.7	124.9	81.9	162.2	29.8	202.1	78.1	4.1	28.5	453.6	4128.4
2001	1.8	1137.8	112.9	481.5	956.5	101.5	46.6	122.2	0.7	124.8	81.8	162.2	29.8	203.7	78.7	4.1	28.4	453.3	4128.4
2002	1.6	1138.8	113.1	479.2	957.2	101.3	46.5	121.3	0.7	124.7	81.7	162.3	29.8	205.3	79.4	4.1	28.3	452.9	4128.4
2003	1.4	1139.8	113.4	476.9	958.0	101.2	46.4	120.4	0.7	124.6	81.6	162.3	29.8	206.8	80.1	4.1	28.3	452.6	4128.4
2004	1.1	1140.7	113.6	474.7	958.7	101.0	46.3	119.5	0.6	124.6	81.5	162.3	29.8	208.4	80.8	4.1	28.2	452.2	4128.4
2005	1.1	1141.4	113.9	473.3	959.0	100.8	46.1	118.5	0.6	124.5	81.4	162.3	29.8	210.0	81.4	4.1	28.0	452.0	4128.4
2006	1.1	1142.1	114.1	471.4	959.4	100.6	46.0	117.5	0.6	124.4	81.4	162.3	29.8	211.6	82.1	4.2	28.0	451.7	4128.4
2007	1.1	1142.8	114.3	469.5	959.8	100.5	45.9	116.9	0.6	124.4	81.3	162.4	29.8	213.1	82.7	4.2	27.9	451.4	4128.4
<b>Change:</b>	-72	2	4	-6	0	-3	-3	-11	-44	-1	-2	0	0	14	14	8	1	-1	0

The mean annual rates of change in the entire territory of Switzerland (change-matrices) are achieved by adding up the mean annual change rates of all hectares per combination category (CC). Each land-use change involves a decreasing (“from”) and an increasing (“to”) change. Because the respective areas may be spatially extrapolated by different area expansion factors, the resulting decreasing area may not be equal to the resulting increasing area for a specific land-use transition. The deviations between both values will diminish once the interpretation of AREA3 has been terminated. Meanwhile, the change matrices are established by calculating the mean of the increasing area and of the decreasing area for each land-use transition, as shown in Table 7-7.

For calculating the carbon stock changes, fully stratified (up to 20 strata, cf. Chapter 7.2.3) land-use change matrices are used for each year (Meteotest 2008).

Table 7-7 Mean annual rates of land-use change in 1990 and 2007 (change matrices). Units: ha/year, rounded values. Empty cells indicate no change.

1990		change to CC																			
		11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	decrease	
change from CC	11		345		0	1	1		1						1		0		0	348	
	12	6		117	6	125	101	9	83		10	22	10	5	130	27	10	19	64	742	
	13	12	488			188	38	0	57		4	0	1	1	8	0		1	8	807	
	21	10	2			705	6	213	50	1	6	2	6	2	734	376	25	22	29	2189	
	31	162	181	350	725		948	121	558	1	71	47	3	6	842	500	26	43	73	4657	
	32	27	851	703	2	199		14	255		20	21	4	1	29	9	3	3	35	2177	
	33	1	0		132	53	3		24	2	1	1	0		65	39	4	3	9	337	
	34	29	582	47	160	903	73	43		3	12	29	4	2	233	128	11	68	14	2339	
	35		0		12	11	0	6	40						5	3	0	1	0	78	
	36	2	16	26	2	230	216	1	27				174	2	0	10	1	0		55	764
	37	6	30	7	0	12	326	2	61		10		1	0	8	2				18	482
	41	0	7		2	2	7	1	6		2	1		33	10	2	1	0	78	153	
	42	4	40	12	2	4	3	0	5			0	6		4	2	0	0	1	83	
	51	44	21	0	92	148	14	8	12		5	4	5	5		292	64	50	3	766	
	52	6	5		19	31	3	2	3		0	1	1	3	366		66	402	0	908	
	53	5	9	0	5	7	1	0	1				0	2	42	25		42		140	
	54	2	7		1	2	0	0	3			0	0		75	134	5			228	
61	5	55	10	25	103	106	20	33		331	77	80	2	10	1	0	1		859		
increase		322	2637	1273	1185	2724	1846	440	1219	7	471	379	124	61	2571	1539	215	656	387	18058	

2007		change to CC																		
		11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	decrease
change from CC	11		79												1					80
	12	1		230	1	144	114	2	81		19	30	18	12	93	27	12	10	52	847
	13	4	478			257	56		46		6	2	0	4	3			0	5	861
	21	3	0			1737	7	132	21		4	10	8	8	557	312	17	3	8	2827
	31	19	100	291	402		656	60	347	0	61	17	3	4	709	372	16	10	56	3123
	32	2	588	524	2	155		2	212		11	12	2		13	4	1	1	18	1547
	33		0		143	82	5		14	1	2	0		0	43	28	1	3	11	332
	34	3	369	34	50	644	59	11		0	7	23	4	1	134	79	3	32	13	1465
	35				1	3		2	8						1	0				15
	36	0	12	19	7	116	186	1	29			101	3		2	0			35	511
	37	3	19	3	3	2	213	0	50		16		1	0	6	1			9	325
	41	0	2	0	0	1	6	2		3	2		10	4	1	0			63	94
	42	0	25	7		0	0		1		0		5		1				0	40
	51	18	9		75	136	9	5	7		5	5	6	3		275	57	21	3	633
	52	5	5		17	36	4	1	4		0	2	1	1	405		52	240	0	773
	53	2	11		2	12	2	1	1			0	0	0	48	33		43	0	156
	54	1	4		0	2	1		3			0			98	264	11			384
61	1	37	6	18	44	82	6	21		295	26	53		4	1				594	
increase		63	1736	1116	722	3370	1399	223	845	2	427	232	104	45	2121	1396	170	364	273	14607

It is worth noting that in general the numbers given in the tables above can not be directly compared with the numbers reported in the CRF tables: The CRF tables 5A2, 5B2, 5C2 and 5D2 contain the cumulative area remaining in the respective category in the reporting year. As described in Chapter 7.2.1.d, a conversion time of 20 years is applied to those land-use transitions and during the conversion time, the converted areas are reported under 5X2. In contrast, the change matrices present the land-use changes occurring in the specified year alone.

## 7.2.6. Uncertainty Estimates of Activity Data

Table 7-8 lists uncertainty estimates of activity data (AD) and of emission factors (or biomass parameters). Uncertainties of AD are presented in this chapter, while uncertainties of the emission factors are presented in detail in the respective chapters (7.X.3) of the source sub-categories.

In most cases (highlighted in yellow), the uncertainty of AD depends on the quality of the AREA survey data, with three exceptions:

- CO<sub>2</sub> emissions of source category 5B1 (Cropland remaining cropland) are due to net carbon stock changes in organic soils. The uncertainty of the area of organic soils is around 30% according to Leifeld et al. (2003: 61).
- CH<sub>4</sub> and N<sub>2</sub>O emissions from source category 5A1 (Forest land remaining forest land) are due to wild fires. The burnt area is surveyed by cantonal authorities. A relatively small uncertainty of 10% is assumed as it is a complete survey and not a sampling approach.

Table 7-8 Uncertainty estimates in the LULUCF sector, expressed as half of the 95% confidence intervals.

IPCC Source category		Gas	Activity data uncertainty	Emission factor uncertainty
			%	%
<b>Key categories</b>				
5A1	1. Forest Land remaining Forest Land	CO2	5	40
5A2	2. Land converted to Forest Land	CO2	20	40
5B1	1. Cropland remaining Cropland	CO2	30	25
5E2	2. Land converted to Settlements	CO2	20	50
<b>Non Key categories</b>				
5A1	1. Forest Land remaining Forest Land	CH4	10	50
5A1	1. Forest Land remaining Forest Land	N2O	10	50
5B2	2. Land converted to Cropland	CO2	20	50
5B2	2. Land converted to Cropland	N2O	20	90
5C1	1. Grassland remaining Grassland	CO2	5	50
5C2	2. Land converted to Grassland	CO2	20	50
5D1	1. Wetlands remaining Wetlands	CO2	25	50
5D2	2. Land converted to Wetlands	CO2	25	50
5E1	1. Settlements remaining Settlements	CO2	20	50
5F2	2. Land converted to Other Land	CO2	20	50

The uncertainty of AREA-based activity data has three main sources (Table 7-9):

1) Statistical sampling error: In the AREA survey, the land-use types are interpreted on points situated on a regular 100x100 m grid. Thus, the uncertainty of the surface area covered by a certain land-use type or land-use change decreases with increasing numbers of sampling points. Assuming a binomial distribution of the errors, this uncertainty is calculated as

$$U_{\text{sampling}} = 100 * 1.96 * (\text{number of points})^{-0.5}$$

The number of sampling points presently lies between 649 (for 5D2) and 461'878 (for 5A1) leading to values of  $U_{\text{sampling}}$  between 7.7% and 0.3%.

2) Extrapolation error: Remaining and converted land-use types in the present sampling region (35% of the territory) may have a frequency that differs from the whole of Switzerland leading to a bias in the extrapolated areas. With the increase of the sampling region, the extrapolation error will converge to zero in the future. For quantifying this error, the relative change of proportions of the land-use types (5A1 to 5F2) between the AREA sample of last year (23% of Switzerland; FOEN 2008) and the present sample (35% of Switzerland) was used. The values are between 0.4% and 25.0% (Table 7-9). In general, the conversion activities have a higher extrapolation uncertainty ( $U_{\text{extrapol}}$ ) than the "remaining" categories. Wetlands and settlements have the highest uncertainties, probably because these categories are spatially clumped and thus the sampling region may be less representative.

3) Substitution error: The spatial strata that are not covered by the present sample of the AREA survey are called substitution region, because the AREA data are substituted here by ASCH1 and ASCH2 data. In the substitution region land-use changes occurring after the ASCH2 survey (1990-1998) are neglected. In order to quantify the uncertainty caused by this simplification, the land-use activities (5A1 to 5F2) taking place between AREA2 and AREA3 were compared with the activities observed between AREA1 and AREA2. The relative change among these two transitions (AREA1-AREA2 and AREA2-AREA3), weighted with the relative size of the substitution region (9% of the country), is used as an indicator for the substitution uncertainty  $U_{\text{subst}}$  (see Table 7-9). It is obvious that the conversion activities have a higher substitution uncertainty than the “remaining” categories.

The overall uncertainty was calculated as:

$$U_{\text{overall}} = (U_{\text{sampling}}^2 + U_{\text{extrapol}}^2)^{0.5} + U_{\text{subst}}$$

As  $U_{\text{subst}}$  contains systematic components it was added linearly to the other uncertainties.

Finally, conservatively rounded values of the calculated overall uncertainties were chosen for further processing in the uncertainty analysis.

Table 7-9 The three sources of AREA AD uncertainty and overall uncertainties in the area calculations, expressed as half of the 95% confidence intervals.

IPCC Description	Sampling uncertainty	Extrapolation uncertainty	Substitution uncertainty	Overall uncertainty, calculated value	Overall uncertainty, chosen value
5A1 Forest Land remaining Forest Land	0.3	1.4	0.1	1.5	5
5A2 Land converted to Forest Land	2.5	7.2	3.6	11.3	20
5B1 Cropland remaining Cropland	0.4	2.6	0.3	3.0	5
5B2 Land converted to Cropland	2.9	5.0	3.6	9.3	20
5C1 Grassland remaining Grassland	0.3	2.0	0.1	2.1	5
5C2 Land converted to Grassland	1.5	8.8	4.9	13.8	20
5D1 Wetlands remaining Wetlands	0.7	25.0	0.0	25.0	25
5D2 Land converted to Wetlands	7.7	5.7	1.7	11.2	25
5E1 Settlements remaining Settlements	0.5	15.0	1.3	16.2	20
5E2 Land converted to Settlements	1.6	13.2	2.1	15.3	20
5F1 Other Land remaining Other Land	0.8	4.7	0.1	4.8	NA
5F2 Land converted to Other Land	6.6	0.4	3.1	9.7	20

### 7.2.7. Carbon Stocks, Emission Factors, and Net Changes at a Glance

Table 7-10 lists all values of carbon stocks, increases, decreases and net changes of carbon specified for land-use category (CC) and associated spatial strata for the year 1990. These values remain constant during the period 1990-2007 with the exception of the carbon stock, increase and decrease of living biomass and carbon stock and net change in dead organic matter of CC 12 (productive forest). The deduction of the annually changing data of CC 12 – according to climate variations, harvest statistics and natural disturbances (like windthrow) – is described in Chapters 7.3.2.f and 7.3.2.h. Annual data are given in Table 7-11.

Table 7-10 Carbon stocks and changes in living biomass, in dead organic matter and in soils for the combination categories (CC), disaggregated for altitude, NFI region, and soil type. The values are valid for the whole period 1990-2007 with the exception of biomass and dead organic matter parameters of CC 12, which change annually (numbers here are for the year 1990); cf. Table 7-11.

land-use code CC	altitude zone z	NFI region	soil type	carbon stock in living biomass (stockLi,i)	carbon stock in dead organic matter (stockCd,i)	carbon stock in soil (stockCs,i)	growth of living biomass (increaseLi,i)	harvesting of living biomass (decreaseLi,i)	net change in dead organic matter (changeCd,i)	net change in soil (changeCs,i)
	Strata			t C ha <sup>-1</sup>			t C ha <sup>-1</sup> yr <sup>-1</sup>			
11	1	1	n.s.	12.72	0	75.00	2.63	0	0	0
	1	2	n.s.	12.72	0	62.60	2.63	0	0	0
	1	3	n.s.	12.72	0	75.30	2.63	0	0	0
	1	4	n.s.	12.72	0	72.10	2.63	0	0	0
	1	5	n.s.	12.72	0	109.00	2.63	0	0	0
	2	1	n.s.	6.90	0	75.00	1.75	0	0	0
	2	2	n.s.	6.90	0	62.60	1.75	0	0	0
	2	3	n.s.	6.90	0	75.30	1.75	0	0	0
	2	4	n.s.	6.90	0	72.10	1.75	0	0	0
	2	5	n.s.	6.90	0	109.00	1.75	0	0	0
	3	1	n.s.	2.48	0	75.00	0.88	0	0	0
	3	2	n.s.	2.48	0	62.60	0.88	0	0	0
	3	3	n.s.	2.48	0	75.30	0.88	0	0	0
	3	4	n.s.	2.48	0	72.10	0.88	0	0	0
	3	5	n.s.	2.48	0	109.00	0.88	0	0	0
	12	1	1	n.s.	130.68	12.78	75.00	3.35	-2.40	0.23
1		2	n.s.	138.36	10.58	62.60	4.75	-4.30	0.08	0
1		3	n.s.	145.82	17.95	75.30	3.96	-2.93	0.04	0
1		4	n.s.	96.41	35.39	72.10	2.89	-2.55	0.15	0
1		5	n.s.	70.76	25.67	109.00	1.91	-0.97	0.25	0
2		1	n.s.	130.90	12.81	75.00	3.17	-2.38	0.23	0
2		2	n.s.	151.31	11.01	62.60	4.86	-4.00	0.11	0
2		3	n.s.	153.62	19.86	75.30	3.84	-3.04	0.18	0
2		4	n.s.	103.93	38.10	72.10	2.26	-1.81	0.34	0
2		5	n.s.	73.75	24.34	109.00	2.09	-0.84	0.15	0
3		1	n.s.	85.05	10.93	75.00	1.86	-1.48	0.09	0
3		2	n.s.	112.31	21.45	62.60	1.59	-0.95	0.88	0
3		3	n.s.	121.29	21.98	75.30	2.37	-2.08	0.34	0
3		4	n.s.	100.38	37.85	72.10	1.97	-1.76	0.33	0
3		5	n.s.	81.08	25.45	109.00	1.69	-0.52	0.23	0
13		1	1	n.s.	45.90	9.7	75.00	0	0	0
	1	2	n.s.	46.64	9.5	62.60	0	0	0	0
	1	3	n.s.	45.90	17.4	75.30	0	0	0	0
	1	4	n.s.	40.47	33.4	72.10	0	0	0	0
	1	5	n.s.	38.59	22.3	109.00	0	0	0	0
	2	1	n.s.	48.20	9.7	75.00	0	0	0	0
	2	2	n.s.	45.90	9.5	62.60	0	0	0	0
	2	3	n.s.	47.68	17.4	75.30	0	0	0	0
	2	4	n.s.	38.37	33.4	72.10	0	0	0	0
	2	5	n.s.	33.46	22.3	109.00	0	0	0	0
	3	1	n.s.	48.03	9.7	75.00	0	0	0	0
	3	2	n.s.	12.86	9.5	62.60	0	0	0	0
	3	3	n.s.	29.08	17.4	75.30	0	0	0	0
	3	4	n.s.	18.58	33.4	72.10	0	0	0	0
	3	5	n.s.	21.14	22.3	109.00	0	0	0	0
	21	n.s.	n.s.	0	5.66	0	53.40	0	0	0
n.s.		n.s.	1	5.66	0	240.00	0	0	0	-9.52
31	1	n.s.	0	7.45	0	62.02	0	0	0	0
	1	n.s.	1	7.45	0	240.00	0	0	0	-9.52
	2	n.s.	0	6.26	0	67.50	0	0	0	0
	2	n.s.	1	6.26	0	240.00	0	0	0	-9.52
	3	n.s.	0	4.45	0	75.18	0	0	0	0
	3	n.s.	1	4.45	0	240.00	0	0	0	-9.52
32	1	n.s.	n.s.	11.60	0	68.23	0	0	0	0
	2	n.s.	n.s.	11.60	0	68.23	0	0	0	0
	3	n.s.	n.s.	11.60	0	68.23	0	0	0	0
33	n.s.	n.s.	0	3.74	0	53.40	0	0	0	0
	n.s.	n.s.	1	3.74	0	240.00	0	0	0	-9.52
34	1	n.s.	n.s.	11.60	0	68.23	0	0	0	0
	2	n.s.	n.s.	11.60	0	68.23	0	0	0	0
	3	n.s.	n.s.	11.60	0	68.23	0	0	0	0
35	n.s.	n.s.	0	24.63	0	64.76	0	0	0	0
	n.s.	n.s.	1	24.63	0	240.00	0	0	0	-9.52
36	n.s.	n.s.	n.s.	4.06	0	26.31	0	0	0	0
37	n.s.	n.s.	n.s.	6.05	0	68.23	0	0	0	0
41	n.s.	n.s.	n.s.	0	0	0	0	0	0	0
42	n.s.	n.s.	n.s.	8.20	0	154.00	0	0	0	0
51	n.s.	n.s.	n.s.	0	0	0	0	0	0	0
52	n.s.	n.s.	n.s.	11.40	0	53.40	0	0	0	0
53	n.s.	n.s.	n.s.	8.90	0	53.40	0	0	0	0
54	n.s.	n.s.	n.s.	18.60	0	53.40	0	0	0	0
61	n.s.	n.s.	n.s.	0	0	0	0	0	0	0

(table continued)

Legend		
<i>altitude zones:</i>	<i>NFI-regions:</i>	<i>soil type:</i>
1 < 600 m	1 Jura	0 mineral soil
2 601 - 1200 m	2 Central Plateau	1 organic soil
3 > 1200 m	3 Pre-Alps	
	4 Alps	n.s. = no stratification
	5 Southern Alps	annually changing data

Please note that Table 7-5 is the result of a spatial overlay of geo-data of different scales (digital terrain model, SFSO 1997; digital soil map, SFSO 2000a; land-use survey, SFSO 2008) leading to some artefacts in border areas (e.g. 'other land' on organic soil), while Table 7-10 shows information related to carbon contents in organic and mineral soils under various land-use types.

In order to avoid unrealistic carbon fluxes due to those artefacts, a value of 240 t C ha<sup>-1</sup> for stockC<sub>s</sub> was assumed for all land-use categories on organic soils, even where this is not explicitly indicated in Table 7-10, i.e. where no stratification according to soil type is indicated (e.g. in CC 12). Thus, when calculating carbon changes in soils as a consequence of land-use changes, the difference of carbon stocks in organic soils is always zero.

An example may elucidate this assumption: In case of land-use changes from a CC without differentiation of mineral and organic soil (e.g. CC 61 Other Land) to a CC with differentiation (e.g. CC 21 Cropland), the soil type of the former CC is assigned to mineral or to organic soil according to the digital soil map (see Chapter 7.2.3). If, according to this dataset, the former CC (other land) is situated on a mineral soil, then the new soil carbon stock value is attributed 53.4 t C ha<sup>-1</sup> (for cropland), resulting in a carbon change of 53.4 T C ha<sup>-1</sup>. If the former CC appears to be situated on an organic soil, the carbon change in soil results in 0 t C ha<sup>-1</sup>.

In the CRF Table 5A all forest land is reported in the columns for mineral soils, as the present information about forest soils do not allow to quantify carbon stocks of organic soils. Furthermore, the available soil map does not allow to identify the extent of organic soils under forest land (see Chapter 7.2.3).

While the carbon data for forests are derived from monitoring data of NFI 1, NFI 2 and NFI 3, the data for agriculture, grassland and settlements are based on experiments, field studies, literature and expert estimates. For wetlands and other land, expert estimates or default values are available. The deduction of the individual values (carbon stocks in biomass and soils; growth and harvesting of living biomass, net changes in dead organic matter in soils) is explained in detail in the following chapters.

Table 7-11 Annually changing carbon data for productive forest (CC 12) disaggregated for altitude and NFI region, 1990-2007, three-year-averages.

land-use code CC	altitude zone z	NFI region	soil type	carbon stock in living biomass (stockCl,i) [t C ha <sup>-1</sup> ]																					
				Strata	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007			
12	1	1	n.s.	130.68	131.63	132.45	133.55	134.73	135.93	135.26	134.26	133.11	131.88	130.91	129.59	128.57	127.89	127.44	126.81	125.99	125.17				
			1	138.36	138.81	139.14	139.54	140.21	141.23	142.03	142.66	142.92	142.79	142.80	140.67	138.60	136.47	135.86	135.19	134.24	133.79				
	1	3	n.s.	145.82	146.86	147.88	149.06	150.70	152.68	154.72	156.34	157.77	158.87	160.20	160.23	160.33	160.27	160.96	161.52	161.81	162.34				
			1	96.41	96.75	96.96	97.11	97.53	98.44	99.98	101.44	102.91	103.88	105.26	106.67	108.78	110.69	112.30	113.42	114.31	115.59				
	1	5	n.s.	70.76	71.70	72.48	73.34	74.30	75.19	76.19	77.07	77.90	78.73	79.71	80.93	82.15	83.37	84.17	84.83	85.34	85.92				
			1	130.90	131.70	132.34	133.25	134.26	135.44	136.21	136.89	137.49	137.99	138.47	138.60	139.11	139.84	140.74	141.44	141.80	142.03				
	2	2	n.s.	151.31	152.17	152.84	153.64	154.70	156.09	157.22	158.13	158.67	158.82	159.08	157.13	155.19	153.18	152.66	152.06	151.27	150.97				
			2	153.62	154.43	155.18	156.08	157.62	159.50	161.04	162.35	163.66	164.62	165.78	164.93	163.75	162.14	161.76	161.48	161.28	161.47				
	2	4	n.s.	103.93	104.38	104.61	104.78	105.41	106.51	107.65	108.65	109.61	110.28	111.28	112.32	113.84	115.19	116.30	117.04	117.67	118.60				
			2	73.75	75.01	76.21	77.41	78.62	79.76	81.40	83.01	84.66	86.29	87.96	89.74	91.56	93.42	95.02	96.48	97.89	99.34				
	3	1	n.s.	85.05	85.43	85.90	86.50	87.27	87.99	88.90	89.69	90.40	90.98	91.53	91.89	92.51	93.20	93.98	94.62	95.13	95.62				
			3	112.31	112.94	113.52	114.13	114.84	115.64	115.92	115.88	115.50	115.08	114.63	113.48	112.21	110.93	110.19	109.48	108.66	107.92				
	3	3	n.s.	121.29	121.58	121.90	122.22	123.03	124.05	125.21	126.25	127.27	128.08	128.95	128.52	127.86	126.93	126.70	126.56	126.76	127.16				
			3	100.38	100.59	100.50	100.25	100.46	101.11	101.79	102.45	103.03	103.46	103.97	104.56	105.42	106.21	106.73	107.09	107.43	107.68				
	3	5	n.s.	81.08	82.26	83.40	84.57	85.76	86.92	88.08	89.17	90.15	91.21	92.39	93.85	95.49	97.13	98.42	99.55	100.33	100.96				

				growth of living biomass (increaseCl,i) [t C ha <sup>-1</sup> yr <sup>-1</sup> ]																					
				Strata	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007			
12	1	1	n.s.	3.35	3.14	3.37	3.42	3.56	3.53	3.21	3.05	2.96	3.32	3.27	3.24	3.30	3.01	2.93	2.66	3.31	3.71				
			1	4.75	4.45	4.49	4.42	4.94	5.17	4.92	4.54	4.16	4.57	4.62	5.09	4.91	4.51	4.20	3.83	4.57	5.15				
	1	3	n.s.	3.96	3.91	4.04	4.24	4.56	4.76	4.37	4.23	3.97	4.36	4.01	4.36	4.18	4.15	3.88	3.65	4.05	4.55				
			1	2.89	2.92	2.97	3.05	3.43	3.73	3.54	3.45	3.29	3.80	3.71	4.05	3.79	3.60	3.15	2.93	3.08	3.62				
	1	5	n.s.	1.91	1.74	1.89	2.14	2.16	2.18	2.13	2.16	2.25	2.41	2.58	2.50	2.47	2.06	1.91	1.74	1.90	2.06				
			2	3.17	2.89	3.06	3.09	3.38	3.34	3.23	3.14	3.01	3.07	3.05	3.21	3.23	2.99	2.93	2.73	3.01	3.11				
	2	2	n.s.	4.86	4.52	4.60	4.50	5.02	5.19	4.88	4.47	4.08	4.45	4.51	5.00	4.87	4.41	4.09	3.72	4.48	4.98				
			2	3.84	3.79	3.91	4.10	4.39	4.67	4.40	4.36	4.11	4.52	4.21	4.55	4.34	4.34	4.07	3.85	4.19	4.71				
	2	4	n.s.	2.26	2.30	2.31	2.41	2.68	2.88	2.65	2.49	2.37	2.78	2.71	2.99	2.75	2.63	2.27	2.12	2.21	2.62				
			2	2.09	2.02	2.07	2.20	2.23	2.25	2.27	2.34	2.37	2.41	2.46	2.46	2.47	2.22	2.09	2.00	2.10	2.21				
	3	1	n.s.	1.86	1.85	1.89	1.96	2.02	1.98	1.86	1.76	1.63	1.63	1.61	1.77	1.75	1.64	1.59	1.57	1.66	1.72				
			3	1.59	1.50	1.52	1.50	1.64	1.40	1.04	0.68	0.64	0.68	0.69	0.74	0.73	0.67	0.63	0.60	0.68	0.73				
	3	3	n.s.	2.37	2.40	2.41	2.50	2.66	2.83	2.66	2.60	2.45	2.63	2.39	2.62	2.53	2.48	2.33	2.25	2.56	2.79				
			3	1.97	1.96	1.88	1.90	2.11	2.22	2.10	1.90	1.82	1.96	1.94	2.08	1.96	1.81	1.63	1.55	1.60	1.62				
	3	5	n.s.	1.69	1.59	1.62	1.73	1.77	1.73	1.69	1.66	1.74	1.85	1.98	2.04	2.00	1.71	1.57	1.17	1.27	1.24				

				harvesting of living biomass (decreaseCl,i) [t C ha <sup>-1</sup> yr <sup>-1</sup> ]																					
				Strata	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007			
12	1	1	n.s.	-2.40	-2.32	-2.27	-2.24	-2.36	-4.21	-4.21	-4.19	-4.19	-4.30	-4.59	-4.26	-3.97	-3.46	-3.55	-3.78	-4.14	-4.53				
			1	-4.30	-4.13	-4.09	-3.74	-3.93	-4.37	-4.29	-4.27	-4.30	-4.56	-6.75	-7.16	-7.04	-5.11	-4.87	-5.26	-5.52	-5.60				
	1	3	n.s.	-2.93	-2.89	-2.87	-2.60	-2.58	-2.72	-2.76	-2.80	-2.87	-3.03	-3.98	-4.27	-4.24	-3.47	-3.32	-3.46	-3.76	-4.02				
			1	-2.55	-2.71	-2.82	-2.63	-2.52	-2.19	-2.08	-1.98	-2.32	-2.42	-2.30	-1.94	-1.87	-1.99	-2.04	-2.07	-2.18	-2.33				
	1	5	n.s.	-0.97	-0.96	-1.03	-1.17	-1.27	-1.18	-1.25	-1.33	-1.42	-1.42	-1.36	-1.29	-1.25	-1.26	-1.25	-1.23	-1.38	-1.48				
			2	-2.38	-2.25	-2.16	-2.07	-2.21	-2.57	-2.55	-2.53	-2.51	-2.59	-2.91	-2.70	-2.51	-2.08	-2.23	-2.43	-2.66	-2.88				
	2	2	n.s.	-4.00	-3.84	-3.80	-3.44	-3.62	-4.07	-3.97	-3.93	-3.93	-4.19	-6.46	-6.94	-6.88	-4.93	-4.69	-5.07	-5.28	-5.28				
			2	-3.04	-3.03	-3.01	-2.56	-2.51	-3.13	-3.09	-3.06	-3.14	-3.36	-5.06	-5.73	-5.95	-4.72	-4.35	-4.33	-4.39	-4.52				
	2	4	n.s.	-1.81	-2.07	-2.14	-1.78	-1.58	-1.74	-1.64	-1.54	-1.70	-1.78	-1.68	-1.46	-1.41	-1.52	-1.53	-1.54	-1.58	-1.70				
			2	-0.84	-0.81	-0.87	-0.99	-1.08	-0.62	-0.65	-0.70	-0.74	-0.74	-0.68	-0.63	-0.61	-0.62	-0.63	-0.62	-0.69	-0.75				
	3	1	n.s.	-1.48	-1.37	-1.28	-1.19	-1.30	-1.07	-1.06	-1.05	-1.04	-1.08	-1.25	-1.16	-1.07	-0.86	-0.95	-1.05	-1.14	-1.23				
			3	-0.95	-0.92	-0.91	-0.79	-0.84	-1.12	-1.08	-1.06	-1.05	-1.13	-1.84	-2.01	-2.01	-1.41	-1.35	-1.46	-1.50	-1.47				
	3	3	n.s.	-2.08	-2.09	-2.08	-1.69	-1.63	-1.67	-1.63	-1.59	-1.63	-1.76	-2.82	-3.27	-3.46	-2.71	-2.46	-2.41	-2.36	-2.39				
			3	-1.76	-2.06	-2.12	-1.69	-1.46	-1.54	-1.43	-1.32	-1.39	-1.46	-1.35	-1.22	-1.17	-1.29	-1.28	-1.27	-1.26	-1.36				
	3	5	n.s.	-0.52	-0.44	-0.45	-0.54	-0.61	-0.57	-0.60	-0.68	-0.68	-0.67	-0.52	-0.41	-0.35	-0.41	-0.44	-0.46	-0.49	-0.62				

(table continued on next page)

(Table 7-11 continued)

land-use code CC	altitude zone z	NFI region	soil type	carbon stock in dead organic matter (stockCd,i) [t C ha <sup>-1</sup> ]																			
				Strata	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	
12	1	1	n.s.	12.78	12.98	13.01	13.21	13.68	14.21	14.67	14.78	14.97	14.97	15.26	15.54	15.86	16.21	16.25	16.09	15.69	15.51		
	1	2	n.s.	10.58	10.65	10.66	10.73	10.89	11.09	11.27	11.32	11.39	11.39	11.49	11.59	11.70	11.83	11.84	12.73	13.51	14.39		
	1	3	n.s.	17.95	17.99	17.99	18.03	18.11	18.22	18.31	18.35	18.38	18.38	18.44	18.49	18.55	18.62	18.62	20.49	22.26	24.10		
	1	4	n.s.	35.39	35.52	35.54	35.66	35.97	36.35	36.69	36.79	36.92	36.92	37.11	37.30	37.52	37.75	37.77	38.34	38.72	39.26		
	1	5	n.s.	25.67	25.90	25.93	26.14	26.66	27.32	27.92	28.13	28.35	28.35	28.67	29.00	29.37	29.77	29.81	30.44	30.77	31.36		
	2	1	n.s.	12.81	13.02	13.05	13.24	13.72	14.25	14.72	14.83	15.02	15.02	15.31	15.60	15.93	16.28	16.31	16.17	15.77	15.60		
	2	2	n.s.	11.01	11.11	11.12	11.22	11.45	11.74	12.00	12.09	12.19	12.19	12.34	12.48	12.65	12.82	12.84	13.70	14.41	15.24		
	2	3	n.s.	19.86	20.02	20.04	20.20	20.57	21.04	21.47	21.60	21.76	21.76	22.00	22.23	22.50	22.79	22.81	23.90	24.75	25.80		
	2	4	n.s.	38.10	38.42	38.46	38.76	39.48	40.51	41.45	41.84	42.16	42.16	42.64	43.12	43.65	44.23	44.28	43.52	42.36	41.55		
	2	5	n.s.	24.34	24.48	24.50	24.62	24.94	25.34	25.70	25.82	25.95	25.95	26.15	26.35	26.57	26.81	26.83	27.22	27.43	27.80		
	3	1	n.s.	10.93	11.02	11.03	11.11	11.30	11.51	11.70	11.75	11.82	11.82	11.94	12.05	12.18	12.32	12.34	12.86	13.26	13.76		
	3	2	n.s.	21.45	22.25	22.37	23.12	24.95	27.28	29.36	30.06	30.83	30.83	32.00	33.16	34.45	35.86	35.99	31.04	25.22	20.22		
	3	3	n.s.	21.98	22.29	22.33	22.62	23.32	24.15	24.89	25.09	25.38	25.38	25.82	26.25	26.73	27.26	27.31	28.81	29.90	31.34		
	3	4	n.s.	37.85	38.15	38.19	38.47	39.16	40.09	40.94	41.27	41.56	41.56	42.01	42.45	42.94	43.49	43.54	42.96	42.01	41.40		
	3	5	n.s.	25.45	25.67	25.70	25.89	26.38	26.99	27.53	27.71	27.91	27.91	28.22	28.53	28.87	29.24	29.27	29.10	28.66	28.46		
					net change in dead organic matter (changeCd,i) [t C ha <sup>-1</sup> yr <sup>-1</sup> ]																		
					Strata	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	12	1	1	n.s.	0.23	0.21	0.03	0.19	0.47	0.53	0.46	0.11	0.19	0.00	0.29	0.29	0.32	0.35	0.03	-0.15	-0.40	-0.18	
		1	2	n.s.	0.08	0.07	0.01	0.07	0.16	0.20	0.18	0.05	0.07	0.00	0.10	0.10	0.11	0.13	0.01	0.89	0.78	0.87	
		1	3	n.s.	0.04	0.04	0.01	0.03	0.08	0.11	0.10	0.03	0.04	0.00	0.05	0.05	0.06	0.07	0.01	1.87	1.77	1.84	
		1	4	n.s.	0.15	0.13	0.02	0.12	0.30	0.38	0.34	0.11	0.13	0.00	0.19	0.19	0.21	0.23	0.02	0.56	0.38	0.54	
1		5	n.s.	0.25	0.23	0.03	0.21	0.52	0.67	0.60	0.20	0.22	0.00	0.33	0.33	0.37	0.40	0.04	0.63	0.33	0.59		
2		1	n.s.	0.23	0.21	0.03	0.20	0.48	0.54	0.47	0.11	0.19	0.00	0.29	0.29	0.32	0.35	0.03	-0.15	-0.39	-0.17		
2		2	n.s.	0.11	0.10	0.01	0.09	0.23	0.29	0.26	0.09	0.10	0.00	0.15	0.15	0.16	0.18	0.02	0.86	0.71	0.83		
2		3	n.s.	0.18	0.16	0.02	0.15	0.38	0.47	0.42	0.14	0.16	0.00	0.24	0.24	0.26	0.29	0.03	1.09	0.85	1.05		
2		4	n.s.	0.34	0.32	0.04	0.30	0.72	1.03	0.95	0.39	0.32	0.00	0.48	0.48	0.53	0.58	0.05	-0.77	-1.16	-0.80		
2		5	n.s.	0.15	0.14	0.02	0.13	0.31	0.40	0.36	0.12	0.13	0.00	0.20	0.20	0.22	0.24	0.02	0.39	0.21	0.37		
3		1	n.s.	0.09	0.08	0.01	0.08	0.19	0.22	0.19	0.05	0.08	0.00	0.12	0.12	0.13	0.14	0.01	0.52	0.40	0.50		
3		2	n.s.	0.88	0.80	0.11	0.75	1.83	2.33	2.09	0.70	0.77	0.00	1.16	1.16	1.29	1.42	0.13	-4.95	-5.82	-5.00		
3		3	n.s.	0.34	0.31	0.04	0.29	0.70	0.83	0.73	0.20	0.29	0.00	0.43	0.43	0.48	0.53	0.05	1.50	1.09	1.44		
3		4	n.s.	0.33	0.30	0.04	0.28	0.68	0.93	0.85	0.33	0.30	0.00	0.44	0.44	0.49	0.54	0.05	-0.58	-0.95	-0.61		
3		5	n.s.	0.23	0.21	0.03	0.20	0.48	0.61	0.55	0.18	0.20	0.00	0.31	0.31	0.34	0.37	0.03	-0.18	-0.44	-0.20		

## 7.3. Source Category 5A – Forest Land

### 7.3.1. Source Category Description

#### Key category 5A1

CO<sub>2</sub> from Forest Land remaining Forest Land (level and trend)

#### Key category 5A2

CO<sub>2</sub> from Land converted to Forest Land is a new key category (trend)

Only temperate forests are occurring in Switzerland. Forest is defined as a minimum area of land of 0.0625 ha with crown cover of at least 20% and a minimum width of 25 m. The minimum height of the dominant trees must be 3 m or have the potential to reach 3 m at maturity in situ (FOEN 2006h). The following forest areas are not subject of the criteria of minimum stand height and minimum crown cover, but must have the potential to achieve it: afforested, regenerated, as well as burned, cut or damaged areas. Although orchards, parks, camping grounds, open tree formations in settlements, gardens, cemeteries, sports and parking fields may fulfil the (quantitative) forest definition, they are not considered as forests (FOEN 2006h).

For reporting in the CRF tables, the different forest types are allocated to afforestations (CC 11), productive forest (CC 12) and unproductive forest (CC 13) based on AREA categories (see Table 7-2; FOEN 2007f; SFSO 2006a).

### 7.3.2. Methodological Issues

#### a) National Forest Inventories

Data for growing stock, gross growth, cut (harvesting), and mortality were derived from the first, second and third Swiss National Forest Inventories (NFI, see Table 7-12). A description of NFI 1 and NFI 2 methodologies can be found in EAFV/BFL (1988) and in Brassel and Brändli (1999). Data and methodology of NFI 3 have not yet been published.

Table 7-12 Characteristics of the National Forest Inventories I, II and III.

	NFI 1	NFI 2	NFI 3
Inventory cycle	1983-1985	1993-1995	2004-2006
Grid size	1 x 1 km	1.4 x 1.4 km	1.4 x 1.4 km
Terrestrial sample plots	~12'000	~6'000	~6'000
Measured single trees	~130'000	~70'000	~70'000

#### b) Three-year averaging of forest carbon pools

The Revised 1996 IPCC Guidelines (IPCC 1997a) recommend to work with three-year averages to report carbon changes in "Forest and Other Woody Biomass Stocks". Further, the 2003 IPCC GPG (IPCC 2003) describes how to deal with interannual variability and states that "it is good practice to consistently report emissions using longer-term averages of environmental conditions or actual annual estimates of emissions when estimating stock changes".

The carbon pools reported for the Swiss forest sector are annual values reflecting annual fluctuations in management, weather conditions and natural disturbances. Therefore, three-year moving averages are calculated for all forest carbon pools in order to smooth out high interannual fluctuations.

Three-year moving averages for the inventory year X are calculated as the average of the years X, X-1 and X-2. For example, the value for the inventory year 2004 is the average value of the years 2002-2004. This "backward-averaging" was used instead of calculating the arithmetic mean (mean of the years X-1, X, X+1), because

1. if X is the most recent inventory year, X+1 data generally are not available in time (for submission in year x+2);
2. we argue, that growth of living biomass, cut and mortality and the amount of dead wood is more influenced by the previous years than by the following year.

This "backward-averaging" introduces a certain time-lag in the calculated values and can complicate the interpretation of the resulting CO<sub>2</sub> emissions and removals.

## c) Stratification

### Spatial strata

Forests in Switzerland reveal a high heterogeneity in terms of elevation, growth conditions, tree species composition, and inter-annual growth variability. We therefore stratified Switzerland to reduce the variance of following variables: gross growth, biomass expansion factors, tree species, and inter-annual growth variability.

To find explanatory variables that significantly reduce the variance of gross growth and biomass expansion factors an analysis of variance was done (Thürig et al. 2005a). The explanatory variables considered in this study are:

- the five NFI production regions (1. Jura, 2. Central Plateau, 3. Pre-Alps, 4. Alps, 5. Southern Alps)
- altitude (<601 m, 601-1200 m, >1200 m)
- tree species (coniferous and deciduous species).

The analysis of variance (Thürig et al. 2005a) indicated that production region, elevation, and tree species all significantly explain differences in gross growth and biomass expansion factors (Table 7-13). Therefore, values for growing stock, gross growth, harvesting, mortality and biomass conversion and expansion were calculated and applied for each of these 30 strata.

Table 7-13 Analysis of variance of gross growth and biomass expansion factors. Explanatory variables: Tree species, production region, and altitude.

	Gross growth		Biomass expansion factors	
	F value	p-value	F value	p-value
Coniferous/Deciduous	421	<0.0001	18'832	<0.0001
Production region	45	<0.0001	2'434	<0.0001
Altitude	34	<0.0001	103	<0.0001

### Separating mixed forests into coniferous and deciduous sites

In Switzerland, most forests are mixed stands. However, the forest area derived by the Swiss land use statistics does not allow separating coniferous and deciduous sites.

To derive species specific measures for growing stock, gross growth, harvesting, mortality and biomass conversion and expansion factors, the total forest area has to be divided according to the species mixture. The emission factor per stratum is then calculated as the weighted mean of both species. The weights were derived from the single tree NFI data. It was assumed that the space asserted by a single tree is highly correlated with its basal area. The required ratio of coniferous forest area ( $R_c$ ) per spatial stratum was calculated by dividing the sum of the basal area of the conifers ( $BA_c$ ) over the sum of the basal area of all trees ( $BA$ ).

$$R_{ci} = BA_{ci} / BA_i \quad i = \text{spatial strata}$$

As both species add up to 1 (or 100%) the rate of deciduous forest area ( $R_d$ ) is:

$$R_{di} = 1 - R_{ci} \quad i = \text{spatial strata}$$

The weights for each spatial stratum are displayed in Table 7-14.

Table 7-14 Ratio of coniferous and deciduous species for 1985-1994 (source: NFI 2; Brassel and Brändli 1999) and for the time period 1995-2005 (derived from NFI 2 and NFI 3 data).

NFI region	Altitude [m]	1985 - 1994		1995 - 2005	
		Coniferous	Deciduous	Coniferous	Deciduous
1	<601	0.352	0.648	0.335	0.665
	601-1200	0.581	0.419	0.575	0.425
	>1200	0.751	0.249	0.747	0.253
2	<601	0.558	0.442	0.508	0.492
	601-1200	0.646	0.354	0.587	0.413
	>1200	0.902	0.098	0.850	0.150
3	<601	0.395	0.605	0.387	0.613
	601-1200	0.713	0.287	0.679	0.321
	>1200	0.925	0.075	0.911	0.089
4	<601	0.369	0.631	0.310	0.690
	601-1200	0.652	0.348	0.631	0.369
	>1200	0.962	0.038	0.944	0.056
5	<601	0.060	0.940	0.063	0.937
	601-1200	0.152	0.848	0.147	0.853
	>1200	0.810	0.190	0.798	0.202

### Additional stratification: eastern and western Alps

To correct the approximately ten-year averaged NFI growth data for inter-annual climate variability, we applied annual climate data. In the Swiss Alps below an altitude of 1200 m, climate between the eastern and the western part differs substantially. We therefore included an additional stratification for the eastern and the western part of the Alps below 1200 m (Alps < 601 m east, Alps < 601 m west, Alps 601-1200 m east, Alps 601-1200 m west; cf. Thürig et al. 2005a for details). Regarding the small size of the total forest area of Switzerland, this additional stratification resulted in very small datasets per stratum.

To limit the stratification of the forest area derived from the Swiss land use statistics to a manageable amount, the same procedure as aforementioned under the subject of separating mixed forests into coniferous and deciduous sites was applied. Growth parameters and particularly growth correction factors according to annual climate data were estimated for the eastern and western Alps separately. The emission factors for the Alps below 1200 m were

then calculated as a weighted mean of the percentage of forest area situated in the western and in the eastern Alps. The weights for the pooled emission factors derived from the NFI 2 and NFI 3 are listed in Table 7-15.

Table 7-15 Ratio of forest area in the eastern and western Alps (NFI production region 4) for the time period 1985-1994 and 1995-2005, respectively, as derived from NFI data.

Altitude [m]	1985 - 1994		1995 - 2005	
	NFI 2	NFI 2	NFI 3	NFI 3
	Eastern	Western	Eastern	Western
<601	0.43	0.57	0.50	0.50
601-1200	0.56	0.44	0.60	0.40

#### d) Biomass Conversion and Expansion Factors

In the Swiss NFI, growing stock, gross growth, cut and mortality are expressed as stem-wood over bark including the above-ground part of the stock. Stem-wood over bark including stock was expanded to total biomass as described in Thürig et al. (2005) and by applying allometric single-tree functions to all trees measured at the NFI 3. Functions for twigs (diameter < 7 cm) and branches (diameter > 7 cm) were parameterized based on measurements from approximately 12'000 trees (Kaufmann 2001). Bark volume was estimated using the model by Altherr et al. (1978). Foliages were estimated using functions based on samples from 400 trees (Perruchoud et al. 1999). Coarse roots were estimated with functions from Wirth et al. (2004) for coniferous trees and from Wutzler et al. (2008) for deciduous trees.

Values of stem-wood over bark including stock and branches, delivered in volume units ( $\text{m}^3 \text{ha}^{-1}$ ) were converted into mass units ( $\text{t ha}^{-1}$ ) by multiplying with species specific wood densities (Assmann 1961). Values for twigs, foliages and coarse roots are already given in mass units ( $\text{t ha}^{-1}$ ).

A biomass conversion and expansion factor (BCEF; IPCC 2006) combines the conversion of volume-units into mass-values and the expansion into total biomass. BCEF is calculated as the ratio between stem-wood over bark including stock ( $\text{m}^3 \text{ha}^{-1}$ ) and the total above- and below-ground biomass ( $\text{t ha}^{-1}$ ). BCEF has the dimension ( $\text{t m}^{-3}$ ) and transforms by means of one single multiplication growing stock, net annual increment, or wood removals ( $\text{m}^3$ ) directly into total living biomass, total biomass growth, or biomass removals (t). Multiplication with species specific wood densities to convert volume-based forest inventory data into mass-based values is no longer needed. Biomass conversion and expansion factors were calculated for each spatial stratum and are listed in Table 7-16.

Table 7-16 Biomass conversion and expansion factors to convert stem-wood over bark including stock ( $\text{m}^3 \text{ha}^{-1}$ ) to total biomass ( $\text{t ha}^{-1}$ ) for conifers and deciduous species, respectively. The factors are derived from NFI 3 data. In the Alps (NFI production region 4) below 1200 m, BCEFs are additionally separated for eastern and western Alps.

NFI region	Altitude [m]	BCEF conifers [ $\text{t m}^{-3}$ ]	BCEF deciduous species [ $\text{t m}^{-3}$ ]
1	<601	0.60	0.81
	601-1200	0.63	0.80
	>1200	0.67	0.83
2	<601	0.60	0.86
	601-1200	0.61	0.86
	>1200	0.72	0.82
3	<600	0.61	0.82
	601-1200	0.61	0.79
	>1200	0.66	0.83
4 east	<601	0.61	0.87
4 west	<601	0.59	0.81
4 east	601-1200	0.62	0.81
4 west	601-1200	0.64	0.81
4	>1200	0.68	0.83
5	<601	0.69	0.81
	601-1200	0.66	0.90
	>1200	0.72	0.84

The weighted mean BCEF for conifers amounts to 0.64 and for deciduous species 0.83. For comparison, BCEF values were calculated from typical values for BEF, wood density and root-shoot ratio, which are listed in the 2003 IPCC GPG (IPCC 2003). Based on the IPCC tables, a mean BCEF of 0.84 was calculated for conifers and a mean BCEF of 0.99 for deciduous tree species. Thus, the BCEF values derived from IPCC defaults are in general higher than the values calculated for Switzerland.

#### e) Carbon Content

The IPCC default carbon content of solid wood of 50% was applied (IPCC 2003; p. 3.25).

#### f) Growing Stock, Gross Growth and Cut & Mortality in Productive Forests (CC 12)

Values for growing stock, gross growth, cut and mortality for productive forests (without afforestations) were derived from 5'425 common sample plots measured during NFI 1 and NFI 2 (Kaufmann 2001) and 5'581 samples measured during NFI 2 and NFI 3. All values derived from the national inventories are related to stem-wood over bark with the above-ground part of the stock and are available in volume units ( $\text{m}^3 \text{ha}^{-1}$ ) per spatial stratum (Table 7-17 and Table 7-18).

Table 7-17 Growing stock, gross growth, cut and mortality for coniferous trees (related to coniferous forest area). In the Alps (NFI production region 4) below 1200 m, data are additionally separated for eastern and western Alps.

NFI region	Altitude [m]	Growing stock 1985 [m <sup>3</sup> ha <sup>-1</sup> ]	Growing stock 1995 [m <sup>3</sup> ha <sup>-1</sup> ]	Growing stock 2005 [m <sup>3</sup> ha <sup>-1</sup> ]	Gross growth [m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ] NFI 1-2	Cut and mortality [m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ] NFI 1-2	Gross growth [m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ] NFI 2-3	Cut and mortality [m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ] NFI 2-3
1	<601	354.12	410.93	364.82	9.70	6.97	10.55	14.07
	601-1200	372.1	399.64	413.97	9.45	7.36	8.92	8.28
	>1200	255.32	255.82	275.99	5.79	4.91	5.01	3.11
2	<601	414.9	472.53	391.10	13.99	12.95	14.36	21.39
	601-1200	458.41	521.17	441.76	14.11	12.21	13.97	20.39
	>1200	282.75	329.91	300.27	3.23	2.44	0.87	4.03
3	<601	473.58	526.98	478.89	12.73	9.53	12.80	12.97
	601-1200	482.43	548.33	515.12	13.14	9.79	13.80	16.45
	>1200	356.09	372.58	379.68	7.61	5.96	7.53	7.45
4 east	<601	346.60	412.49	413.83	5.34	4.76	16.21	13.32
4 west	<601	171.38	225.11	241.79	7.59	4.49	7.94	7.12
4 east	601-1200	370.39	390.00	423.15	8.51	6.98	9.16	6.07
4 west	601-1200	260.16	290.12	298.37	7.16	5.56	5.61	5.12
4	>1200	295.36	296.92	319.95	5.72	4.80	5.40	4.01
5	<601	234.46	232.53	240.97	1.82	1.58	0.32	0.49
	601-1200	245.82	282.02	325.97	4.72	2.97	4.97	1.64
	>1200	229.02	245.93	282.54	4.38	1.42	4.45	1.56

Table 7-18 Growing stock, gross growth, cut and mortality for deciduous trees (related to deciduous forest area). In the Alps (NFI production region 4) below 1200 m, data are additionally separated for eastern and western Alps.

NFI region	Altitude [m]	Growing stock 1985 [m <sup>3</sup> ha <sup>-1</sup> ]	Growing stock 1995 [m <sup>3</sup> ha <sup>-1</sup> ]	Growing stock 2005 [m <sup>3</sup> ha <sup>-1</sup> ]	Gross growth [m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ] NFI 1-2	Cut and mortality [m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ] NFI 1-2	Gross growth [m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ] NFI 2-3	Cut and mortality [m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ] NFI 2-3
1	<601	322.29	351.65	334.88	9.61	6.12	7.51	9.85
	601-1200	318.04	361.61	392.04	8.93	5.41	8.51	5.96
	>1200	196.67	217.30	240.49	4.81	1.17	3.99	2.64
2	<601	342.05	341.68	357.23	13.05	9.61	10.96	9.47
	601-1200	370.66	373.17	407.98	13.66	8.52	10.75	7.52
	>1200	144.81	158.68	285.81	10.33	2.04	6.65	2.89
3	<601	379.93	419.41	417.42	11.13	6.59	10.36	7.25
	601-1200	374.75	381.12	429.69	11.23	6.02	11.15	6.01
	>1200	257.27	270.39	316.99	7.23	1.79	5.70	1.59
4 east	<601	382.98	316.64	365.78	10.91	11.86	7.44	4.62
4 west	<601	156.46	176.68	235.31	7.88	4.58	8.54	3.54
4 east	601-1200	249.86	282.71	319.42	8.39	3.50	7.01	3.59
4 west	601-1200	193.29	210.57	262.76	4.68	2.30	6.72	2.79
4	>1200	168.69	158.14	192.39	8.25	2.47	5.51	2.21
5	<601	152.10	176.19	208.48	5.26	2.84	5.82	3.36
	601-1200	134.02	163.75	210.28	5.04	2.12	5.39	1.51
	>1200	142.14	157.41	222.40	6.16	1.66	5.69	0.96

### Influence of climate variability on annual gross growth

To estimate the influence of annual climate variability on gross growth, the process-based model Biome-BGC<sup>18</sup> was applied. The application of Biome-BGC in Switzerland has been evaluated by Schmid et al. (2006).

Biome-BGC was run for climatic conditions typical for the differentiated spatial strata. The climate data were obtained from MeteoSchweiz<sup>19</sup> and cover a period of at least 27 years (see Thürig and Schmid 2008 for details). First, the model was run with annual climate data (monthly resolution) to simulate the annual net primary production (NPP). Second, the model was run with climate data averaged over all years (but still with monthly resolution) to simulate the average NPP for the same time period of at least 27 years (depending on the climate data available). The ratio between the annual growth and the average growth is defined as "climate factor". This factor can be calculated yearly and represents the deviation of the growth of a specific year from the average growth in the simulation period.

In order to calculate climate factors for future years without applying the complex model Biome-BGC but by using simple climate data, multiple regression analyses were done: For each spatial stratum, the dependencies of the annual climate factors calculated by Biome-BGC (dependent variables) were correlated with monthly climate data of the corresponding years (explanatory variables). All explanatory variables had a significant influence on the dependent climate factor (P-Value ≤ 0.05). The coefficient of determination R<sup>2</sup> of this multiple

<sup>18</sup> See for example [http://www.ntsg.umd.edu/ecosystem\\_modeling/BiomeBGC/](http://www.ntsg.umd.edu/ecosystem_modeling/BiomeBGC/)

<sup>19</sup> <http://www.meteoschweiz.admin.ch/web/en/weather.html>

regression analysis was between 0.43 and 0.82; the parameters of the calibrated functions per spatial stratum can be found in Thürig et al. (2005a). These functions were then applied to calculate climate factors for current and future years from simple climate data (monthly values of precipitation and temperature).

To test the quality of the parameterized functions, annual climate factors for the years 1986-1995 were calculated for all spatial strata. As the annual climate factors display the relative deviance from the average growth, the average climate factors over the same time period should be equal to 1. Figure 7-8 shows the climate factors for all spatial strata averaged for the time period 1986-1994. The maximum deviance from the expected value is 9%, whereas the average deviance is 2.6%. Hence, these functions were assumed to be sufficiently precise to calculate annual growth values on the basis of simple annual climate data. A more detailed description of this analysis can be found in Thürig et al. (2005a), Thürig and Schmid (2008).

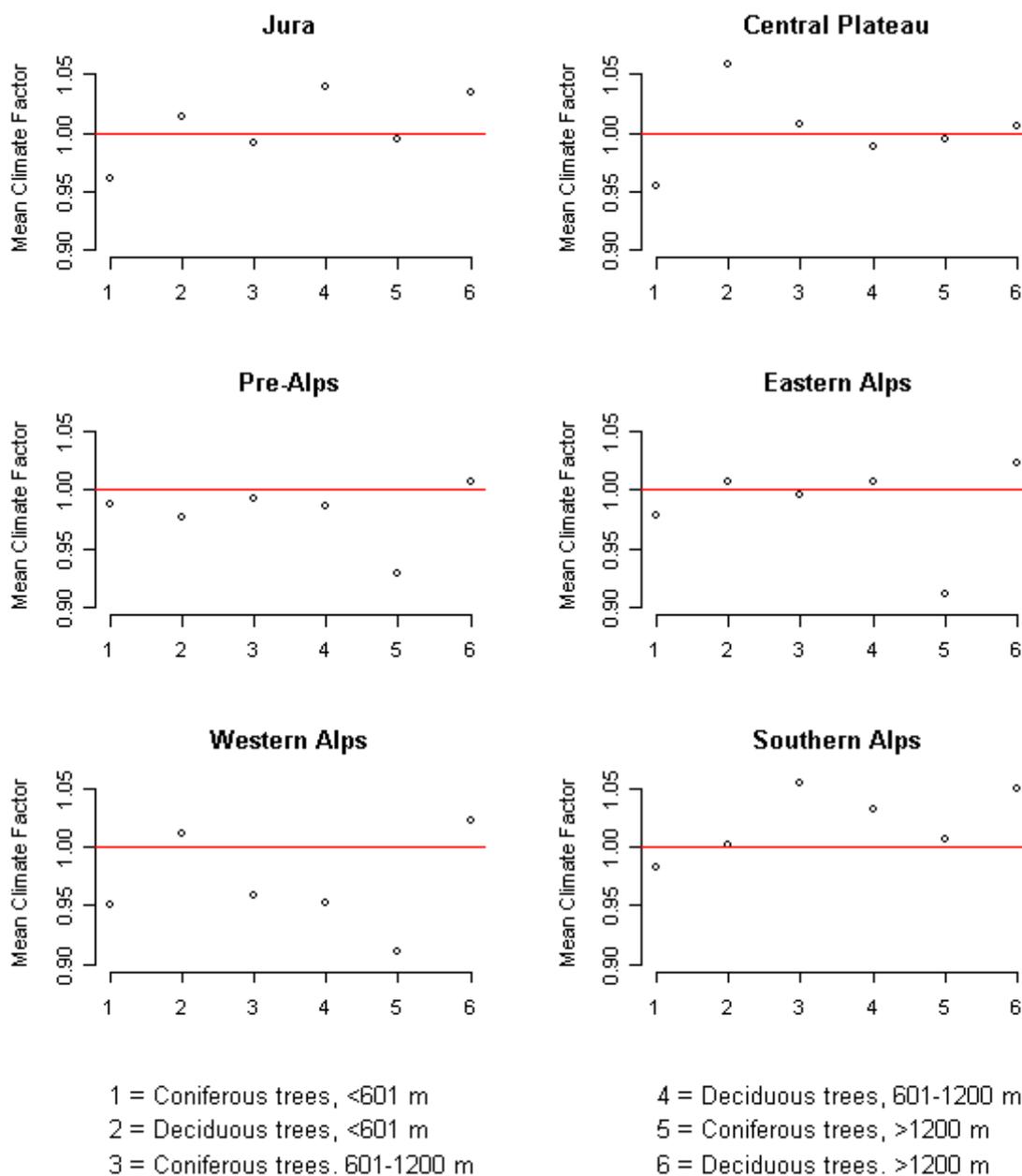


Figure 7-8 Climate factors calculated for the individual spatial strata, averaged for the years 1986-1994.

To avoid a systematic overestimation of the annual gross growth, the climate factors were standardized over the two intersurvey periods 1986-1995 and 1995-2005, such that these standardized climate factors are on average 1 over all spatial strata. Climate factors for years after 2005 were standardized by dividing the respective climate factor by the mean climate factor of the period 1995-2005. The resulting standardized climate factors for the time series 1986 to 2007 are displayed in Figure 7-9.

To calculate a time series of annual gross growth from 1990 to 2007, the values of average gross growth, which are derived from NFI 1-2 and NFI 2-3 respectively (see Table 7-17 and Table 7-18) were multiplied with the corresponding annual standardized climate factors as calculated by the functions mentioned above. Finally, the annual values of gross growth were averaged over a moving three-year period to smooth out strong fluctuations from interannual climatic variations (see Chapter 7.3.2.b).

Except for the Southern Alps below 600 m a.s.l., the estimated climate correction factors vary between 0.4 and 1.5. This leads to a variation of gross growth between -60% and +50% of the average gross growth between 1986 and 2007. The estimated climate correction factors for the lower Southern Alps (< 600 m) show an extreme growth reduction for the hot year 2003. This indicates that with respect to growth conditions prevailing in the lower Southern Alps and during dry climate years, the applied model Biome-BGC is outside its range of calibration and should be recalibrated. However, only 0.1% of the Swiss forest area is affected by this outlier. The climate correction factors estimated for the remaining 99.9% of the forest area and the corresponding growth variability due to annual climate variation are well in line with internationally published results.

International studies show that summer heat waves have an important influence on the average growth of forest ecosystems. For the year 2003, Ciais et al. (2005) estimated a 30% reduction in gross primary productivity over Europe. Their results suggested that productivity reduction in Eastern and Western Europe can be explained by rainfall deficit and extreme summer heat, respectively. According to a study by Dobbertin and Giuggiola (2006), stem growth in 2003 was reduced by 20 to 60% at low elevations (< 1200 m) in Switzerland. Similar results were published by Leuzinger et al. (2005) for a forest near Basel, Switzerland.

However, not all forests show the same reaction to extreme climatic events. A study by Jolly et al. (2005) indicated that growth responses to extreme climatic events vary along altitudinal levels. In 2003, satellite-derived photosynthetic activity estimates across the Alps revealed a pattern of enhanced growth at high elevation and reduced growth at low elevation in response to the extreme summer temperatures. The observed growth enhancement at high elevation is only partly reflected in the climate correction factors presented in this study (Figure 7-9). This identifies a missing sensitivity of the model, which is used to derive climate correction factors from simple climate data. This missing sensitivity could be caused by the fact that the method works with measured climate data from only 10 different climate stations. To cover all regions in Switzerland, precipitation and temperature were extrapolated by a climate model (see Thürig et al. 2005a for more details). To increase the sensitivity of the applied model and the estimated climate correction factors according to different altitudinal levels, the model should be re-run and stratified more explicitly for all altitudinal levels.

In Europe, the summer of 2003 was the hottest and driest in over 500 years (Luterbacher et al. 2004; Schär et al. 2004). Several studies predict an increasing frequency of summers like this one. Modeling results from Fuhrer et al. (2006) point out a summer trend towards decreasing frequency of wet days, and shorter recurrence times of heat waves and droughts. Comparison of our results with international studies increases the necessity of taking into account the effect of inter-annual climate variability on annual gross growth.

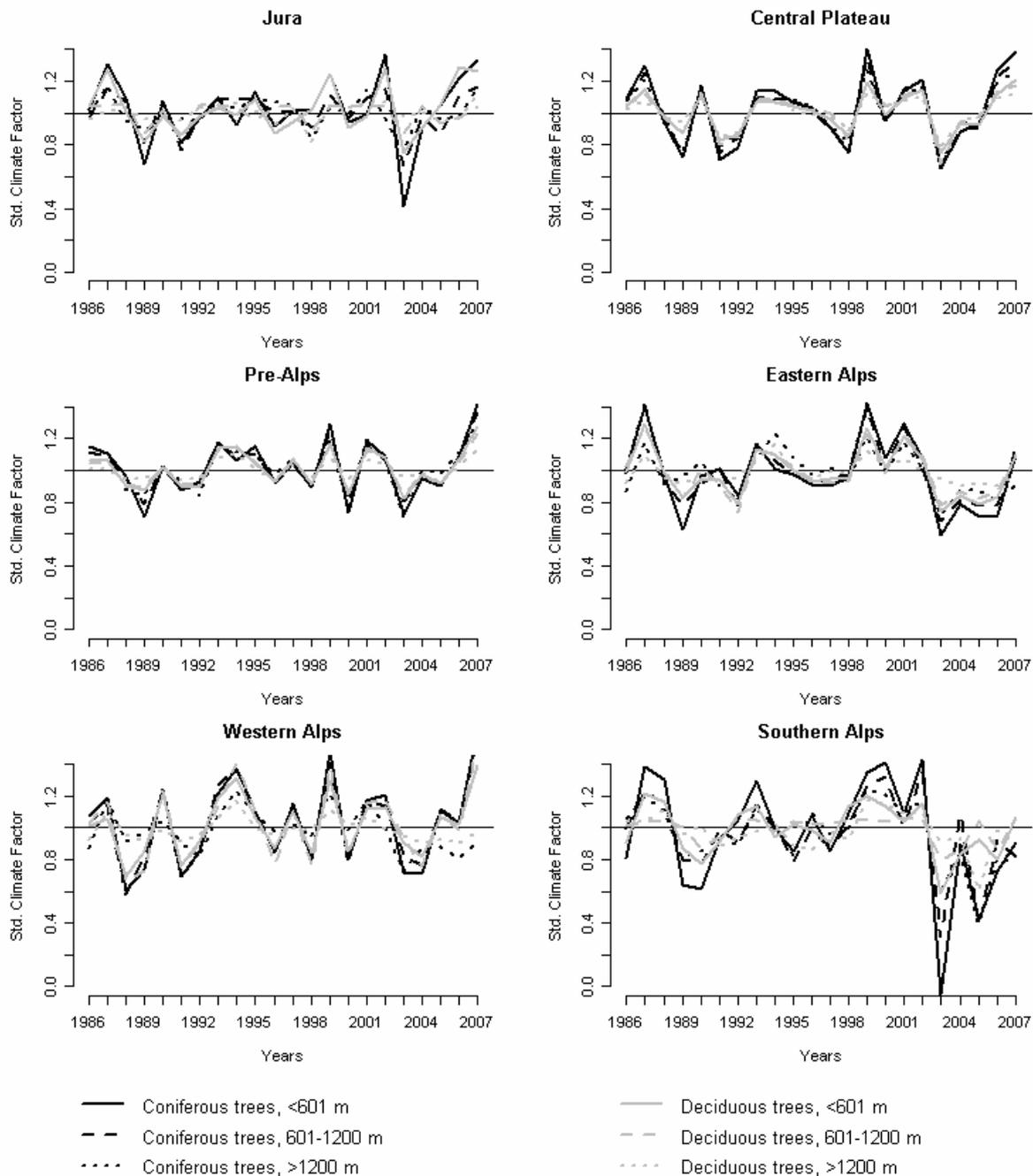


Figure 7-9 Standardized climate factors for the individual spatial strata from 1986 to 2007.

As mentioned before, annual values of gross growth were averaged over a moving three-year period. Annual and averaged values of gross growth for 1990-2007 for the Swiss Forest (values averaged over all spatial strata) are shown in Figure 7-10. By averaging annual values, the direct influence of climate is partially blanketed and the interpretation of the data is complicated. The reduction in gross growth in 2003 is strongly tempered by averaging over a three-year period. On the other hand, the influence of the hot summer 2003 is still detectable in the averaged value of gross growth for 2005.

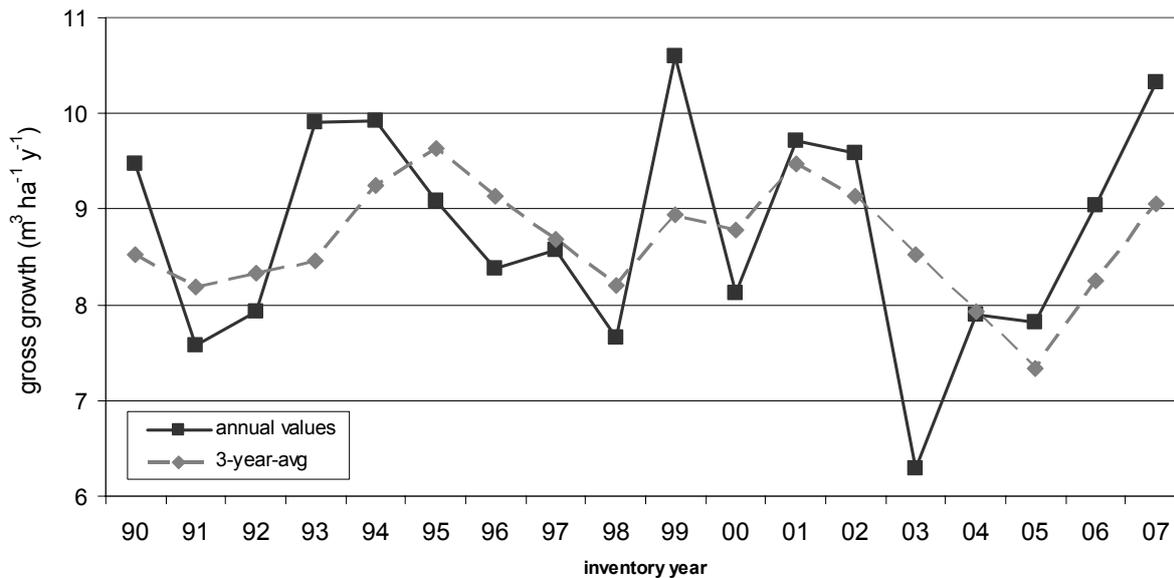


Figure 7-10 Annual and three-year-averaged values of gross growth (averaged over all strata) for the Swiss forest area from 1990 to 2007.

### Annual cut and mortality

An average value for cut and mortality (CM) is derived from the NFI 1 and NFI 2 dataset for the period 1985-1994 and from the NFI 2 and NFI 3 datasets for the period 1995-2005. To calculate annual values of cut and mortality (CM<sub>y</sub>) for the years 1985 to 1994 and 1995 to 2005, respectively, the average amount of cut and mortality was weighted by the percentage of the annual harvesting amounts taken from the forest statistics (Table 7-19; SFSO 2008a; FOEN 2009b, and additional data from former editions 1985-2008). Moving three-year averages of the harvesting amounts from the forest statistics were calculated in order to level out extreme events (see Chapter 7.3.2.b) such as storm Vivian in 1990 and storm Lothar in 1999.

Table 7-19 Annual harvesting amount in m<sup>3</sup> merchantable timber specified for NFI production region as well as for coniferous and deciduous tree species for the period 1990-2007 as derived from forest statistics (SFSO 2008a; FOEN 2009b, and additional data from former editions 1985-2008). All values were averaged over three years to compensate for extreme events.

Year	1. Jura		2. Central plateau		3. Pre-Alps		4. Alps		5. Southern Alps	
	Conif. [m <sup>3</sup> ]	Dec. [m <sup>3</sup> ]	Conif. [m <sup>3</sup> ]	Dec. [m <sup>3</sup> ]	Conif. [m <sup>3</sup> ]	Dec. [m <sup>3</sup> ]	Conif. [m <sup>3</sup> ]	Dec. [m <sup>3</sup> ]	Conif. [m <sup>3</sup> ]	Dec. [m <sup>3</sup> ]
2007	727'255	397'149	1'726'102	667'116	1'090'739	213'537	568'604	79'224	47'235	41'950
2006	681'354	357'113	1'788'551	606'050	1'082'363	191'691	524'433	75'116	36'300	39'261
2005	622'087	326'862	1'751'762	549'665	1'108'437	162'449	530'563	67'811	34'189	34'890
2004	551'910	316'752	1'617'068	509'352	1'135'069	147'134	534'976	65'377	32'781	35'617
2003	481'195	327'776	1'698'975	535'598	1'254'485	144'789	542'312	62'065	30'195	35'667
2002	626'798	351'805	2'448'000	674'298	1'603'283	168'724	491'872	60'187	24'903	35'522
2001	680'175	374'861	2'426'715	722'713	1'514'372	181'804	513'772	62'014	29'343	36'651
2000	733'872	402'682	2'196'853	733'718	1'300'811	184'017	562'665	78'246	38'806	38'572
1999	602'445	405'237	1'283'404	614'399	801'259	163'971	608'468	80'428	52'075	40'285
1998	575'006	399'476	1'191'359	590'606	744'730	156'410	579'223	77'391	53'319	40'188
1997	590'296	394'443	1'210'678	571'579	723'808	152'997	557'039	60'013	53'658	37'649
1996	597'544	393'817	1'241'999	556'409	742'348	147'125	604'935	61'095	46'972	35'501
1995	607'611	391'128	1'288'507	554'563	765'351	140'962	652'879	62'517	45'047	33'467
1994	575'928	379'505	1'225'395	554'916	752'565	132'571	701'336	67'181	43'628	31'723
1993	527'672	366'516	1'141'041	541'195	779'032	131'588	816'939	68'958	38'085	29'386
1992	573'269	361'633	1'328'880	556'023	966'390	133'405	1'034'064	71'000	31'106	25'943
1991	616'629	360'660	1'348'951	557'776	967'684	135'699	1'002'608	68'221	31'210	24'093
1990	669'756	364'296	1'400'390	582'340	963'683	138'833	851'765	65'707	38'790	24'026

For inventory years after 2005, no NFI data are available. Therefore, CM<sub>y</sub> for these years are calculated on the basis of the annual harvesting amounts derived from the annual forest statistics and corrected for the amount of total losses as observed in the NFI (e.g. natural mortality, harvesting damage). The correction factor (Table 7-20) was derived for all production regions and both tree species by building the ratio between total cut and mortality in the period 1995-2005 and the sum of the annual harvesting amount reported in the forest statistics from 1995 to 2005:

$$\text{Correction factor}_i = [ \sum_a \text{CM}_a * 11 ]_i / [ \sum_y \text{Harvesting amount forest statistics}_y ]_i$$

i = 1-10 (five NFI production regions and two tree species)

a = 1-3 (three zones of altitude: <601 m, 601-1200 m, >1200 m)

y = 1995-2005

Table 7-20 Correction factors to convert annual harvesting amounts from the forest statistics (SFSO 2008a) into total amount of cut and mortality for inventory years after 2005.

NFI region	Tree species	Correction factors
1	coniferous	1.459
1	deciduous	1.819
2	coniferous	1.537
2	deciduous	1.528
3	coniferous	1.889
3	deciduous	1.888
4	coniferous	2.225
4	deciduous	2.507
5	coniferous	2.222
5	deciduous	3.798

### Growing stock: Calculation of time series

In order to develop a consistent time series, annual growing stocks (GS) are calculated backward or forward starting from the growing stock 2005, determined from NFI 3.

A backward calculation is used for the time period 1985-2004, meaning that the annual growing stock equals the growing stock 2005 minus the cumulated gains of the annual gross growths and plus the cumulated annual amounts of cut and mortality (CM<sub>y</sub>).

Growing stocks for inventory years after 2005 are determined using a forward calculation, i.e. adding the cumulated annual gross growths to the growing stock 2005, and subtracting the cumulated annual amounts of cut and mortality (CM<sub>y</sub>).

$$GS_{iy} = GS_{2005} - \sum_y [\text{annual gross growth}_y] + \sum_y [CM_y] \quad \text{for } iy < 2005$$

$$GS_{iy} = GS_{2005} \quad \text{for } iy = 2005$$

$$GS_{iy} = GS_{2005} + \sum_y [\text{annual gross growth}_y] - \sum_y [CM_y] \quad \text{for } iy > 2005$$

where the "iy" indicates the inventory year and "y" refers to the years between 2005 and the inventory year.

These values, given in stem-wood over bark including stock [m<sup>3</sup> ha<sup>-1</sup>], were converted to carbon in living biomass [t C ha<sup>-1</sup>] as follows:

$$[C \text{ in living biomass}]_s = \sum_t [\text{stem-wood over bark incl. stock}]_{s,t} * BCEF_{s,t} * C\text{-content} * [\text{percentage of tree species}]_{t,s}$$

where "s" refers to the 15 spatial strata and "t" the two tree species classes (coniferous and deciduous trees).

An overview of the values of gross growth, cut & mortality and calculated growing stock for the period 1990 to 2007 specified for all spatial strata are displayed in Table 7-11.

All steps, data and Excel files needed to reproduce the calculation of the CC12 emission factors of the period 1990-2007 are summarized in FOEN (2008e).

## g) Growing Stock, Gross Growth and Cut and Mortality in Unproductive Forests (CC 13)

### Brush forest

Brush forests in Switzerland mainly consist of *Alnus viridis* and horizontal *Pinus mugo* var. *prostrata*. No NFI data are available to derive their growing stock. Therefore, following assumptions were met to describe the stocks: 4000 trees per ha, average height of 2.5 m and an average diameter at 1.3 m of 10 cm. Hence, an average growing stock (> 7 cm diameter) of 40 m<sup>3</sup> ha<sup>-1</sup> was estimated. Multiplied by the mean BCEF for coniferous trees of 0.64, an average biomass for brush forest of 25.7 t ha<sup>-1</sup>, which translates to 12.9 t C ha<sup>-1</sup> (using the IPCC default carbon content of 50%) was estimated.

### Forest on unproductive areas

Forest on unproductive areas in Switzerland is mainly located in the Alps and the Southern Alps where the average growing stock is around 318 m<sup>3</sup> ha<sup>-1</sup> and 219 m<sup>3</sup> ha<sup>-1</sup>, respectively (Brassel and Brändli 1999). In those forests, no NFI data are available to derive growing stocks. As those forests are assumed to grow preferably on bad site conditions, an average growing stock (> 7 cm diameter) of 150 m<sup>3</sup> ha<sup>-1</sup> was estimated. Multiplied by the mean BCEF for coniferous trees of 0.64, an average biomass for forest on unproductive areas of 96.4 t ha<sup>-1</sup>, which translates to 48.2 t C ha<sup>-1</sup> (using the IPCC default carbon content of 50%) was estimated.

### Carbon content of unproductive forests (CC 13): Weighted means

The unproductive forest in Switzerland mainly consists of brush forest and forest on unproductive areas. The carbon content of unproductive forest was therefore calculated as a weighted average of brush forest and forest on unproductive areas per spatial stratum:

$$[\text{weighted C content}]_i = \text{RS}_i * \text{CS} + (1 - \text{RS}_i) * \text{CI}$$

where  $\text{RS}_i$  is the rate of the brush forest per spatial stratum  $i$ ,

CS is the carbon content of brush forest (12.9 t C ha<sup>-1</sup>),

CI is the carbon content of forest on unproductive areas (48.2 t C ha<sup>-1</sup>).

Table 7-21 shows the carbon content per spatial stratum in t C ha<sup>-1</sup>.

Table 7-21 Rate of brush forest and forest on unproductive areas and the resulting weighted carbon content in t C ha<sup>-1</sup> of Swiss unproductive forests (CC 13) specified for all spatial strata.

NFI region	Altitude [m]	Brush forest(*) [ha]	Forest on unproductive area [ha]	Total unproductive forest [ha]	Rate of brush forest	Weighted C content [t C ha <sup>-1</sup> ]
1	<601	25	356	381	0.066	45.90
	601-1200	1	1780	1781	0.001	48.20
	>1200	1	178	179	0.006	48.03
2	<601	25	534	559	0.045	46.64
	601-1200	25	356	381	0.066	45.90
	>1200	1	0	1	1.000	12.86
3	<601	25	356	381	0.066	45.90
	601-1200	50	3204	3254	0.015	47.68
	>1200	2100	1780	3880	0.541	29.08
4	<601	100	356	456	0.219	40.47
	601-1200	1925	4984	6909	0.279	38.37
	>1200	36925	7120	44045	0.838	18.58
5	<601	200	534	734	0.272	38.59
	601-1200	2550	3560	6110	0.417	33.46
	>1200	16875	5162	22037	0.766	21.14

\* Derived from the NFI 2 (Brassel and Brändli 1999)

### Gross growth and cut and mortality of unproductive forests (CC 13)

As no harvesting is conducted in unproductive forests, gross growth and cut and mortality of unproductive forest are assumed to be in balance.

#### h) Dead Organic Matter

##### Dead wood pool

In the second and third NFI, the DBH of all dead trees (standing and lying) with a diameter of at least 12 cm was measured. Applying the biomass functions of living trees, stemwood volume including bark, tree-top and stump as well as dead roots were estimated. According to the degree of decay the volume of large branches ( $\geq 7$  cm) was also added. The volume of dead wood was converted to biomass by applying wood densities of living trees and dead wood stock (DWS) larger than 12 cm was calculated for NFI 2 (DWS<sub>2,>12</sub>) and NFI 3 (DWS<sub>3,>12</sub>) per spatial stratum.

Additionally, during NFI 3, the amount of dead wood between 7 and 12 cm (DWS<sub>3,7-12</sub>) was measured by the line intersect method. On basis of this dataset dead wood stock between 7 and 12 cm for the second NFI (DWS<sub>2,7-12</sub>) was estimated as follows:

$$DWS_{2,7-12} = DWS_{3,>12} * ( DWS_{2,>12} / DWS_{3,>12} )$$

Estimates of the total dead-wood pool for trees with a diameter larger than 7 cm (DWS<sub>2,>7</sub> and DWS<sub>3,>7</sub>) in Swiss productive forests (CC 12) are shown in Table 7-22, differentiated for 15 spatial strata.

Table 7-22 Dead wood stock in Swiss productive forests (CC 12) per spatial stratum in t C ha<sup>-1</sup> derived from NFI 2 (DWS<sub>2,>7</sub>; Brassel and Brändli 1999) and NFI 3 (DWS<sub>3,>7</sub>).

NFI region	Altitude [m]	Carbon in dead wood stock > 7 cm [t C ha <sup>-1</sup> ] NFI 2	Carbon in dead wood stock > 7 cm [t C ha <sup>-1</sup> ] NFI 3
1	<601	4.83	5.89
	601-1200	4.87	5.98
	>1200	1.94	4.12
2	<601	1.73	4.95
	601-1200	2.46	5.82
	>1200	19.53	10.87
3	<601	0.90	6.79
	601-1200	3.99	8.52
	>1200	7.31	14.13
4	<601	3.22	5.94
	601-1200	8.02	8.27
	>1200	7.47	8.11
5	<601	5.53	9.18
	601-1200	3.34	5.57
	>1200	5.14	6.24

### Annual changes in dead wood pool

By analysing the difference in dead wood with a diameter larger than 7 cm between the NFI 2 and NFI 3, temporal changes of the dead wood pool were calculated.

Weighted annual changes in the dead wood pool in Swiss forests were calculated using additional data from the Sanasilva-monitoring network (Brang 1998, Dobbertin et al. 2001). The Sanasilva network provides annual data on the relative basal area of lying and standing trees. A statistical regression was calculated between the dead wood stock, provided by the NFI, and the relative basal area, found in the Sanasilva database. Based on this regression, annual values of dead wood stock were calculated for the period 1990-2007 (see Figure 7-11). For the inter-survey period 1995-2005, the difference in the dead wood pool between the two national forest inventories was weighted by the relative share of the basal area. For the time period 1990-1995 and for the years after 2005, annual values were calculated by extrapolating the dependency found between the relative basal area and the amount of dead wood for the period 1995-2005. Finally, all annual changes were averaged over a moving three-year period.

All steps, data and Excel files needed to reproduce the calculation of annual changes in dead wood stock are summarized in FOEN (2008f).

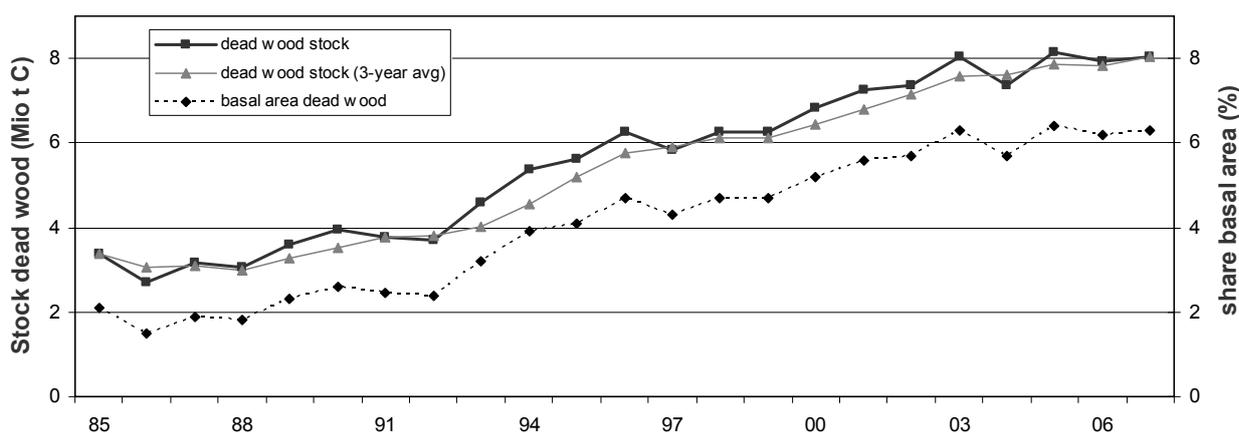


Figure 7-11 Annual changes in dead wood stock and in the share of basal area of dead wood (Dobbertin 2008) 1985-2007. Weighted annual values of dead wood stock in Swiss productive forests were averaged over three years (3-year avg).

### Carbon in organic soil horizons on mineral forest soils

According to the Good Practice Guidance LULUCF (IPCC 2003) soil carbon of the organic soil horizons should be estimated as dead organic matter, together with dead wood.

Therefore, soil carbon of mineral forest soils in organic soil horizons of Swiss productive and unproductive forests (CC 12 and CC 13) is added to the dead wood pool.

The soil horizons L (litter), F (fermentation) and H (humus) were estimated in a study done by Moeri (2007) as follows.

#### Acquisition of data:

Thirty sites were sampled for which the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) already had a complete data set of soil C concentrations and density in the mineral soils. On each of these 30 study sites, measurements were made within an area of 50 x 50 m: eight randomly distributed samples of the forest floor (20 x 20 cm) were taken, stratified for the individual organic layers. The thickness of the organic layers (L-, F-, H- horizons) was measured perpendicular to the surface. In addition, the thickness of the organic layers was recorded along two transects with 20 measurements.

Samples were dried at a temperature of 60°C to constant weight (at least 24 hours), weighted and the densities ( $\text{g/cm}^3$ ) were calculated. The average densities ( $\pm$  sd) were: L =  $0.09 \pm 0.05$ , F =  $0.14 \pm 0.06$ , H =  $0.22 \pm 0.08$ . Finally, samples were milled and analysed for their C and N concentrations (NC 2500, Carlo Erba Instruments).

#### Database:

Data of approximately 1300 soil profiles, investigated during the past 10-15 years, are stored in a database at WSL. Approximately 870 sites with different information on the soil characteristics distributed among different forest types throughout Switzerland were chosen for this study. The information included thickness of the organic layers and sometimes measured carbon content analysis. Additional information had to be deduced from pictures and field protocols.

The soil organic carbon stock at each site as shown in Table 7-23 was calculated in two steps:

(1) The mass of the organic layers was assessed by their thickness and density (mass = density \* thickness).

(2) The C concentration (%) was derived from laboratory data contained in the WSL database. Approximately 400 sites were selected and used for this study. The C concentrations were stratified for coniferous, mixed and for deciduous forests and average C concentrations were calculated. These average C concentration values per stratum enabled the calculation of the amount of carbon in organic soil horizons for each site.

In this submission, no changes in carbon stocks in organic soil horizons on mineral forest soils are reported for all inventory years.

### **Total dead organic matter**

Annual values of carbon stock in dead organic matter are calculated as the sum of carbon in dead wood and of carbon in the organic soil horizons of mineral forest soils (CC 12, CC 13). While carbon in the dead wood pool consists of annual changing values, no changes in carbon stocks of organic soil horizons are reported. Annual changes in dead organic matter are calculated for all 15 spatial strata as shown in Table 7-11.

In Switzerland, afforestations (CC11) occur mostly on grasslands (see Table 7-7 in Section 7.2.5) where there is no litter and no dead wood. Therefore, assuming no carbon stock in dead organic matter on afforestation sites, we could follow the Tier 1 approach in terms of IPCC good practice (IPCC 2003, Sect. 3.1.5) and consistently report no changes in the litter and dead wood pool.

So far, there are no data available about dead wood in unproductive forests (CC 13) and dead wood stock is reported as NE in Table 7-24. Assuming no carbon stock in dead wood on CC13 sites, we followed the Tier 1 approach in terms of IPCC good practice (IPCC 2003, Sect. 3.1.5) and report no changes in the dead wood pool. Thus, for unproductive forests the amount of dead organic matter is estimated as the carbon content in organic soil horizons of mineral forest soils.

Table 7-23 exemplarily presents the CC12 values for the year 2007 (see Table 7-11 for entire 1990-2007 dataset), while CC13 values listed in Table 7-24 are valid for the period 1990-2007.

Table 7-23 Carbon stock in dead organic matter of productive forests (CC 12) for 2007.

NFI Region	Altitude [m]	Carbon in dead wood [t C ha <sup>-1</sup> ]	Carbon in L, F and H horizon [t C ha <sup>-1</sup> ]	Carbon stock in dead organic matter (stockCd,i) [t C ha <sup>-1</sup> ]
1	<601	5.81	9.7	15.51
1	601-1200	5.90	9.7	15.60
1	>1200	4.06	9.7	13.76
2	<601	4.89	9.5	14.39
2	601-1200	5.74	9.5	15.24
2	>1200	10.72	9.5	20.22
3	<601	6.70	17.4	24.10
3	601-1200	8.40	17.4	25.80
3	>1200	13.94	17.4	31.34
4	<601	5.86	33.4	39.26
4	601-1200	8.15	33.4	41.55
4	>1200	8.00	33.4	41.40
5	<601	9.06	22.3	31.36
5	601-1200	5.50	22.3	27.80
5	>1200	6.16	22.3	28.46

Table 7-24 Carbon stock in dead organic matter of unproductive forests (CC 13); values valid for all inventory years.

NFI Region	Altitude [m]	Carbon in dead wood [t C ha <sup>-1</sup> ]	Carbon in L, F and H horizon [t C ha <sup>-1</sup> ]	Carbon stock in dead organic matter (stockCd,i) [t C ha <sup>-1</sup> ]
1	<601	NE	9.7	9.7
1	601-1200	NE	9.7	9.7
1	>1200	NE	9.7	9.7
2	<601	NE	9.5	9.5
2	601-1200	NE	9.5	9.5
2	>1200	NE	9.5	9.5
3	<601	NE	17.4	17.4
3	601-1200	NE	17.4	17.4
3	>1200	NE	17.4	17.4
4	<601	NE	33.4	33.4
4	601-1200	NE	33.4	33.4
4	>1200	NE	33.4	33.4
5	<601	NE	22.3	22.3
5	601-1200	NE	22.3	22.3
5	>1200	NE	22.3	22.3

### i) Soil carbon in Productive Forests (CC 12), Unproductive Forests (CC 13) and Afforestations (CC 11)

Perruchoud et al. (2000) interpolated 136 forest soil samples from the "Waldzustandsinventar 1993 - Bodenkundliche Erhebungen" (Lüscher et al. 1994). According to this study an average carbon stock of mineral forest soils of  $76 \text{ t C ha}^{-1}$  in 0-30 cm topsoil is assumed. These soil samples were stratified for the five NFI production regions (Table 7-25).

Table 7-25 Soil organic carbon (SOC) of mineral forest soils (CC 11, CC 12, CC 13) in mineral soil horizons (0-30 cm) in  $\text{t C ha}^{-1}$  in the 5 NFI production regions (N = number of samples): The average values  $\pm$  standard deviation are given.

NFI region (N)	SOC of mineral topsoil 0-30 cm
1. Jura (32)	75.0 ( $\pm$ 37.2)
2. Central Plateau (24)	62.6 ( $\pm$ 32.6)
3. Pre-Alps (25)	75.3 ( $\pm$ 21.4)
4. Alps (39)	72.1 ( $\pm$ 40.6)
5. Southern Alps (16)	109.0 ( $\pm$ 43.7)
Total Switzerland (136)	76.0 ( $\pm$ 37.6)

Due to following reasons it is assumed that in the years 1990 to 2007 forest soils in Switzerland were no source of carbon:

- Within the last decades, no drastic changes of management practices in forests have been taken place because the Swiss forest law (Swiss Confederation 1991) is very restrictive.
- Fertilization of forests is prohibited by the Swiss forest law and adherent ordinances (Swiss Confederation 1991, 1992). Drainage of forests is not a permitted practice in Switzerland.
- As growing stock has increased since many years, soil carbon is assumed to increase due to increasing litter production.
- As shown in the study by Thürig et al. (2005), wind-throw may have a slightly increasing effect on soil carbon. However, this study neglected the effect of soil disturbances which could equalize those effects.

### k) Carbon Stock of Afforestations (CC 11)

#### Growing stock and growth

As the NFI 3 data have not yet been analyzed with respect to afforestations, the average growing stock and growth of afforestations were empirically assessed from NFI 1 and NFI 2 data, specifically with those stands that were approximately 10 years old in the first NFI and 20 years old in the second NFI. The average growing stock of those 20 year old stands was derived from NFI 2. The NFI data were therefore stratified for site quality. It was assumed that forest areas below 600 m show a good site quality, areas between 600 and 1200 m a moderate site quality, and forest areas above 1200 m show a poor site quality. The growing stock of forest stands on good sites was  $90 \text{ m}^3 \text{ ha}^{-1}$ . The growing stock on moderate sites was assumed to be one-third smaller than on good sites ( $60 \text{ m}^3 \text{ ha}^{-1}$ ), and two-thirds smaller on bad sites ( $30 \text{ m}^3 \text{ ha}^{-1}$ ). As trees below 12 cm diameter at breast height (DBH) were not measured in the NFI, the growing stock of 10 year old stands on good sites was assumed to be  $2 \text{ m}^3 \text{ ha}^{-1}$ . Within the first few years of stand age, the growing stock was assumed to

develop exponentially. The development of the growing stock on good sites between 10 and 20 years was therefore simulated by calibrating an exponential growth function. To simulate the development of growing stock on intermediate and poor sites, growing stock was assumed to develop one-third slower on intermediate, and two-thirds slower on poor sites. The annual growth was calculated as the difference between growing stocks of the two following years. These assumptions are not valid for single stands, but can be applied as a rough simplification. Table 7-26 shows the simulated growing stock and growth for the three altitudinal levels.

Table 7-26 Estimated average growing stock and annual growth of forest stands in stem-wood over bark including stock (defined in Table 7-27) up to 20 years (CC 11) specified for altitude zone. Bench marks derived from NFI 1 and NFI 2 (see text above) in bold letters.

Stand age [yr]	< 601 m altitude		601 - 1200 m altitude		> 1200 m altitude	
	Growing stock [m <sup>3</sup> ha <sup>-1</sup> ]	Growth [m <sup>3</sup> ha <sup>-1</sup> year <sup>-1</sup> ]	Growing stock [m <sup>3</sup> ha <sup>-1</sup> ]	Growth [m <sup>3</sup> ha <sup>-1</sup> year <sup>-1</sup> ]	Growing stock [m <sup>3</sup> ha <sup>-1</sup> ]	Growth [m <sup>3</sup> ha <sup>-1</sup> year <sup>-1</sup> ]
0-9	0	0	0	0	0	0
10	<b>2</b>	2	0	0	0	0
11	7	5	0	0	0	0
12	13	6	1	1	0	0
13	19	6	5	4	0	0
14	27	8	10	5	0	0
15	35	8	16	6	1	1
16	44	9	23	7	5	4
17	54	10	31	8	10	5
18	66	12	40	9	16	6
19	78	12	50	10	23	7
20	<b>90</b>	12	<b>60</b>	10	<b>30</b>	7

To convert the estimated growing stock (m<sup>3</sup> ha<sup>-1</sup>) and growth [m<sup>3</sup> ha<sup>-1</sup> year<sup>-1</sup>], both expressed in volume units, into tonnes of carbon, the following equations were applied:

$$\text{C stock in living biomass} = \text{Average growing stock} * \text{BCEF} * \text{C-content}$$

$$\text{Growth of living biomass} = \text{Average growth} * \text{BCEF} * \text{C-content}$$

In Table 7-27, abbreviations and units are explained. Table 7-28 shows the values of the specific parameters.

Table 7-27 Conversion of growing stock and growth to total carbon in biomass.

Name	Description	Value	Unit
Average growing stock	Average growing stock of stem-wood over bark including stock without branches	See Table 7-28	m <sup>3</sup> ha <sup>-1</sup>
Average growth	Average growth per ha and year	See Table 7-28	m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup>
BCEF	Biomass conversion and expansion factor converts the volume of growing stock and the volume of net annual increment to total tree biomass and total tree biomass growth, respectively; averaged value for coniferous and deciduous trees (see Chapter 7.3.2.c)	0.7	-
C-content	Carbon to total biomass ratio (IPCC default)	0.5	-
C stock in living biomass	Carbon content in total above- and belowground biomass	See Table 7-28	t C ha <sup>-1</sup>
Growth of living biomass	Growth of carbon in t C per ha and year	See Table 7-28	t C ha <sup>-1</sup> yr <sup>-1</sup>

Table 7-28 Carbon stock in living biomass and growth of living biomass in afforestations (CC 11) specified for altitude zone.

Altitude [m]	Average growing stock [m <sup>3</sup> ha <sup>-1</sup> ]	Average growth [m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ]	BCEF	Carbon content	Carbon stock in living biomass [t C ha <sup>-1</sup> ]	Growth of living biomass [t C ha <sup>-1</sup> yr <sup>-1</sup> ]
<601	36.25	7.5	0.7	0.5	12.72	2.63
601-1200	19.67	5	0.7	0.5	6.90	1.75
>1200	7.08	2.5	0.7	0.5	2.48	0.88

### l) Specifications for Calculating Carbon Fluxes in Case of Land-use Change Comprising Forest Land

According to the land use statistics (SFSO 2008), each year certain areas switch from a non-Forest Land use category to Forest Land. These are mainly areas that used to be populated with grassland or woody biomass (see Table 7-7) not fulfilling the definition of minimal forest density and area. According to the stock change approach, the growing stock of e.g. shrub vegetation (CC 32) (living biomass and soil carbon) should be subtracted and the average growing stock of forests should be added. However, these forests are supposed to have a growing stock smaller than the growing stock of an average forest and adding the average growing stock of forest areas would possibly overestimate the carbon increase. In terms of IPCC good practice a legitimate conservative assumption was met (see also Chapter 7.2.1): The amount of living biomass (carbon stock in living biomass) on land changing from non-forest to forest was not increased but left unchanged. The annual increase of biomass (carbon flux) on these areas was approximated by the annual gross growth rate of the respective forest type (CC 11, CC 12, CC 13). The change in dead organic matter and in soil carbon was not considered and was set to zero.

Cut and mortality was inferred from NFI data, applying the stock change approach on forest areas remaining forest. Thus, the total harvesting amount of Switzerland was already considered. To avoid double-counting of the harvesting amount on areas changing from non-forested to forested areas, no additional loss in terms of cut and mortality was accounted for, but the converted areas were only multiplied with the average annual gross growth of the respective spatial stratum.

The annual area of forest changing to other land-use categories was also derived from the land use statistics. To account for the "decrease of carbon", the current above- and belowground biomass, the amount of dead wood and the amount of soil carbon of forest areas changing into other land use categories were subtracted. To account for the "increase of carbon", the carbon stock in biomass and soil of the new land use category was added.

### m) N<sub>2</sub>O Emissions from N Fertilization and Drainage of Soils

Fertilization of forests is prohibited by the Swiss forest law and adherent ordinances (Swiss Confederation 1991, 1992). Therefore, no emissions are reported in CRF Table 5(I).

Drainage of forests is not a permitted practice in Switzerland. There are no survey data available, but the drained area is probably very small, if existing at all (see also Chapter 7.6.2. As a first guess drainage activity was set to zero, and no emissions are reported for forest land in CRF Table 5(II).

## n) Emissions from Wildfires

Data on wildfires affecting Swiss forest land can be obtained from cantonal authorities and is compiled by the FOEN (FOEN 2009b). Table 7-29 shows the annual number of fires and the burnt area from 1990 to 2007.

As controlled burning is not allowed in Switzerland all fires are assigned to “wildfires”. It was assumed that all fires affected productive forests.

The emission factor for CH<sub>4</sub> is 0.354 Mg CH<sub>4</sub> ha<sup>-1</sup> as proposed by EEA (2006).

For N<sub>2</sub>O, the default emission factor of 0.11 g (kg combusted biomass)<sup>-1</sup> is applied (IPCC 2003, Table 3A.1.16).

The mass of available fuel is estimated to average 250'000 kg biomass ha<sup>-1</sup>. This value has been derived from the mean growing stock in Switzerland (Brassel and Brändli 1999) using a value of 1.45 for BEF and 0.47 t m<sup>-3</sup> for wood density. The fraction of the biomass combusted is 0.45 (IPCC 2003, Table 3A.1.12). Inserting these values in equation 3.2.20 of IPCC (2003), the emissions shown in Table 7-29 are calculated.

CO<sub>2</sub> emissions caused by wildfires are included in CRF Table 5A.

Table 7-29 Productive forest land affected by wildfires (FOEN 2009b) and resulting GHG emissions 1990-2007.

Year	Number	Area burnt [ha]	CH <sub>4</sub> [Mg]	N <sub>2</sub> O [Mg]
1990	216	1102	390.11	13.64
1991	157	148	52.39	1.83
1992	111	52	18.41	0.64
1993	99	42	14.87	0.52
1994	52	293	103.72	3.63
1995	56	438	155.05	5.42
1996	61	233	82.48	2.88
1997	77	1511	534.89	18.70
1998	88	249	88.15	3.08
1999	31	9	3.19	0.11
2000	41	36	12.74	0.45
2001	39	37	13.10	0.46
2002	75	410	145.14	5.07
2003	189	564	199.66	6.98
2004	46	20	7.08	0.25
2005	97	47	16.64	0.58
2006	70	101	35.75	1.25
2007	64	234	82.84	2.90

## o) NMVOC Emissions

Estimates for annual biogenic emissions of NMVOC in Switzerland for forests (and natural grassland) are available in SAEFL (1996a): The values are 92.0 Gg for coniferous forests, 2.4 Gg for deciduous forests and 0.61 Gg for forest fires. These numbers are based on a study from Andreani-Aksoyoglu and Keller (1995). Approximately 97% of the total emissions are monoterpene and the rest consists of isoprene (Keller et al. 1995).

### 7.3.3. Uncertainties and Time-Series Consistency

In the forest sector, an overall uncertainty of 40% was calculated for the emission factors (biomass changes in terms of carbon per unit area) (see also Table 7-8).

For living biomass, the following information was used:

- Growth: NFI data without application of climate factor: 2% (background: Brassel and Brändli 1999)
- Cut & mortality: NFI-Data with application of climate factor: 15% (background: Brassel and Brändli 1999)
- Carbon content in solid wood: 5-10% (background: Lamtom and Savidge 2003, assessment of carbon content in wood; Monni et al. 2007, 2%)
- Wood density: guess 10-20% (background: Lamtom and Savidge 2003)
- Biomass expansion: The uncertainty is estimated to be 30% (background: Monni et al. 2007, Appendix 1, 2.7-21.3%; Vanninen and Mäkelä 1999; Cronan 2003; Helmisaari and Hallbäcken 1998).

Thus, the overall uncertainty of carbon losses and gains in living biomass in terms of carbon per unit area can be calculated as:

$$U_{\text{overall}} = (2^2 + 15^2 + 10^2 + 15^2 + 30^2)^{0.5} = 38\%$$

The total uncertainty of the annual changes in dead wood depends on several factors:

- Accuracy of the Sanasilva observations: The estimate of the share of the basal area of dead wood shows relatively large confidence intervals, resulting in an error of 37.7% (Dobbertin 2008).
- Spatial representativity of the Sanasilva plots: Sanasilva plots have to be representative for Swiss forests. The 48 Sanasilva plots cover ca. 10 000 ha, corresponding to an error of 12% (Brassel and Brändli 1999).
- Biomass expansion: The uncertainty of applying biomass functions is comparable with the uncertainty typical for BCEF and is estimated to be 30% (e.g. Monni et al. 2007).
- Accuracy of the estimations of dead wood, provided by the NFI data: The error is estimated to be 2-3% and thus only plays a minor role.

Thus, the total uncertainty for dead wood also amounts to approximately 50%. For comparison, the uncertainty on mortality data from Finnish NFI is assessed to be 30% (Monni et al. 2007).

Uncertainties of activity data of Forest land are described in Chapter 7.2.6.

Consistent time series of annual growing stocks were calculated backward or forward starting from the growing stock 2005, as derived from NFI 3.

A consistent time series of dead wood was calculated for the inter-survey period 1995-2005 by weighting the difference in the dead wood pool between the two national forest inventories with the relative share of the basal area. For the time period 1990-1995 and for the years after 2005, annual values of dead wood were calculated by extrapolating the dependency found between the relative basal area and the amount of dead wood for the period 1995-2005. Finally, values of dead wood were stratified over the 15 spatial strata by using a distribution pattern derived from NFI 2 and NFI 3 data.

#### 7.3.4. Source-Specific QA/QC and Verification

During the inventory compilation of FOEN (2008) the estimated forest area was validated to ensure compliance of the forest definition specified in FOEN 2006h (internal FOEN document).

### 7.3.5. Source-Specific Recalculations

The increase of available AREA activity data (see Chapter 7.2.2.a), methodological improvements and the incorporation of the new NFI 3 dataset have led to a profound recalculation in source category 5A.

The availability of the dataset of the third national forest inventory (NFI 3) has had a major impact on the greenhouse-gas emissions and removals in source category 5A. Values for growing stocks were derived from NFI 3 and values for rates of gross growth and for losses by harvesting amounts and mortality were derived from NFI 2 (1994-1996) and NFI 3 (2004-2006).

In detail, the methodological approach has been revised with respect to:

- All carbon pools are averaged over a three-year time period (see Chapter 7.3.2.b).
- Consistent time series of annual growing stocks were calculated backward or forward starting from the growing stock 2005, derived from NFI 3.
- A land-use conversion period of 20 years (instead of one year) has been applied to carbon stock changes in living and dead biomass and in soil for Land converted to afforestations (CC11).
- Carbon stocks and temporal changes in carbon stocks of the dead organic matter pool were estimated (see Chapter 7.3.2.h).
- The biomass expansion factor (BEF) has been replaced by a biomass conversion and expansion factor (BCEF; see Chapter 7.3.2.c).

### 7.3.6. Source-Specific Planned Improvements

Applying Biome-BGC and parameterized functions based on simple climate data to derive climate correction factors is an interesting and innovative first step to estimate annual variability of growth caused by climate. Comparison with international results supports the plausibility of the estimated climate correction factors. Due to a most probable increase of extreme climatic events such as summer 2003 (Schär et al. 2004; Fuhrer et al. 2006), including the effect of inter-annual climate variability on estimating gross growth becomes more and more important. However, first results show that the methodology should be improved. To increase the sensitivity of the applied model and the estimated climate correction factors according to different altitudinal levels, the model should be re-calibrated for more sites, with more climatic data and stratified for more altitudinal levels.

To improve the estimation of soil carbon pools and its changes, some case studies are underway. The YASSO model will be applied to proof the sink effect of Swiss forest soils. First results are expected for the 2010 inventory submission.

For the next submission, the decomposition of dead wood pool will be investigated in detail. Especially the influence of wood decay on wood density and on carbon contents in dead wood will be quantified. This will allow making better estimates of temporal changes in the dead wood pool.

The amount of burned biomass by wild fires will be calculated using a mean BCEF instead of a BEF and wood density.

In future, it is planned to calculate the conversion and expansion of stem-wood over bark including stock and branches ( $\text{m}^3 \text{ha}^{-1}$ ) into total biomass ( $\text{t ha}^{-1}$ ) by means of single-tree-biomass-equations.

Due to the annually increasing sample size of the AREA activity data, a continuous check of the compliance of the forest definition (FOEN 2006h) by the combination category matrix

(FOEN 2007f) will be done. Resultant minor adjustments of the combination category matrix are subject to alteration.

## 7.4. Source Category 5B – Cropland

### 7.4.1. Source Category Description

#### Key category 5B1

CO<sub>2</sub> from 5B1 Cropland remaining Cropland (level).

The category 5B2 Land converted to Cropland is **not a key category**.

Swiss croplands belong to the cold temperate wet climatic zone. Carbon stocks in aboveground living biomass and carbon stocks in mineral and organic soils are considered. Croplands (CC 21) include annual crops and leys in arable rotations. Because arable cropping only occurs in the temperate Swiss Central Plateau and no elevation-dependent soil carbon stock could be identified for Swiss croplands (Leifeld et al. 2005), no correction for elevation was necessary.

### 7.4.2. Methodological Issues

#### a) Carbon in Living Biomass

Biomass carbon stocks are calculated as area-weighted means of standing stocks at harvest for the seven most important annual crops (wheat, barley, maize, silage maize, sugar beet, fodder beet, potatoes) and as cumulated annual harvested biomass for leys (Table 7-30).

Table 7-30 Standard values for arable crop yields (t C ha<sup>-1</sup>; FAL/RAC 2001, assuming a carbon fraction of 0.5 (IPCC default).

Crop	Yield [t C ha <sup>-1</sup> ]
Barley	2.6
Wheat	2.6
Maize	3.4
Silage maize	21.3
Sugar beet	7.2
Fodder beet	6.8
Potatoes	4.3
Ley	5.5

The mean standing biomass carbon stock per hectare is calculated as:

$$\text{Biomass cropland} = \sum_f (A_f / A_t) * C_f$$

where  $A_f$  = Area of crop type  $f$ ,  $A_t$  = total cropping area and  $C_f$  = standard yield (annual crops, leys) for the particular crop (t C ha<sup>-1</sup>) according to Table 7-30. For  $A_f$ , means were calculated for each crop from the time series 1988 - 2003 as published by SBV (2004).

The resulting mean biomass stock for Swiss cropland is 5.66 t C ha<sup>-1</sup>.

## b) Carbon in Soils

Soil carbon stocks in mineral soils under cropland are calculated based on Leifeld et al. (2003, 2005). The approach correlates measured soil organic carbon stocks ( $\text{t ha}^{-1}$ ) for arable land and leys with soil texture after correction for soil depth and stone content. Area upscaling uses the Swiss digital soil map (SFSO 2000a), and average stocks are calculated as weighted means using the area of arable land and leys. The mean soil organic carbon stock (0-30 cm) for cropland is  $53.40 \pm 5 \text{ t C ha}^{-1}$ .

Soil carbon stocks in organic soils under cropland are calculated based on Leifeld et al. (2003, 2005). The approach uses measured carbon stocks in Swiss organic soils. The mean soil organic carbon stock (0-30 cm) for cultivated organic soils is  $240 \pm 48 \text{ t C ha}^{-1}$ .

## c) Changes in Carbon Stocks

Changes of carbon stocks in biomass and in mineral soil are assumed to be zero for cropland remaining cropland.

The annual net carbon stock change in organic soils was estimated to  $-9.52 \text{ t C ha}^{-1}$  according to measurements in Europe including Switzerland as compiled by Leifeld et al. (2003, 2005).

## d) N<sub>2</sub>O Emissions from Land Use Conversion to Cropland

N<sub>2</sub>O emissions as a result of the disturbance associated with land-use conversion to cropland are reported in CRF Table 5 (III). The emissions are calculated with default values proposed by IPCC (2003, following Equations 3.3.14 and 3.3.15, and Chapter 3.3.2.3.1.2):

$$\text{Emission (N}_2\text{O)} = \text{deltaC}_s * 1 / (\text{C} : \text{N}) * \text{EF1} * 44 / 28 \quad [\text{Gg N}_2\text{O}]$$

where:

deltaC<sub>s</sub>: soil carbon loss in soils induced by land-use conversion to cropland [Gg C]

C:N: C:N ratio = 9.8 in grassland soils (Leifeld et al. 2007)

EF1: IPCC default emission factor =  $0.0125 \text{ kg N}_2\text{O-N (kg N)}^{-1}$

DeltaC<sub>s</sub> is calculated according to the methodology described in Chapter 7.2.1.b. If DeltaC<sub>s</sub> is positive (carbon gain) there is no N<sub>2</sub>O emission. On organic soils the carbon stock difference is zero (see explanations in Chapter 7.2.7).

The country specific ratio of 9.8 for grassland proposed by Leifeld et al. (2007) has been used because the largest part of the area converted to cropland consisted of grassland (cf. CRF Table 5B2).

## e) Carbon Emissions from Agricultural Lime Application

The total annual amount of limestone input to agricultural soils (CRF Table 5 (IV)) is 45'000 Mg. It was estimated by Würsch (2004) and has been stable over the period 1990-2004.

The IPCC default carbon conversion factor for limestone is 0.12 Mg C per Mg Ca(CO<sub>3</sub>). The resulting carbon emissions associated with liming are  $19.8 \text{ Gg CO}_2 \text{ year}^{-1}$ .

### 7.4.3. Uncertainties and Time-Series Consistency

Uncertainties for soil carbon stocks are given together with the mean value in the text above: 9% for mineral soils and 20% for cultivated organic soils. They take into account uncertainties in measured C contents and predicted soil bulk densities, i.e., they consider only uncertainties in emission factors.

The relative uncertainty in yield determination has been estimated at 13% for biomass carbon from agricultural land (Leifeld and Fuhrer 2005). Data on biomass yields for different elevations and management intensities as published by FAL/RAC (2001) are based on many agricultural field experiments and have a high reliability. Time-series are not considered yet.

In the uncertainty analysis, a higher, conservative value of 50% was chosen for the overall emission factor uncertainty in sector 5B2 (Land converted to Cropland) (Table 7-8).

The uncertainty of the carbon stock change in organic soils is 23% as reported by Leifeld et al. (2003: 56). A rounded value of 25% is used for further processing.

For the uncertainty of the emission factor for N<sub>2</sub>O on land converted to cropland a default value of 90% is used (Table 7-8).

Uncertainties of activity data of Cropland are described in Chapter 7.2.6.

### 7.4.4. Source-Specific QA/QC and Verification

The published data on Swiss soil carbon stocks were used to calculate C fluxes from land-use changes, and no further data for cross checking are currently available. No source-specific QA/QC has been carried out.

### 7.4.5. Source-Specific Recalculations

The increase of available AREA activity data (see Chapter 7.2.2.a) has led to a significant recalculation in source category 5B.

### 7.4.6. Source-Specific Planned Improvements

Ongoing efforts to combine SOC measurements on the level of soil fractions with modelled pools (Zimmermann et al. 2007) will allow for an independent check of rates from cropland to grassland emissions and removals and vice versa in the future.

## 7.5. Source Category 5C – Grassland

### 7.5.1. Source Category Description

The categories 5C1 Grassland remaining Grassland and 5C2 Land converted to Grassland are **not key categories**.

Swiss grasslands belong to the cold temperate wet climatic zone.

Carbon stocks in living biomass and carbon stocks in soils are considered. Grasslands include permanent grassland (CC 31), shrub vegetation (CC 32), vineyards, low-stem orchards ('Niederstammobst') and tree nurseries (CC 33), copse (CC 34), orchards ('Hochstammobst'; CC 35), stony grassland (CC 36), and unproductive grassland (CC 37).

In the CRF Table 5C2, the land-use types CC 32, 33, 34 and 35 are merged under the notation 'woody' as well as CC 36 and 37 are merged under 'unproductive' (see Table 7-2).

## 7.5.2. Methodological Issues

### a) Carbon in Living Biomass

#### Permanent Grassland (CC 31)

Permanent grasslands range in altitude from < 300 m to 3000 m above sea level. Because both biomass productivity and soil carbon rely on the prevailing climatic and pedogenic conditions, grassland stocks were calculated separately for three altitude zones (corresponding to those used in source category 5A - Forest Land).

Standing stocks for permanent grasslands ( $t C ha^{-1}$ ) are calculated as the annual cumulative yield of differentially managed grasslands (meadows, pastures, alpine meadows and pastures) based on FAL/RAC (2001; Table 7-31), assuming a carbon fraction of 0.5 (IPCC default). Mean standing above-ground biomass stocks were taken for each of the altitudinal zones because the spatial distribution of grassland management types is not known.

Table 7-31 Annual yields of differentially managed permanent grassland (CC 31). Each value represents the mean of two fertilization levels.

Management	Altitude [m]	Annual yield [t C ha <sup>-1</sup> ]
Meadow	<601	5.88
	601-1200	4.38
	>1200	3.25
Pasture	<601	4.63
	601-1200	3.75
	>1200	2.75
Alpine pasture and meadow	601-1200	3.75
	>1200	0.75

Root biomass-C is assumed to be  $2.2 t C ha^{-1}$  (0-1 m; Ammann et al. 2007) for all grasslands due to lack of additional data. Root biomass is added to above-ground biomass to derive the total living biomass for CC 31. Table 7-32 shows the living biomass of permanent grassland for the three altitudinal zones as the cumulated annual yield including roots.

Table 7-32 Living biomass  $C_i$  of permanent grassland (CC 31).

Altitude [m]	$C_i$ [t C ha <sup>-1</sup> ]
<601	7.45
601-1200	6.26
>1200	4.45

### Shrub Vegetation (CC 32) and Copse (CC 34)

Due to a lack of more precise data, the living biomass of shrub vegetation and copse was assumed to correspond with brush forest as described in Chapter 7.3.2.g. in FOEN (2008), where brush forest is assumed to contain 11.6 t C ha<sup>-1</sup>.

### Vineyards, Low-stem Orchards and Tree Nurseries (CC 33)

Low-stem orchards are small fruit trees distinguished from CC 35 ('orchards') by a maximum stem-height of 1 m and a much higher stand density. Only low-stem orchards and vineyards are considered in the following because no stand densities for tree nurseries are available. Data from SFSO (2002) indicate a very small contribution of tree nurseries (1'378 ha) as compared to the sum of vineyards (15'436 ha, ASCH2) and low-stem orchards (240 ha, based on Widmer 2006).

The standing carbon stock of living biomass (CI) for CC 33 is therefore calculated as:

$$CI = [(CI \text{ vineyards} * \text{area vineyards}) + (CI * \text{area low-stem orchards})] / (\text{area vineyards} + \text{area low-stem orchards})$$

CI of vineyards is 3.61 t C ha<sup>-1</sup>, calculated based on the mean stand density (5556 vines ha<sup>-1</sup>) and woody biomass of a plant including roots (0.65 kg C; Ruffner 2005).

For small fruit trees on low-stem orchards, no literature value was found for biomass expansion factors. Therefore, following assumptions were met. Diameter at breast height (DBH) of such trees was assumed to be around 10 cm and the tree height was assumed to be around 1 m. The bole shape of low-stem apple trees can be approximated by a cylinder shape.

$$\text{Stem wood volume} = r^2 * \pi * \text{height} = (5 \text{ cm})^2 * 3.1 * 100 \text{ cm} = 7.75 \text{ dm}^3$$

Based on expert knowledge (Kaufmann 2005), the percentage of branches was estimated as 100%, and the percentage of roots was estimated as 30% of the stem wood volume. This results in a BEF of 2.3. A wood density of 0.55 kg dm<sup>-3</sup> (Vorreiter 1949) and the default carbon content of 50% were assumed. With these assumptions the carbon content of a tree of the type low-stem ('Niederstamm') is calculated as follows:

$$\begin{aligned} \text{C low-stem} &= \text{stem wood volume} * \text{BEF} * \text{wood density} * \text{carbon content} \\ &= 7.75 \text{ dm}^3 * 2.3 * 0.55 \text{ kg/dm}^3 * 50\% \text{ C-content} = 4.9 \text{ kg C} \end{aligned}$$

The mean stand density of low-stem orchards is estimated at 2500 ha<sup>-1</sup> (Widmer 2006), resulting in a CI of 12.25 t C ha<sup>-1</sup>.

The resulting CI for CC 33 is 3.74 t C ha<sup>-1</sup>.

### Orchards (CC 35)

Orchards are loosely planted larger fruit trees ('Hochstammobst') with grass understory. CI of orchards trees is calculated as:

$$CI \text{ biomass} = (\text{carbon per fruit tree [t]} * \text{number fruit trees [ha}^{-1}] / \text{area orchards [ha]}) + \text{carbon in grass [ha}^{-1}]$$

The carbon content of a large fruit tree with a DBH of 25 - 35 cm was calculated as follows:

$$C \text{ (Hochstamm)} = \text{Stem wood volume} * \text{KE-Factor} = 225 \text{ kg C}$$

where:

Stem wood volume of an apple tree with DBH between 25 and 35 cm: 0.5 m<sup>3</sup> (expert estimate);

KE-Factor [t C m<sup>-3</sup>] = BEF \* Density \* C-content = 0.45, (Wirth et al. 2004:68, Table 16).

From the total fruit-growing area of 41'480 ha (ASCH2 data), the area of small fruit trees (240 ha, see CC 33) was subtracted, and the remaining area was divided by the number of large fruit trees. Large fruit trees were counted in 1991 (3'616'301) and 2001 (2'900'000; SFSO 2002), and the mean value was divided by 41'240 ha to obtain a mean stand density of 79 trees ha<sup>-1</sup>. The resulting woody biomass of CC 35 is thus 17.78 t C ha<sup>-1</sup>. Because orchards typically have a grass understory, the biomass of CC 31 was added to the woody biomass. ASCH2 data showed that orchards are located below 1000 m a.s.l., so the mean of grass biomass of the classes <601 and 600-1200 m a.s.l. (i.e., 6.86 t C ha<sup>-1</sup>; Table 7-32) was taken to obtain a total biomass stock of 24.63 t C ha<sup>-1</sup> for CC 35.

### **Stony Grassland (CC 36)**

Approximately 35% of the surface of CC 36 (herbs and shrubs on stony surfaces) is covered by vegetation. No accurate data were available for this category. Therefore, the carbon content of brush forest as described in FOEN (2008) (11.60 t C ha<sup>-1</sup>) was multiplied by 0.35 to account for the 35% vegetation coverage. This results in a carbon content of 4.06 t C ha<sup>-1</sup>.

### **Unproductive Grassland (CC 37)**

The category CC 37 includes grass and herbaceous plants at watersides of lakes and rivers including dams and other flood protection structures, constructions to protect against avalanches and rock slides, and alpine infrastructure (e.g. for skiing). For none of these land-use types, biomass data are currently available. Therefore, the mean value of all grasslands from Table 7-32, 6.05 t C ha<sup>-1</sup>, is arbitrarily chosen as the preliminary biomass value for CC 37.

## **b) Carbon in Soils**

### **Permanent Grassland (CC 31)**

Carbon stocks in grassland soil refer to a depth of 0-30 cm.

Soil carbon stocks in mineral soils under permanent grassland CC 31 are calculated based on Leifeld et al. (2003, 2005). The approach correlates measured soil organic carbon stocks (t ha<sup>-1</sup>) for permanent grasslands with soil texture and elevation after correction for soil depth and stone content. Area upscaling makes use of the Swiss digital soil map (SFSO 2000a) and topography. Mean C<sub>s</sub> values calculated for grasslands CC 31 are given in Table 7-33.

Table 7-33 Mean carbon stocks under permanent grassland on mineral soils.

<b>Altitude</b> [m]	<b>C<sub>s</sub></b> [t C ha <sup>-1</sup> , 0-30 cm]
<601	62.02 ± 13
601-1200	67.50 ± 12
>1200	75.18 ± 9

Soil carbon stocks in organic soils under permanent grassland are calculated based on Leifeld et al. (2003, 2005). The approach uses measured carbon stocks in Swiss organic

soils without differentiation among cropland and grassland. The mean soil organic carbon stock (0-30 cm) for organic soils is  $240 \pm 48 \text{ t C ha}^{-1}$ .

### **Shrub Vegetation (CC 32)**

Due to lack of data, the mean value of Table 7-33,  $68.23 \text{ t ha}^{-1}$  was used as the soil carbon default for this category.

### **Vineyards, Low-stem Orchards and Tree Nurseries (CC 33)**

The category includes carbon stocks in soils of vineyards, small fruit trees and tree nurseries. In accordance to carbon stocks in biomass, only vineyards and small fruit trees are considered. Both land-use types are assumed to have no grass undercover. Therefore, the soil carbon values of cropland, i.e.  $53.40 \text{ t C ha}^{-1}$  (mineral soils) and  $240 \text{ t ha}^{-1}$  (organic soils) are taken for CC 33 (see Chapter 7.4.2.b).

### **Copse (CC 34)**

Due to lack of data, the mean value of Table 7-33,  $68.23 \text{ t ha}^{-1}$  was used as the soil carbon default for this category.

### **Orchards (CC 35)**

Cs of orchards was calculated in accordance to the biomass calculation. No specific Cs orchards values are available, and so the mean value of grassland soil carbon stocks (mineral soils) from the two lower altitudinal zones (i.e.,  $64.76 \text{ t C ha}^{-1}$ ; cf. Table 7-33) was taken as Cs orchards, and the value of  $240 \text{ t ha}^{-1}$  for organic soils (see Chapter 7.4.2.b).

### **Stony Grassland (CC 36)**

Soil organic carbon stocks under herbs and shrubs on stony surfaces were calculated according to the procedure described in Chapter 7.5.2.a. It is assumed that not more than 35% of the area of CC 36 are covered with vegetation and thus only 35% of the area bears a mineral soil while the remainder is bare rock. Land-use of this category mostly belongs to 'grassland' and 'unproductive land' and likely includes many of the former (ASCH2) alpine grasslands. These grasslands are mainly located at altitudes  $> 1200 \text{ m a.s.l.}$  Thus, using the respective value from Table 7-33, the carbon stock Cs of CC 36 is calculated as:

$$\text{Cs of CC 36} = 0.35 * \text{Cs permanent grassland} > 1200 \text{ m} = 26.31 \text{ t C ha}^{-1}$$

### **Unproductive Grassland (CC 37)**

The category CC 37 'unproductive grasslands' includes grass and herbaceous plants at watersides of lakes and rivers including dams and other flood protection structures, constructions to protect against avalanches and rock slides, and alpine infrastructure (e.g. for skiing). For none of these land-use types, Cs data are currently available. Soil carbon stocks of CC 37 'unproductive grassland' were arbitrarily set as the mean value of carbon stocks under permanent grassland on mineral soils (Table 7-33) in accordance to the procedure followed for biomass. Cs of CC 37 is thus  $68.23 \text{ t C ha}^{-1}$ .

### c) Changes in Carbon Stocks

Changes of carbon stock in biomass and in mineral soil are assumed to be zero for grassland remaining grassland.

The annual net carbon stock change in organic soils was estimated to  $-9.52 \text{ t C ha}^{-1}$  according to measurements in Europe including Switzerland as compiled by Leifeld et al. (2003, 2005).

### d) Carbon Emissions from Agricultural Lime Application

All  $\text{CO}_2$  emissions caused by agricultural lime application are included under the land use Cropland (Chapter 7.4.2.e).

### e) NMVOC Emissions

Estimates for annual biogenic emissions of NMVOC in Switzerland for forests and natural grassland are available in SAEFL (1996a): the value for natural grassland (unproductive vegetation) is 0.51 Gg.

## 7.5.3. Uncertainties and Time-Series Consistency

Uncertainties for soil carbon stocks are given together with the mean value in the text above: 12-21% for mineral soils and 20% for organic soils. They take into account uncertainties in measured C contents and predicted soil bulk densities, i.e., they consider only uncertainties in emission factors.

The relative uncertainty in yield determination has been estimated at 13% for biomass carbon from both, cropland and grassland (Leifeld and Fuhrer 2005). Data on biomass yields for different elevations and management intensities as published by FAL/RAC (2001) are based on many agricultural field experiments and have a high reliability. Time-series are not considered yet.

In the uncertainty analysis, a higher, conservative value of 50% was chosen for the overall emission factor uncertainty in sector 5C (see Table 7-8).

Uncertainties of activity data of Grassland are described in Chapter 7.2.6.

## 7.5.4. Source-Specific QA/QC and Verification

The published data on Swiss soil carbon stocks were used to calculate C fluxes from land-use changes, and no further data for cross checking are currently available. No source-specific QA/QC has been carried out.

## 7.5.5. Source-Specific Recalculations

The increase of available AREA activity data (see Chapter 7.2.2.a) has led to a significant recalculation in the source category 5C:

## 7.5.6. Source-Specific Planned Improvements

A planned survey of existing data on root biomass in alpine grasslands will help to improve root data for CC 31.

## 7.6. Source Category 5D – Wetlands

### 7.6.1. Source Category Description

The categories 5D1 Wetlands remaining Wetlands and 5D2 Land converted to Wetlands are **not key categories**.

Wetlands consist of surface waters (CC 41) and unproductive wet areas such as shore vegetation and fens (CC 42) (see Table 7-2)

### 7.6.2. Methodological Issues

#### a) Carbon in Living Biomass

##### Surface Waters (CC 41)

Surface waters have no carbon stocks by definition.

##### Unproductive Wetland (CC 42)

In AREA land use statistics unproductive wetland may be covered by trees to a certain degree (SFSO 2006a). The tree vegetation is indicated by different tags, e.g. for tree groups or tree lines. Due to the additional woody vegetation, unproductive wetland contains more carbon than unproductive grassland. Using the information provided by the tags, the carbon stock in living biomass of unproductive wetland was estimated. CC 42 was stratified according to the different tags and each tag was assigned to a carbon content of a known combined category (CC). Table 7-34 shows the different tags and the assigned carbon stock in living biomass.

The CC 42 stratified for different tags were summed up for all 3 AREA inventories and the percentages within each tag category were calculated. Using the percentages and the assigned carbon stock values, a weighted average for category CC 42 was calculated (Table 7-35).

Table 7-34 Assigned carbon content of CC 42 according to different tags.

Tag	Assigned category	CC	Carbon stock in living biomass, [t C ha <sup>-1</sup> ]
0: No tag	Unproductive grassland	37	6.05
3: Tree group on wetland	Unproductive forest	13	33.7*
6: Biotope	Unproductive grassland	37	6.05
19: Linear tree group on wetland	Trees in settlement	54	18.6
36: Clear-cut on wetland	Unproductive grassland	37	6.05

\*Arithmetical average of carbon stock in living biomass of unproductive forests over all altitudinal zones and NFI regions taken from FOEN (2008).

Table 7-35 Occurrence of tags associated with CC 42 and estimated carbon content of CC 42.

Tag	AREA surveys [ha]			Total	Percentage of total	Carbon stock in living biomass [t C ha <sup>-1</sup> ]
	1	2	3			
0	2610	2464	2445	7519	90%	6.05
3	165	202	206	573	7%	33.7
6	6	8	37	51	1%	6.05
19	59	75	76	210	2%	18.6
36	0	0	11	11	0%	6.05
<b>Total</b>	<b>2840</b>	<b>2749</b>	<b>2775</b>	<b>8364</b>	<b>100%</b>	<b>8.2*</b>

\*Weighted average of all categories according to occurrence.

## b) Carbon in Soils

Land cover in CC 42 explicitly includes peatlands protected by Federal Legislation (Swiss Confederation 1991a, 1994) as well as reed. For these peatlands, the same value (240 t C ha<sup>-1</sup>) as for organic soils under 'cropland' and 'grassland' was taken. Currently no soil data are available for other land covers than peat in CC 42. As a first guess, it is suggested that the soil carbon stock of unproductive wetlands is the arithmetic mean of permanent grassland on mineral soils (68.23 t C ha<sup>-1</sup>) and organic soils (240 t C ha<sup>-1</sup>), thus 154 t C ha<sup>-1</sup>.

## c) Changes in Carbon Stocks

Changes of carbon stock in biomass and in soil are assumed to be zero for wetlands remaining wetlands.

In the case of land-use change, the net changes in biomass and soil of both CC 41 and CC 42 are calculated as described in chapter 7.2.1.b.

## d) N<sub>2</sub>O emissions from drainage of soils

Drainage of intact wetlands is very unlikely, as bogs and fens are protected to a large part by Federal Ordinances (Swiss Confederation 1991a, 1994). Therefore, no N<sub>2</sub>O emissions are reported in CRF Table 5 (II).

## 7.6.3. Uncertainties and Time-Series Consistency

As a first guess, a value of 50% was chosen for the overall emission factor uncertainty in sector 5D (Table 7-8).

Uncertainties of activity data of Wetlands are described in Chapter 7.2.6.

## 7.6.4. Source-Specific QA/QC and Verification

No source-specific QA/QC activities have been carried out.

### 7.6.5. Source-Specific Recalculations

The increase of available AREA activity data (see Chapter 7.2.2.a) has led to a significant recalculation in the source category 5D.

In this submission, a new conversion time of 20 years (instead of 1 year) has been applied to soil carbon stock changes in the case of land converted to unproductive wetland (CC42).

### 7.6.6. Source-Specific Planned Improvements

For improvements with respect to the assigned carbon contents of CC 42 in Table 7-34 see Chapters 7.3.6, 7.5.6 and 7.7.6.

## 7.7. Source Category 5E – Settlements

### 7.7.1. Source Category Description

#### Key category 5E2

CO<sub>2</sub> from Land converted to Settlements (level and trend)

The category 5E1 Settlements remaining Settlements is **not a key category**.

Settlements consist of buildings/constructions (CC 51), herbaceous biomass in settlements (CC 52), shrubs in settlements (CC 53), and trees in settlements (CC 54) as shown in Table 7-2.

### 7.7.2. Methodological Issues

#### a) Carbon in Living Biomass

##### Buildings and Constructions (CC 51)

Buildings/constructions contain no carbon by default.

##### Herbaceous Biomass, Shrubs and Trees in Settlements (CC 52, CC 53, CC 54)

In a Tier 1a approach, the IPCC provides a default value for crown cover area based annual growth rate in settlements remaining settlements (IPCC 2003; p. 3.297). This value ranges from 1.8 to 3.4 t C ha<sup>-1</sup> yr<sup>-1</sup>, the arithmetic mean is 2.9 t C ha<sup>-1</sup> yr<sup>-1</sup>. It is an estimate for the average annual growth rate per tree crown cover area in settlements remaining settlements.

Expert assessment in Switzerland estimated the average age of trees in settlements remaining settlements to be older than 20 years. In the GPG LULUCF (IPCC 2003), growth of trees in settlements is limited to the first 20 years. Therefore, the average carbon stock per tree crown cover area in settlements remaining settlements was assumed to be 20 times the crown cover area based annual growth rate (t C ha<sup>-1</sup> yr<sup>-1</sup>).

To estimate the tree crown cover area of the CC 52 (herbaceous biomass in settlements), CC 53 (shrubs in settlements) and CC 54 (trees in settlements) LIDAR<sup>20</sup> data were used. Tree crown cover was derived by Mathys (2005) as follows. The raw LIDAR data for the entire study area was acquired from a helicopter in May 2000 using a small-footprint LIDAR

<sup>20</sup> LIDAR is an acronym for Light Detection And Ranging.

system. The resulting digital terrain and surface model had a spatial resolution of 1 m and both were bilinearly resampled to 2.5 m. The difference between LIDAR-based digital surface model and digital terrain model was used to extract objects taller than 3 m to comply with the Swiss National Forest Inventory, where a tree is defined as woody vegetation higher than 3 m. Objects other than tree vegetation were excluded based on the official building map and secondary mapping information on constructed objects. Tree crown cover was then derived at a hectare scale based on focal analyses within a rectangular moving window of 100 m x 100 m applied to the generated 2.5 m raster of tree vegetation. For the application in the GHG inventory report, the centre of the moving window was shifted to match the corresponding AREA CC interpretation point. The resulting tree crown cover raster covers the Canton of Geneva. This raster was then spatially overlaid with the data from the land use statistics (SFSO 2007a). Figure 7-12 shows the distribution of the percentages of vegetation coverage of CC 52, CC 53 and CC 54. For the CC 52 and CC 53, the arithmetical average of the rate of tree vegetation coverage was calculated. The following equation was applied to estimate the average carbon pool in living vegetation of the CC 52, CC 53 and CC 54.

Carbon stock of CC<sub>i</sub> [t C ha<sup>-1</sup>] = coverage<sub>i</sub> / 100 \* CRW \* 20 years

where coverage means the average (arithmetic mean) percentage of vegetation coverage for the CC 52 (19.6%), CC 53 (15.3%) and CC 54 (32.1%). CRW is the average crown cover area based annual growth rate [t C ha<sup>-1</sup> year<sup>-1</sup>] from the GPG LULUCF (IPCC 2003) and i indicates 52, 53 and 54, respectively.

Using the average value for the CRW (2.9 t C ha<sup>-1</sup> yr<sup>-1</sup>), CC 52 is estimated to contain an average C stock of 11.4 t C ha<sup>-1</sup>, CC 53 8.9 t C ha<sup>-1</sup>, and CC 54 18.6 t C ha<sup>-1</sup> (Figure 7-12).

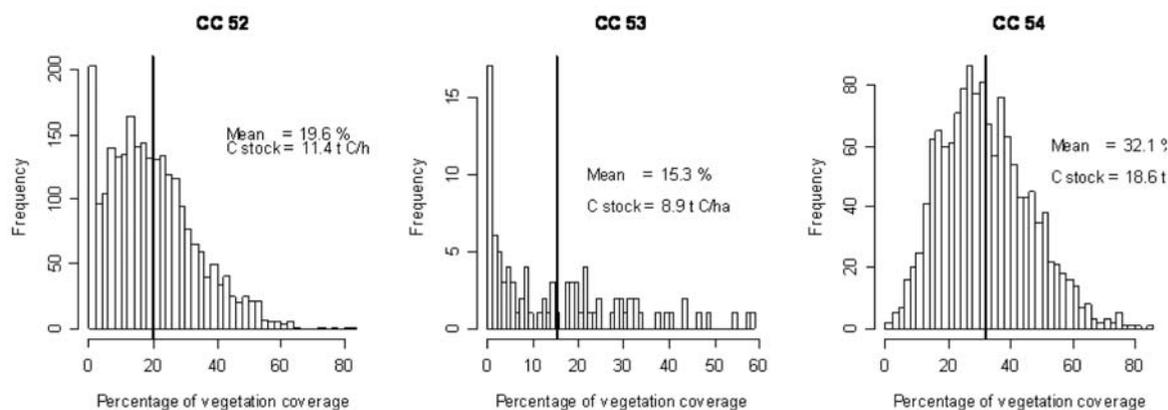


Figure 7-12 Vegetation cover [%] and carbon stock of grassland vegetation with wood biomass larger than 3 m [t C ha<sup>-1</sup>]. CC 52: Herbaceous biomass in settlements, CC 53 Shrubs in settlements, CC 54 Trees in settlement.

## b) Carbon in Soils

The carbon stock in soil for CC 51 (buildings and construction) was set to zero. However, a weighting factor of 0.5 was applied to soil carbon changes due to land-use changes involving CC 51 (see Chapter 7.2.1). The reason for this is that in general the soil organic matter on construction sites is stored temporarily and later used for replanting the surroundings or it is used to vegetate dumps for example. The oxidative carbon loss due to the disturbance of the soil structure may reach 50% (see discussion in Leifeld et al. 2003: 67).

The carbon stock in soil for CC 52, CC 53 and CC 54 is 53.40 t C ha<sup>-1</sup> (0-30 cm, same value as for cropland).

### c) Changes in Carbon Stocks

Changes of carbon stock in biomass and in soil are assumed to be zero for settlements remaining settlements.

In the case of land-use change, the net changes in biomass and soil of CC 51, CC 52, CC 53, and CC 54 are calculated as described in Chapter 7.2.1.b.

#### 7.7.3. Uncertainties and Time-Series Consistency

As a first guess, a value of 50% was chosen for the overall emission factor uncertainty in sector 5E (Table 7-8).

Uncertainties of activity data of Settlements are described in Chapter 7.2.6.

#### 7.7.4. Source-Specific QA/QC and Verification

No source-specific QA/QC activities have been carried out.

#### 7.7.5. Source-Specific Recalculations

The increase of available AREA activity data (see Chapter 7.2.2.a) has led to a significant recalculation in the source category 5E.

#### 7.7.6. Source-Specific Planned Improvements

Categories CC 52, CC 53 and CC 54 were estimated based on tree crown coverage situated in the Canton of Geneva, averaged over 100 m x 100 m. Following improvements will be implemented in a subsequent submission:

- (1) So far, the understory vegetation was not considered in the estimation of the C stocks for CC 52, CC 53 and CC 54. Accounting for understory vegetation will increase the estimated C stock of those categories.
- (2) The interpretation point from the AREA data was situated in the centre of the averaged window. However, this point does not necessarily represent the surrounding landscape, especially in a small-scaled landscape as it is the case in Switzerland. Therefore, planned improvements will try to analyse smaller windows or to generally improve the technique by applying appropriate process models.
- (3) To convert tree crown coverage to carbon pool, the factor given by IPCC for settlements was applied. The accuracy of this factor is assumed to be low as it is only a Tier 1 default. More reliable estimates of this factor could significantly increase the accuracy of the estimation method.

The first point leads to an underestimation of C stocks in CC 52, CC 53, and CC 54. In case of land-use changes, this underestimation influences the general C budget. In the land-use change matrices, those categories show an increasing tendency (CC 52 and CC 53) or are more or less stable (CC 54). This indicates that the inaccuracies of the present submission lead to a slight underestimation of the general sink effect in those categories.

However, it could be shown that the applied method results in plausible estimations of the C stock.

## **7.8. Source Category 5F – Other Land**

### **7.8.1. Source Category Description**

The categories 5F1 Other Land remaining Other Land and 5F2 Land converted to Other Land are **not key categories**.

As shown in Table 7-2 other land (CC 61) covers non-vegetated areas such as glaciers, rocks and shores.

### **7.8.2. Methodological Issues**

By definition, other land has no carbon stocks. Changes of carbon stock in biomass and in soil are assumed to be zero for other land remaining other land. In the case of land-use change, the net C changes in biomass and soil are calculated as described in chapter 7.2.1.b.

### **7.8.3. Uncertainties and Time-Series Consistency**

As a first guess, a value of 50% was chosen for the overall emission factor uncertainty in sector 5F (Table 7-8).

Uncertainties of activity data of Other Land are described in Chapter 7.2.6.

### **7.8.4. Source-Specific QA/QC and Verification**

No source-specific QA/QC activities have been carried out.

### **7.8.5. Source-Specific Recalculations**

The increase of available AREA activity data (see Chapter 7.2.2.a) has led to a significant recalculation in the source category 5F.

### **7.8.6. Source-Specific Planned Improvements**

There are no planned improvements.

## 8. Waste

### 8.1. Overview

#### 8.1.1. Greenhouse Gas Emissions

Within the waste sector emissions from four source categories are considered:

- 6A Solid Waste Disposal on Land,
- 6B Wastewater Handling,
- 6C Waste Incineration,
- 6D Others (Shredder, composting and digesting of organic waste)

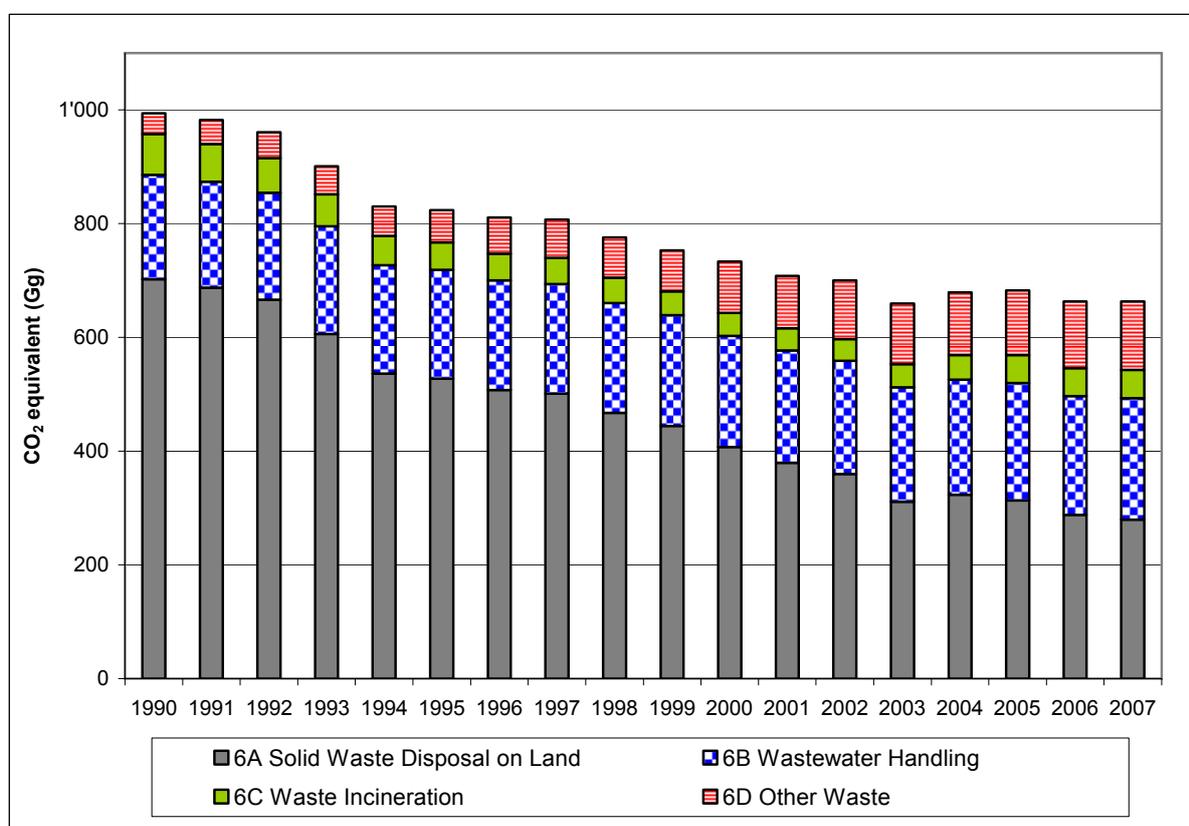


Figure 8-1 Switzerland's greenhouse gas emissions in the waste sector 1990–2007.

Table 8-1 Trend of total GHG emissions from waste management in Switzerland 1990-2007.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	<b>CO<sub>2</sub> equivalent (Gg)</b>									
CO <sub>2</sub>	62	59	55	50	42	37	34	31	29	25
CH <sub>4</sub>	732	720	702	646	583	578	565	562	531	511
N <sub>2</sub> O	200	203	204	205	206	209	212	214	216	217
Sum	994	982	961	901	830	824	811	807	776	753

Gas	2000	2001	2002	2003	2004	2005	2006	2007
	<b>CO<sub>2</sub> equivalent (Gg)</b>							
CO <sub>2</sub>	22	19	16	16	15	15	15	15
CH <sub>4</sub>	490	464	454	409	424	420	398	396
N <sub>2</sub> O	222	225	230	235	240	247	250	252
Sum	733	708	700	659	679	682	663	663

In the waste sector a total of 663 Gg CO<sub>2</sub> equivalents were emitted in the year 2007. 42.1% of the emissions stem from category 6A Solid Waste Disposal on Land, 32.2% from 6B Wastewater Treatment, 18.2% from 6D Others and 7.5% from 6C Waste Incineration.

The total greenhouse gas emissions in the waste sector show a decrease of -33.3% from 1990 until 2007. The greenhouse gas emissions are dominated by the ones from the source category 6A Solid Waste Disposal on Land. In this category the CH<sub>4</sub> emissions decreased from 1990 until 2007 by -59.7%. N<sub>2</sub>O and CO<sub>2</sub> are of minor importance in the waste sector. The relative trends of the gases can be seen in Figure 8-2.

Please note that according to IPCC Good Practice Guide all emissions from waste-to-energy, where waste material is used directly as fuel or converted into a fuel, are reported under the Energy sector. Therefore the largest share of waste-related emissions in Switzerland is not reported under category 6 Waste, as the box below shows.

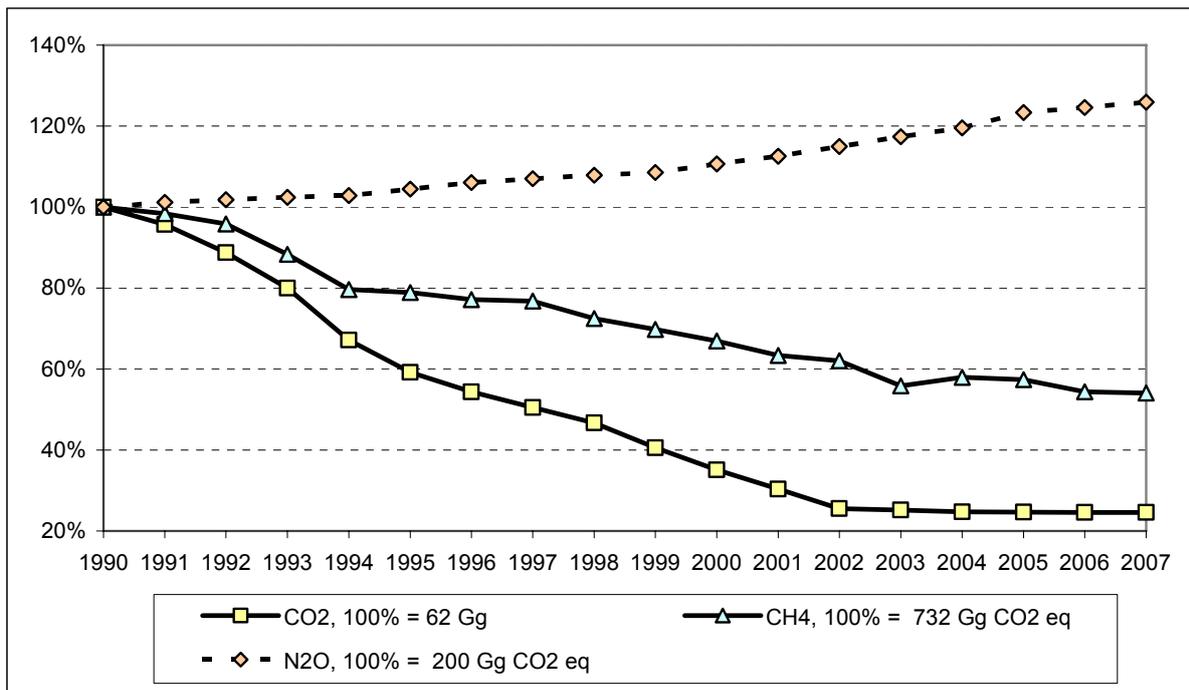


Figure 8-2 Trend of total GHG emissions from waste management in Switzerland 1990-2007.

**Box: Waste related GHG emissions in Switzerland**

There are various activities for a proper waste disposal in Switzerland. The respective GHG emissions are reported in different chapters within the National Inventory. The following Figure provides an overview on all waste related GHG emissions in Switzerland, not only the ones reported in the present Chapter 8.

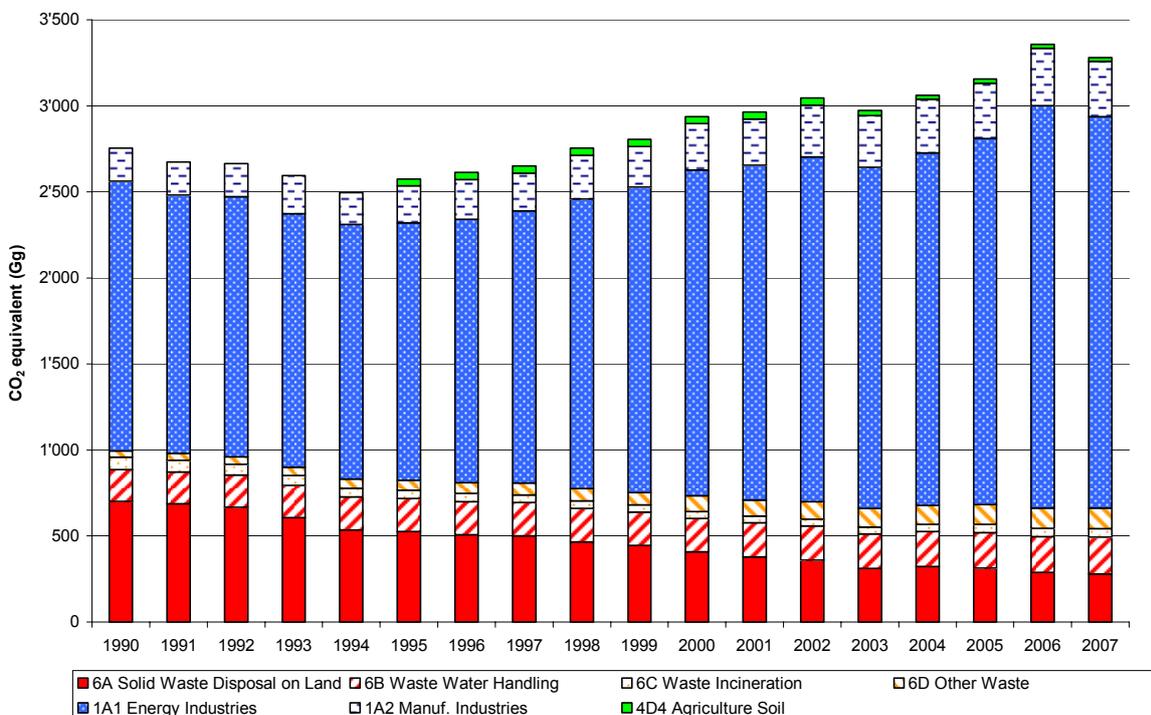


Figure 8-3 Waste related GHG emissions from 1990-2007.

### 8.1.2. Overview on Waste Management in Switzerland

The goals and principles regarding waste management in Switzerland are stated in the Guidelines on Swiss Waste Management (BUS 1986) and in the Waste Concept for Switzerland (SAEFL 1992). The four principles are:

1. The generation of waste shall be avoided as far as possible.
2. Pollutants from manufacturing processes and in products shall be reduced as far as possible.
3. Waste shall be recycled wherever this is environmentally beneficial and economically feasible.
4. Waste shall be treated in an environmentally sound way. In the long term only materials of final storage quality shall be disposed of in landfills.

Table 8-2 gives an overview on the waste quantities generated in Switzerland in 2007, and indicates the main treatment options as well as the waste treatment facilities. Note that the quantities in Table 8-2 does not include imported waste. (For the calculation of greenhouse gas emissions for the present Inventory, other data are used that include imports and exclude exports, therefore Table 8-2 differs in some details from the waste data used for the Inventory.) A more detailed description of the treatment facilities is provided in the respective chapters<sup>21</sup>.

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<sup>21</sup> Detailed data on various aspects of the waste sector in Switzerland can be found on the internet-site of FOEN (<http://www.bafu.admin.ch/abfall/01517/01519/06504/index.html?lang=en>).

Table 8-2 General overview on waste generation and waste disposal in 2007.

<b>Waste category</b>		
<b>Disposal Option and Waste Type</b>	<b>Quantity</b>	
	Gg	%
<b>Municipal solid waste</b>	<b>5'465</b>	<b>100</b>
<b>Recycling</b>	<b>2'785</b>	<b>51</b>
waste paper	1'324	
organic waste	930	
used glas (bottle glas)	320	
electrical and electronic appliances	108	
textiles	48	
PET (bottles)	34	
tinplates (cans + caps)	13	
aluminium, aluminium cans	7	
batteries	2	
<b>Treatment</b>	<b>2'679</b>	<b>49</b>
MSW incineration	2'679	
<b>Final Disposal</b>	<b>1</b>	<b>0.03</b>
landfilled	1	
<b>Construction waste</b>	<b>11'900</b>	<b>100</b>
<b>Recycling</b>	<b>9'700</b>	<b>82</b>
direct use at construction site	5100	
separation and recycling	4600	
<b>Treatment</b>	<b>477</b>	<b>4</b>
incineration (used wood etc.)	477	
<b>Final Disposal</b>	<b>1'723</b>	<b>14</b>
landfilled	1'723	
<b>Hazardous waste</b>	<b>1'167</b>	<b>100</b>
<b>Recycling</b>	<b>65</b>	<b>6</b>
	65	
<b>Treatment</b>	<b>714</b>	<b>61</b>
incineration and chem.-physical treatment	714	
<b>Final Disposal</b>	<b>223</b>	<b>19</b>
landfilled	223	
<b>Exports</b>	<b>165</b>	<b>14</b>
<b>Sewage sludge (dry matter)</b>	<b>210</b>	<b>100</b>
<b>Recycling</b>	<b>21</b>	<b>10</b>
used in agriculture	21	
<b>Treatment</b>	<b>189</b>	<b>90</b>
incineration	189	
<b>Final Disposal</b>	<b>0</b>	<b>0</b>
landfilled	0	

Table 8-2 shows that of the 5'465 Gg of municipal solid waste (MSW) generated in 2007, 2'785 Gg or 51% were recycled. The main recycled waste types were paper/cardboard (1'324 Gg), organic waste (930 Gg treated in centralized composting and digestion plants, without backyard composting), and used glass (320 Gg) (FOEN 2008d). The part of MSW that was not recycled was mainly incinerated (2'679 Gg or 49%) or disposed of in landfills (1 Gg or 0.03%).

About 11'900 Gg construction waste was generated in Switzerland in 2007 (FOEN 2008d). From this quantity about 9'700 Gg (82%) was recycled.<sup>22</sup> About half of the recycling took place at the construction site, e.g. by reusing material left after breaking up the road cover. The other half was separated at the construction site and recycled individually, e.g. used glass, used metals, used concrete etc. A minor amount of the construction waste, approximately 477 Gg (4%), was incinerated and about 1'723 Gg (14%) was disposed of in landfills.

About 1'167 Gg hazardous waste was generated in Switzerland in 2007.<sup>23</sup> 714 Gg hazardous waste was treated. About 65 Gg hazardous waste was recycled, 223 Gg of the hazardous waste were disposed of on landfills and 165 Gg were exported.

About 210 Gg (dry matter) sewage sludge was generated in 2007. 10% of sewage sludge was recycled, i.e. this sewage sludge was used as fertilizer in agriculture. 90% or 189 Gg sewage sludge was incinerated (in MSW incineration plants or mono incineration plants).

The greenhouse gas emissions from domestic waste treatment activities are estimated in the appropriate chapters, i.e. energy, agriculture and waste.

## 8.2. Source Category 6A – Solid Waste Disposal on Land

### 8.2.1. Source Category Description

#### Key category 6A

CH<sub>4</sub> emissions from managed waste disposal on land (level and trend)

The source category 6A1 "Managed Waste Disposal on Land" comprises all emissions from handling of solid waste on managed landfill sites.

Emissions from the source category 6A2 "Unmanaged Waste Disposal Sites" are included in source category 6A1 "Managed Waste Disposal on Land". This is motivated by the fact that in Switzerland officially no unmanaged waste disposal sites exist. The effective quantity of waste not properly treated in landfills is estimated to be very small. However, no reliable data is available.

In Switzerland, nine managed biogenic active landfills are equipped to recover landfill gas (SFOE 2008a). The landfill gas is generally used in co-generation plants in order to produce electricity and heat. Some landfill gas is used to generate heat only. A very small portion of the landfill gas is flared.

<sup>22</sup> The latest available data for the shares of different types of treatments for construction waste on this general level refer to the year 2000 and are derived from a model, not from actual survey data (SAEFL 2001). Shares in the year 2007 are assumed to be the same as in the year 2000.

<sup>23</sup> The latest available data for hazardous waste on this general level refer to the year 2005; with the exception of the exported waste quantities, which refer to the year 2006.

Table 8-3 Specification of source category 6A "Solid Waste Disposal on Land".

6A	Source	Specification	Data Source
6A1	Managed Waste Disposal on Land	Emissions from handling of solid waste on managed landfill sites.	EMIS 2009/6A1
6A2	Unmanaged Waste Disposal Sites	Emissions from all other waste disposal sites that don't fall into 6A1.  (included in 6A1)	EMIS 2009/6A1
6A3	Others	Not occurring in Switzerland	

## 8.2.2. Methodological Issues

### a) Managed Waste Disposal on Land (6A1)

#### Methodology

The emissions are calculated in four steps:

- i) The rate of CH<sub>4</sub> generation over time is based on the First Order Decay model (FOD) according to IPCC (IPCC 1997a-c). The following equation is applied to calculate the CH<sub>4</sub> generation in the year t:

$$\text{CH}_4 \text{ generated in the year } t \text{ [Gg/year]} = \sum_x [A \cdot k \cdot M(x) \cdot L_0(x) \cdot e^{-k(t-x)}] \cdot (1-OX)$$

where

- t = current year
- x = the year of waste input,  $x \leq t$
- A =  $(1-k)/k$ , norm factor (fraction)
- k = methane generation rate [1/yr]
- M(x) = the amount of waste disposed in year x
- L<sub>0</sub>(x) = methane generation potential (MCF(x) • DOC(x) • DOC<sub>F</sub> • F • 16/12) [Gg CH<sub>4</sub> / Gg waste]
- MCF(x) = methane correction factor (fraction)
- DOC(x) = degradable organic carbon [Gg C/ Gg waste]
- DOC<sub>F</sub> = portion of DOC, that is converted to landfill gas (fraction)
- F = portion of CH<sub>4</sub> in landfill gas (fraction)
- 16/12 = factor to convert C to CH<sub>4</sub>.
- OX = oxidation factor (fraction)

The following general assumptions are made:

MCF(x) = constant = 1 (default value according to IPCC for managed solid waste disposal sites)

OX = 0.1 (default value according to IPCC 1997a-c)

DOC<sub>F</sub> = 0.6 (default value according to IPCC 1997a-c)

F = 0.5 (default value according to IPCC 1997a-c)

The degradable organic carbon DOC(x) is also calculated based on the default values from IPCC 1997a-c.

For the calculation of CH<sub>4</sub> generation three different categories of waste are distinguished. The three categories are i) municipal solid waste, ii) construction waste, and iii) sewage sludge.

The following parameters are applied for the calculation of CH<sub>4</sub> generated.

Table 8-4 Parameters used for FOD model

	<b>k</b> [1/yr]	<b>L<sub>0</sub></b> [Gg CH <sub>4</sub> / Gg waste]	<b>DOC</b> [-]
municipal solid waste	0.139	0.050	1990-1992: 0.15 1993-2002: linear interpolation 2003-2007: 0.12
construction waste	0.046	0.08	0.20
sewage sludge	0.069	0.068	0.17

- ii) In a second step, the amount of CH<sub>4</sub> that is recovered and used as fuel for co-generation units as well as for flaring is subtracted from the CH<sub>4</sub> generated in landfills (resulting from step 1).

$$\text{CH}_4 \text{ emissions}_{\text{step ii}} = \text{CH}_4 \text{ emissions}_{\text{step i}} - (\text{CH}_4 \text{ emissions}_{\text{step i}} * \text{FI}(t)) - \text{Qco-gen}(t)$$

where

FI(t) = portion of generated methane that is flared in the present year (fraction)

Qco-gen(t) = CH<sub>4</sub> which is recovered in co-generation units in the present (Gg)

- iii) In the third step CH<sub>4</sub> emissions from on-site open burning are added. This results in the overall CH<sub>4</sub> emissions from landfill sites.

$$\text{CH}_4 \text{ emissions}_{\text{step iii}} = \text{CH}_4 \text{ emissions}_{\text{step ii}} + \text{Qopen}(t)$$

where

Qopen(t) = CH<sub>4</sub> which is emitted from open burning in the present year (Gg)

- iv) In the fourth and last step the emissions of the other gases are calculated. The respective emissions are considered as proportional to the CH<sub>4</sub> burnt (co-generation and flaring), or to the waste quantity burnt (open burning), respectively.

## Emission Factors

Emission factors for CO<sub>2</sub>, CH<sub>4</sub>, CO, NMVOC and SO<sub>2</sub> are country specific based on measurements and expert estimates, documented in EMIS 2009/6A1. CO<sub>2</sub> emissions from non-biogenic wastes are included, while the CO<sub>2</sub> emissions from biogenic wastes are excluded from total emissions.

The following table presents the emission factors used in 6A1:

Table 8-5 Emission Factors for 6A1 "Managed Waste Disposal Sites on Land" in 2007.

Source	CO <sub>2</sub> biogenic	CO <sub>2</sub> fossil	CH <sub>4</sub>	NO <sub>x</sub>	CO	NM VOC	SO <sub>2</sub>
<b>6A1 Managed Waste Disposal on Land</b>	<b>t / t CH<sub>4</sub> produced</b>						
Direct emissions from landfill	3.00	0	1				
	<b>kg / t CH<sub>4</sub> flared</b>						
Flaring	2'750	0		1	17		
	<b>kg / t waste burned</b>						
Open burning	760	510	6	2.5	50	16	0.8

### Activity data

One set of activity data for Managed Waste Disposal on Land (6A1) are the waste quantities disposed on landfills and the municipal solid waste burned on-site.

Activity data for Managed Waste Disposal on Land (6A1) are taken from EMIS 2009/6A1.

Table 8-6 Activity data in 6A1: Waste disposed of on Managed Landfill Sites from 1990 to 2007 (source EMIS 2009/6A1).

Source / Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<b>6A1 Managed Waste Disposal on Land</b>											
Municipal solid waste (MSW)	Gg	637.0	637.0	637.0	637.0	581.2	531.9	482.7	472.8	463.0	465.3
Construction waste	Gg	147.0	170.5	170.5	123.5	59.1	47.3	35.5	35.5	41.4	41.6
Sewage sludge	Gg (dry)	58.8	58.8	58.8	48.8	39.0	27.7	16.3	12.2	8.1	6.1
Open burned waste	Gg	17.0	20.0	20.0	17.9	11.0	9.7	8.5	8.3	8.3	5.5
Total waste quantity	Gg	859.8	886.3	886.3	827.2	690.2	616.6	543.0	528.8	520.7	518.5

Source / Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007
<b>6A1 Managed Waste Disposal on Land</b>									
Municipal solid waste (MSW)	Gg	288.8	184.8	80.8	52.2	23.7	13.6	3.5	0.0
Construction waste	Gg	30.7	17.7	4.8	3.4	2.0	1.4	0.8	0.0
Sewage sludge	Gg (dry)	4.1	3.9	3.6	2.6	1.6	1.0	0.3	0.0
Open burned waste	Gg	3.4	2.2	0.9	0.6	0.1	0.1	0.0	0.0
Total waste quantity	Gg	327.0	208.6	90.1	58.8	27.5	16.1	4.7	0.0

Table 8-6 documents the reduction of municipal solid waste, construction waste, sewage sludge and open burned waste disposed of over the period 1990–2007. This is due to changes in the legislative framework, making incineration the mandatory disposal option for municipal solid waste and banning its disposal on landfills from 1 January 2000.

The other activity data for Managed Waste Disposal on Land (6A1) is CH<sub>4</sub> flared. The landfill gas recovered and used as fuel for co-generation units is reported under 1A1 energy in accordance to the IPCC Good Practice Guide.

Table 8-7 Activity data in 6A1: Share of CH<sub>4</sub> flared from 1990 to 2007. (source EMIS 2009/6A1).

Source / Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<b>6A1 Managed Waste Disposal on Land</b>											
CH <sub>4</sub> flared	Gg	4.2	4.2	4.3	4.3	4.2	4.1	4.0	3.9	3.7	3.6

Source / Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007
<b>6A1 Managed Waste Disposal on Land</b>									
CH <sub>4</sub> flared	Gg	3.4	3.1	2.8	2.5	2.3	2.1	1.8	1.7

The CH<sub>4</sub> generated in landfills decreases since 1990, due to the fact that waste quantities disposed of in landfills are decreasing. Together with the relative increase of CH<sub>4</sub> recovery from 1990 until 2007 this is the reason for CH<sub>4</sub> emissions from the source category 6A being a key source regarding trend.

### 8.2.3. Uncertainties and Time-Series Consistency

#### Uncertainty in CH<sub>4</sub> emissions from Solid Waste disposal on land in 6A

Uncertainty of direct CH<sub>4</sub> emissions from sanitary landfills is estimated at about 60%<sup>24</sup>.

An uncertainty in the amount of waste disposed of on a landfill of 20% is assumed, because most of the emissions in the nineties result from waste disposed of in the eighties, when waste statistics were less elaborated. From this, an emission factor uncertainty of 56.6% is calculated (resulting in combined uncertainty of 60%).

#### Qualitative estimate of uncertainties of non-key source emissions in 6A

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

Consistency: The time series is consistent.

### 8.2.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Chapter 1.6 have been carried out.

### 8.2.5. Source-Specific Recalculations

The greenhouse gas emissions of CO<sub>2</sub> and CH<sub>4</sub> were recalculated for the years 1992-2006 because of an update of the waste statistics.

### 8.2.6. Source-Specific Planned Improvements

It is planned to use country specific parameters for the CH<sub>4</sub> model.

<sup>24</sup> Source: EMIS 2009/6A1. The uncertainty value from EMIS has to be doubled for the NIR, because in EMIS uncertainty relates to *one* standard deviation, whereas in the NIR uncertainty relates to a 95% confidence interval (i.e. *two* standard deviations).

## 8.3. Source Category 6B – Wastewater Handling

### 8.3.1. Source Category Description

#### Key category 6B

N<sub>2</sub>O from domestic and commercial waste water handling (level and trend)

The source category 6B1 “Industrial Waste Water” comprises all emissions from the handling of liquid wastes and sludge from industrial processes such as food processing, textiles, or pulp and paper production. Emissions from this source category 6B1 are included in source category 6B2 “Domestic and Commercial Waste Water”. This is motivated by the fact that most of the industrial waste water is treated in the municipal waste water treatment plants considered under 6B2.

The source category 6B2 “Domestic and Commercial Waste Water” comprises all emissions from handling of liquid wastes and sludge from housing and commercial sources (including gray water and night soil).

Table 8-8 Specification of source category 6B “Wastewater Handling”.

6B	Source	Specification	Data Source
6B1	Industrial Waste Water	Emissions from handling of liquid wastes and sludge from industrial processes.  (included in 6B2)	
6B2	Domestic and Commercial Waste Water	Emissions from handling of liquid wastes and sludge from housing and commercial sources	AD: EMIS 2009/6B1/6B2 and SFOE 2008 EF: EMIS 2009/6B1/6B2
6B3	Others	Not occurring in Switzerland	

The emissions related to wastewater treatment fall under various categories as laid out in Figure 8-4 below. The system boundaries of category 6B contain all emissions from direct wastewater handling, some emissions from sewage sludge drying and no emissions from sewage sludge use or disposal.

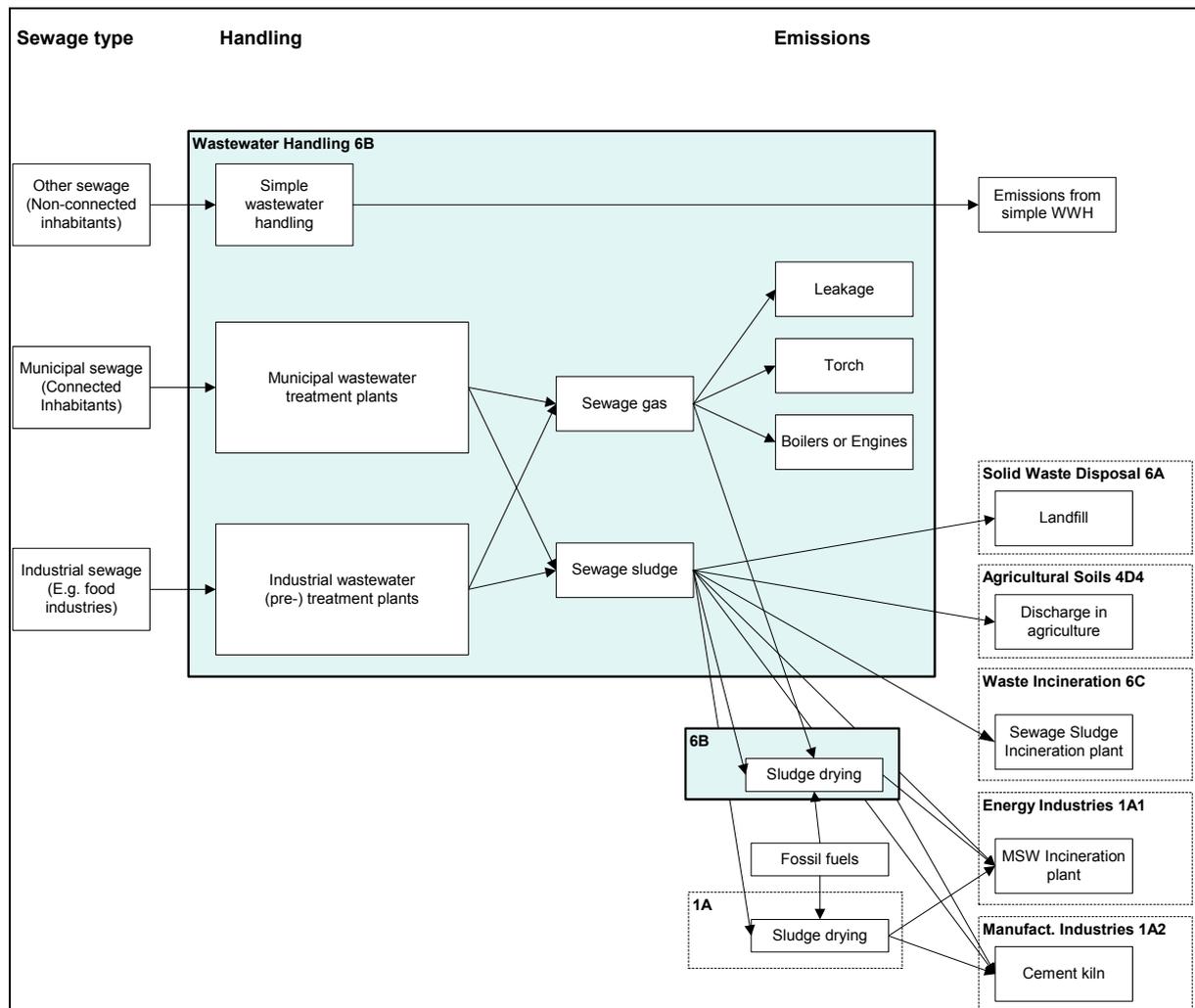


Figure 8-4 System boundaries of emissions related to wastewater treatment.

### 8.3.2. Methodological Issues

#### a) Domestic and Commercial Waste Water (6B2)

##### Methodology

For domestic and commercial waste water treatment (6B2), a country specific method based on CORINAIR is used. The GHG emissions are calculated by multiplying the number of inhabitants connected to waste water treatment plants by emission factors. The unit of emission factors refers to the number of inhabitants connected, and not to the population equivalent, with the exception of N<sub>2</sub>O.

##### Emission Factors

Emission factors for CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CO, NMVOC and SO<sub>2</sub> are country specific based on measurements and expert estimates, documented in the EMIS 2009/6B1/6B2 database. N<sub>2</sub>O are calculated according to IPCC-default method, but using country specific data.

The following table presents the emission factors used in 6B2:

Table 8-9 Emission Factors for 6B2 Domestic and Commercial Waste Water in 2007.

Source	CO <sub>2</sub> biog.	N <sub>2</sub> O	CH <sub>4</sub>	NO <sub>x</sub>	CO	NM VOC	SO <sub>2</sub>
	kg/connected inhabitant	g/inhabitant	g/connected inhabitant				
<b>6B2 Domestic and Commercial Waste Water</b>	25.0	85	81	27	45	0.8	5

Please note that the activity data for N<sub>2</sub>O emissions is the total number of inhabitants, in line with IPCC, whereas the emissions of other gases are calculated based on the fraction of inhabitants that are connected to wastewater treatment plants.

### Activity data

Activity data for Domestic and Commercial Waste Water (6B2) are extracted from EMIS 2009/6B1/6B2 and from SFOE 2008.

Table 8-10 Activity data in 6B2 Domestic and Commercial Waste Water: Population and fraction connected to waste water treatment plants.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
<b>6B2 Domestic and Commercial Waste Water</b>											
Population	inhabitants in 1000	6'796	6'880	6'943	6'989	7'037	7'081	7'105	7'113	7'132	7'167
Fraction connected to waste water treatment plants	%	90.0	91.0	91.5	92.0	93.0	93.5	94.0	94.5	95.0	95.3
connected inhabitants	inhabitants in 1000	6'116	6'261	6'353	6'430	6'544	6'621	6'679	6'722	6'775	6'830

Source/Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007
<b>6B2 Domestic and Commercial Waste Water</b>									
Population	inhabitants in 1000	7'209	7'285	7'343	7'405	7'454	7'501	7'558	7'617
Fraction connected to waste water treatment plants	%	95.4	95.7	96.0	96.3	96.6	96.7	96.7	96.7
connected inhabitants	inhabitants in 1000	6'877	6'972	7'049	7'131	7'201	7'253	7'309	7'366

### 8.3.3. Uncertainties and Time-Series Consistency

#### Uncertainty in N<sub>2</sub>O emissions from 6B

Activity data is highly reliable (estimated uncertainty 0.003%). The uncertainty for the emission factor is estimated to be 100%.

#### Qualitative estimate of uncertainties of non-key category emissions in 6B

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

The time series is consistent.

### 8.3.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### 8.3.5. Source-Specific Recalculations

The data basis for this source has been up-dated (EMIS 2009 / 6B1 / 6B2) for the entire time series. Latest information on activity data and emission factors has been used. Therefore, the greenhouse gas emissions had to be recalculated accordingly. All greenhouse gases are affected. In addition, the number of inhabitants for 2006 was slightly modified, as the number for this year was updated in the Swiss overall energy statistics (SFOE 2008).

### 8.3.6. Source-Specific Planned Improvements

It is planned to report emissions from pre-treatment of industrial effluents separately.

## 8.4. Source Category 6C – Waste Incineration

### 8.4.1. Source Category Description

Source category 6C “Waste Incineration” is **not a key category**.

There is a long tradition in Switzerland for waste to be incinerated. The waste heat generated during the incineration has to be recovered if technically and economically feasible. In accordance with the IPCC provisions (IPCC 1997c) emissions from the combustion of waste-to-energy activities are dealt with in 1A “Fuel Combustion Activities”.

The following sources are included in source category 6C:

Table 8-11 Overview on waste incineration sources reported under 6C.

Waste incineration	Specification	Data Source
<b>Hospital waste incineration</b>	Emissions from incinerating hospital waste in hospital incinerators	AD, EF: EMIS 2009/6C
<b>Illegal waste incineration</b>	Emissions from illegal incineration of municipal solid wastes at home Emissions from waste incineration at construction sites (open burning)	AD, EF: EMIS 2009/6C
<b>Insulation material from cables</b>	Emissions from incinerating cable insulation materials	AD, EF: EMIS 2009/6C
<b>Sewage sludge</b>	Emissions from sewage sludge incineration plants	AD, EF: EMIS 2009/6C
<b>Crematoria</b>	Emissions from the burning of dead bodies	AD, EF: EMIS 2009/6C

The following table gives an overview on other waste incineration sources in Switzerland and the respective source category, where the GHG emissions are reported in the national inventory.

Table 8-12 Overview of other waste incineration activities in Switzerland, and indication of source categories where the waste incineration activity is reported in the national inventory.

Waste incineration	Specification	Source category
Paper and pulp industries	Emissions from incineration of residues and sludge from industrial waste water treatment plants as fuel for paper/pulp production	1A2d Biomass
Municipal solid waste incineration plants	Emissions from waste incineration in municipal solid waste incineration plants	1A1a Other
Waste in cement plants	Emissions from waste use as alternative fuels in cement kilns	1A2f Other
Special waste	Emissions from incinerating industrial and hazardous wastes	1A1a Other

## 8.4.2. Methodological Issues

### Methodology

For the calculation of the greenhouse gas emissions a country specific Tier 2 method is used. In general, the GHG emissions are calculated by multiplying the waste quantity incinerated by emission factors. For crematoria, the GHG emissions are calculated by multiplying the number of cremations by emission factors.

For sewage sludge incineration plants the respective waste quantities are based on reliable statistical data and the emission factors are taking into account different flue gas cleaning standards.

For hospital waste incineration, illegal waste incineration and incineration of insulation material, the waste quantities used are based on rough expert estimates.

### Emission Factors

Emission factors for CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, CO, NMVOC and SO<sub>2</sub> are country specific based on measurements and expert estimates, documented in the EMIS 2009/6C database. In the years with no specific data for the emission factors the respective data are interpolated.

The following table presents the emission factors used in 6C:

Table 8-13 Emission Factors for 6C "Waste Incineration" in 2007 (source EMIS 2009/6C).

6C Waste Incineration							
Source	CO <sub>2</sub> t/t	CH <sub>4</sub> kg/t	N <sub>2</sub> O g/t	NO <sub>x</sub> kg/t	CO kg/t	NMVOC kg/t	SO <sub>2</sub> kg/t
Hospital waste incineration	0.9	0	60	1.5	1.4	0.3	1.3
Illegal waste incineration	0.508	6	0	2.5	50	16	0.75
Insulation material cables	1.3	0	0	1.3	2.5	0.5	6
Sewage sludge plants	0	0.08	800	0.7	0.165	0.0043	0.37
	CO <sub>2</sub> t/crem.	CH <sub>4</sub> kg/crem.	N <sub>2</sub> O g/crem.	NO <sub>x</sub> kg/crem.	CO kg/crem.	NMVOC kg/crem.	SO <sub>2</sub> kg/crem.
Crematoria	0	0	0	0.270	0.196	0.017	0

Additional information on the emission factor CO<sub>2</sub>:

For all waste incineration options the CO<sub>2</sub> emissions only from non-biodegradable waste is taken into account.

- Hospital waste incineration plants: Mainly waste of fossil origin. Default value for the CO<sub>2</sub> emission factor taken from CORINAIR (1992).
- Illegal waste incineration: The main source of non-biodegradable CO<sub>2</sub> emissions is plastic. The assumption was taken, that the waste mix will be the same as the one for municipal solid waste incineration, i.e. 40% of the waste mix is of fossil origin.
- Insulation materials: The CO<sub>2</sub> emission factor is based on measurements of the flue gas quantity and the assumption, that the ratio CO<sub>2</sub>/O<sub>2</sub> is the same as in municipal solid waste incineration plants.
- Sewage sludge plants: Sewage sludge is biodegradable waste. Emission factor for CO<sub>2</sub> is 0. The assumption is taken, that the share of fossil fuel used during the start-ups is very small.

## Activity Data

The activity data for Waste Incineration (6C) are the quantities of waste incinerated.

Table 8-14 Activity data for the different emission sources within source category 6C "Waste Incineration".

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Hospital Waste Incineration	Gg	30.0	27.5	25.0	22.5	20.0	17.5	15.0	12.5	10.0	7.5
Illegal waste	Gg	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Insulation material cables	Gg	7.5	6.0	4.5	3.0	1.5	0.0	0.0	0.0	0.0	0.0
Sewage sludge	Gg dry	57.0	53.9	50.7	47.6	44.4	50.2	56.0	59.6	63.2	63.8
<b>Total</b>	<b>Gg</b>	<b>124.5</b>	<b>117.4</b>	<b>110.2</b>	<b>103.1</b>	<b>95.9</b>	<b>97.7</b>	<b>101.0</b>	<b>102.1</b>	<b>103.2</b>	<b>101.3</b>
Cremations	Numb.	37'513	37'407	37'939	38'884	39'620	40'968	40'998	42'460	42'536	43'480

Source/Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007
Hospital Waste Incineration	Gg	5.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0
Illegal waste	Gg	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Insulation material cables	Gg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sewage sludge	Gg dry	64.3	70.2	76.0	86.5	97.0	120.0	122.0	124.0
<b>Total</b>	<b>Gg</b>	<b>99.3</b>	<b>102.7</b>	<b>106.0</b>	<b>116.5</b>	<b>127.0</b>	<b>150.0</b>	<b>152.0</b>	<b>154.0</b>
Cremations	Numb.	43'604	45'681	46'419	48'080	48'100	48'710	48'872	49'034

Note: Since 2002, all special hospital waste incinerator plants have been closed and all hospital waste is incinerated in municipal solid waste incineration plants (accounted for in 1A1).

### 8.4.3. Uncertainties and Time-Series Consistency

#### Qualitative estimate of uncertainties of (non-key source) emissions in 6C

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

The time series is consistent.

### 8.4.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

### 8.4.5. Source-Specific Recalculations

Emissions from greenhouse gases CH<sub>4</sub> and N<sub>2</sub>O were recalculated for the period 2003-2006.

### 8.4.6. Source-Specific Planned Improvements

There are no planned improvements.

## 8.5. Source Category 6D – Other

### 8.5.1. Source Category Description

#### Key category 6D

CH<sub>4</sub> from composting and digesting organic waste (trend)

The source category 6D “Other” comprises the GHG emissions from car shredding plants, and the process related GHG emissions from composting and from digesting organic waste.

Within the composting activity four types of composting means are distinguished, i.e. i) hall composting, ii) field edge composting, iii) box composting and iv) windrow composting. Composting covers the GHG emissions from centralized composting plants with a capacity of more than 100 tons organic matter/year. Backyard composting is also common practice in Switzerland. However, there are only estimates concerning these respective quantities.

The digestion of organic waste takes places under anaerobic conditions. The digestate (solids left-overs after completion of a process of anaerobic microbial degradation of organic matter) is composted. The biogas generated during the fermentation is used as fuel in co-generation plants or upgraded and used as fuel for cars. However, respective emissions are reported under the energy sector.

Table 8-15 Specification of source category 6D “Other”.

6D		Specification	Data Source
	Car shredding plants	Emissions from car shredding plants	AD, EF: EMIS 2009/2A7
	Composting and digesting	Process related emissions from composting and digesting organic waste	AD, EF: EMIS 2009/6D

### 8.5.2. Methodological Issues

#### Methodology

For the emissions from car shredding a country specific method is used. The GHG emissions are calculated by multiplying the quantity of scrap by the emission factors. For all years the same constant emission factors have been applied.

For the emissions from composting a country specific method is used. The GHG emissions are calculated by multiplying the quantity of wastes by the emission factors. For all years the same constant emission factors have been applied.

For the emissions from digesting a country specific method is used. Digestion plants lead to GHG emissions from the composting of the residues of the fermentation process. The GHG

emissions are calculated by multiplying the quantity of fermented wastes by the emission factors. For all years the same constant emission factors have been applied.

Because of the increase in composting and digesting organic waste the source category 6D "Others" is a key source regarding trend.

### Emission Factors

Emission factors for car shredding, composting and digestion are country specific based on measurements and expert estimates, documented in the EMIS 2009/2A7 and EMIS 2009/6D database. Data used included Edelmann and Schleiss 1999, and AQMD 2002.

The following table presents the emission factors used in 6D:

Table 8-16 Emission Factors for 6D Others in 2007.

Source	CH <sub>4</sub>	N <sub>2</sub> O	NO <sub>x</sub>	CO	NM VOC	SO <sub>2</sub>
Shredder [g/t scrap]				5	100	
Composting [g/t composted waste]	5'000	70			1'700	
Fermentation [g/t fermented waste]	5'300	70			1'700	

### Activity data

Activity data for Other (6D) are extracted from EMIS 2009/2A7 and EMIS 2009/6D.

Activity data for composting and digesting are generally based on reliable statistical data. The quantities for backyard composting are estimated values, i.e. 10% of the amount of waste from composting plants.

Table 8-17 Activity data in 6D Other.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Shredder	Gg	280	284	288	292	296	300	300	300	300	300
Compost	Gg	260	300	320	350	370	400	450	480	500	510
Fermentation	Gg	27.3	31.8	33.9	37.1	39.2	42.8	48.2	51.8	54.0	55.6

Source/Parameter	Unit	2000	2001	2002	2003	2004	2005	2006	2007
Shredder	Gg	300	300	300	300	300	300	300	300
Compost	Gg	640	650	730	745	760	775	790	805
Fermentation	Gg	69.8	71.5	81.0	92.5	104.0	115.5	127.0	138.5

## 8.5.3. Uncertainties and Time-Series Consistency

### Uncertainty in CH<sub>4</sub> emissions from composting and digestion 6D

The uncertainty of the CH<sub>4</sub> emissions in Category 6D from composting and digestion of organic waste is estimated to be 50% (expert estimate). The uncertainty of the related activity data is estimated to be 10% (expert estimate), because waste statistics are rather reliable.

### Qualitative estimate of uncertainties of non-key source emissions in 6D

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

The time series is consistent.

#### **8.5.4. Source-Specific QA/QC and Verification**

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out.

#### **8.5.5. Source-Specific Recalculations**

No source-specific recalculations have been carried out.

#### **8.5.6. Source-Specific Planned Improvements**

The activity data for backyard composting are based on rough estimates. For further submissions more reliable data will be sought.

## 9. Recalculations

### 9.1. Explanations and Justifications for Recalculation

After the in-country review that took place in March 2007 the Inventory Development Plan (see FOEN 2009a) had been updated, mainly based on the "Report of the individual review of the greenhouse gas inventory of Switzerland submitted in 2006 (FCCC/ARR/2006/CHE)" (UNFCCC 2007). The centralized review of the inventories submitted in 2007 and 2008 (FCCC/ARR/2008/CHE) could not be considered for the 2009 inventory submission because it was still unpublished at editorial deadline. However, several findings that had been discussed with the expert review team in course of the review process in September 2008 were incorporated into the inventory improvement process.

The processing of the expert review team's recommendations in the course of inventory preparation and compilation led to several recalculations. Further recalculations had to be carried out due to improvements in some sectors. The details are explained below. All sectors have been recalculated for the full time series 1990-2006.

#### 1 Energy

- a) Activity data for Municipal solid waste and special waste (1A1a Other fuels) have been recalculated for the year 2006. A minor correction was also made to activity data for natural gas in 1A1a.
- b) The modelling of the disaggregation of fuel consumption in the sectors 1A2a-f and 1A4a has been updated according to the latest industry data (Basics 2008, CEPE 2008). Sources 1A2 and 1A4a have been recalculated for 1990-2006.
- c) Activity data in 1A2a has been revised for 2003-2006 due to new industry data.
- d) In 1A2f, activity data and emission factors have been updated due to new data from industry and the Swiss overall energy statistics for several processes from 2000-2006.
- e) 1A3b: Due to double-counting of fugitive emissions from transmission, storage and fuelling of gasoline, the emissions had to be subtracted from 1A3b (they are reported under 1B2av Distribution of oil products). The CO<sub>2</sub> emissions of 1A3b were recalculated for time series 1990–2006.
- f) Off-road emissions have been recalculated due to the update of the off-road database. 1A3c Railways, 1A3d Navigation, 1A4c agriculture/forestry machinery and 1A5 Other/Off-road are concerned.
- g) In 1A4b implied emission factors for CH<sub>4</sub> of liquid fuels and gaseous fuels have been slightly changed for the period 1994-2006. Activity data were updated and emissions factors for CH<sub>4</sub> are not all similar for the different sectors.
- h) The implied CO<sub>2</sub> emission factor in 1B2a v. Distribution of oil products was recalculated from 1995 to 2006.
- i) The implied CO<sub>2</sub> emission factor in 1B2b iii Transmission of natural gas was recalculated for 2006, because an extrapolation was replaced by a calculation.
- j) N<sub>2</sub>O emissions in 1B2d Other was recalculated for 2006 due to updated data in the Swiss overall energy statistics .

#### 2 Industrial Processes

- k) Recalculations have been carried out for the whole time series for CO and NMVOC emissions in 2A5 and for NMVOC emissions in 2A6.

- l) 2B1 Ammonia production activity data has been revised for 1991 to 2006 based on new industry data.
- m) 2B2 Nitric Acid production activity data has been revised for 1997-2006 based on new industry data.
- n) 2B5 Other CH<sub>4</sub> emission factor and activity data have been recalculated for 2005 and 2006 based on new industry data.
- o) 2C1 Iron and Steel production activity data has been improved for the years 2003-2006 based on more precise industry data for 2006 and industry data for 2003-2005 that replace a previous interpolation. CO<sub>2</sub> emissions in 2C1 decreased by 2.03 Gg in 2003, increased by 5.16 Gg in 2004, decreased by 8.77 Gg in 2005 and decreased by 0.06 Gg in 2006.
- p) 2F Consumption of Halocarbons and SF<sub>6</sub>: Some improvements in the emission modelling have been carried out for Commercial Refrigeration, Air Conditioning etc. Details are described in Table 4-16.
- q) 2G CO<sub>2</sub> emissions have been recalculated since 1991 due to updating of activity data for blasting and shooting.

### 3 Solvent and Other Product Use

- r) 3A Paint Application: CO<sub>2</sub> and NMVOC emissions have been recalculated for 2005 and 2006 based on new industry data and expert estimates on NMVOC emissions in these years, replacing a previous extrapolation. CO<sub>2</sub> emissions decreased by 0.044 Gg in 2005 and by 0.11 Gg in 2006.
- s) for the whole time series based on new industry data and expert estimates for these years. CO<sub>2</sub> emissions decreased for all years, by between 0.73 Gg (1990) and 2.5 Gg (2006).
- t) 3C Chemical Products, Manufacture and Processing: CO<sub>2</sub> and NMVOC emissions have been recalculated for 1991 to 2006 based on new industry data and expert estimates for these years. CO<sub>2</sub> emissions decreased for all years, by between 0.19 Gg (1990) and 1.5 Gg (2006).
- u) 3D Other: N<sub>2</sub>O emissions were recalculated for 2006. They decreased by 0.000022 Gg CO<sub>2</sub> eq. The number of inhabitants for 2006 was slightly modified, as the number for this year was updated in the Swiss overall energy statistics (SFOE 2008). Since the number of inhabitants is used as activity data for the modelling of the emissions of 3D Other, they had to be revised accordingly. In addition to that, CO<sub>2</sub> and NMVOC emissions have been recalculated for the whole time series based on new industry data and expert estimates for these years. CO<sub>2</sub> emissions changed to varying extents, between a decrease by 5.0 Gg CO<sub>2</sub> in 2006 and an increase of 7.1 Gg in 1994. In 1990, CO<sub>2</sub> emissions increased by 1.3 Gg CO<sub>2</sub>.

### 4 Agriculture

- v) 4A Enteric fermentation, 4B Manure Management and 4D Agricultural Soils: 2005 and 2006 data have been recalculated due to the availability of updated activity data.

### 5 Land Use, Land-Use change and Forestry

- w) The increment of available AREA activity data (SFSO 2008), ongoing implementation of UNFCCC review reports' recommendations, and some minor methodological improvements and amendments have led to a significant recalculation in the LULUCF sector. In source category 5A the incorporation of the new third national forest inventory (NFI 3)

dataset additionally had a major impact on the emissions by sources and removal by sinks of CO<sub>2</sub>. The concomitant revision of the methodological approach is described in detail in Chapter 7.3.5. In the present inventory, all carbon pools in the sub-sector Forest Land have been averaged over a three-year time period.

Further improvements comprise the application of a land-use conversion period of 20 years (instead of one year) to

- carbon stock changes in living and dead biomass and in soil for “Land converted to afforestations” (CC11);
- soil carbon stock changes in the case of “Land converted to unproductive wetland” (CC42).

## 6 Waste

- x) 6A1 Managed Waste Disposal on Land: The greenhouse gas emissions of CO<sub>2</sub> and CH<sub>4</sub> were recalculated for the years 1992-2006 because of an update of the waste statistics.
- y) 6B Waste Water Handling: The data basis for this source has been up-dated (EMIS 2009 / 6B1 / 6B2) for the entire time series. Latest information on activity data and emission factors has been used. Therefore, the greenhouse gas emissions had to be recalculated accordingly. All greenhouse gases are affected. In addition, the number of inhabitants for 2006 was slightly modified, as the number for this year was updated in the Swiss overall energy statistics (SFOE 2008).
- z) 6C Incineration: Emissions from greenhouse gases CH<sub>4</sub> and N<sub>2</sub>O were recalculated for the period 2003-2006 due to a slight change of the activity data sewage sludge incinerated.

## 9.2. Implications for Emission Levels 1990 and 2006

Table 9-1 shows the recalculation results for the base year 1990. It results in a decrease of the total emissions in CO<sub>2</sub> equivalents (without CO<sub>2</sub> emissions from LULUCF) of -91.10 Gg CO<sub>2</sub> eq. This corresponds to a decrease of the latest submission compared to the previous submission of -0.17% of the national total. If the LULUCF sector is included, there is an increase of 143.04 Gg CO<sub>2</sub> eq due to major recalculations of the LULUCF sector.

Table 9-1 Overview of implications of recalculations on 1990 data. Emissions are shown before the recalculation according to the previous submission in 2008 "Prev." (FOEN 2008) and after the recalculation according to the present submission "Latest". The differences "Differ." are defined as latest minus previous submission.

Recalculation	CO <sub>2</sub>			CH <sub>4</sub>			N <sub>2</sub> O			Sum (CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O)		
	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
<b>Emissions for 1990</b>												
Source and Sink Categories	CO <sub>2</sub> equivalent (Gg)									CO <sub>2</sub> equivalent (Gg)		
1 Energy	41'307	41'253	-54.27	566.5	564.8	-1.67	268.2	267.8	-0.38	42'141.87	42'085.55	-56.32
2 Ind. Processes (without syn. gases)	2'831	2'831	0.00	9.1	9.1	0.00	173.8	173.8	0.00	3'014.19	3'014.19	0.00
3 Solvent and Other Product Use	357	358	0.62			0.00	110.1	110.1	0.00	467.31	467.93	0.62
4 Agriculture				3'042	3'042	0.00	2'861	2'861	0.00	5'903.39	5'903.39	0.00
5 LULUCF	-2'594	-2'360	234.79	8.2	8.2	0.00	12.0	11.3	-0.65	-2'574.11	-2'339.97	234.14
6 Waste	62	62	0.00	755.9	731.9	-24.09	211.6	200.3	-11.31	1'029.53	994.13	-35.40
Sum (without synthetic gases)	41'963	42'144	181.13	4'382	4'356	-25.76	3'637	3'624	-12.34	49'982.18	50'125.21	143.04
<b>Recalculation</b>	<b>HFC</b>			<b>PFC</b>			<b>SF6</b>			<b>Sum (synthetic gases)</b>		
Emissions for 1990	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO <sub>2</sub> equivalent (Gg)									CO <sub>2</sub> equivalent (Gg)		
2 Ind. Processes (only syn. gases)	0.02	0.02	0.00	100.2	100.2	0.00	143.6	143.6	0.00	243.85	243.85	0.00
<b>Recalculation</b>										<b>Sum (all gases)</b>		
Emissions for 1990										Prev.	Latest	Differ.
Source and Sink Categories										CO <sub>2</sub> equivalent (Gg)		
<b>Total CO<sub>2</sub> eq Em. with LULUCF</b>										<b>50'226.03</b>	<b>50'369.07</b>	<b>143.04</b>
										100.00%	100.28%	0.28%
<b>Total CO<sub>2</sub> eq Em. without LULUCF</b>										<b>52'800.14</b>	<b>52'709.04</b>	<b>-91.10</b>
										100.00%	99.83%	-0.17%

For 2006, the recalculation results in a decrease of the total emissions in CO<sub>2</sub> equivalents (without emissions/removals from LULUCF) of -35.76 Gg CO<sub>2</sub> eq. This corresponds to a decrease of the latest submission compared to the previous submission of -0.07% of the national total. If the LULUCF sector is included, an increase of 3270.99 Gg CO<sub>2</sub> (6.42%) is found due to major recalculations in the LULUCF sector.

Table 9-2 Overview of implications of recalculations on 2006 data. Emissions are shown before the recalculation according to the previous submission in 2008 "Prev." (FOEN 2008) and after the recalculation according to the present submission "Latest". The differences "Differ." are defined as latest minus previous submission.

Recalculation Emissions for 2006	CO <sub>2</sub>			CH <sub>4</sub>			N <sub>2</sub> O			Sum (CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O)		
	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO <sub>2</sub> equivalent (Gg)									CO <sub>2</sub> equivalent (Gg)		
1 Energy	43'286	43'312	26.65	291.2	288.6	-2.60	347.0	351.8	4.76	43'923.86	43'952.67	28.81
2 Ind. Processes (without syn. gases)	2'074	2'071	-2.91	7.1	7.0	-0.11	143.9	98.1	-45.85	2'225.37	2'176.49	-48.88
3 Solvent and Other Product Use	186	176	-9.20			0.00	52.7	52.7	0.01	238.35	229.16	-9.19
4 Agriculture			0.00	2'815	2'811	-3.59	2'473	2'476	2.59	5'288.41	5'287.40	-1.01
5 LULUCF	-2'237	1'070	3'307.19	0.8	0.8	0.00	5.7	5.2	-0.44	-2'230.48	1'076.27	3'306.75
6 Waste	15	15	-0.07	425.1	398.1	-26.96	256.9	249.6	-7.26	697.27	662.98	-34.29
Sum (without synthetic gases)	43'324	46'646	3'321.67	3'539.1	3'505.8	-33.28	3'279.6	3'233.4	-46.20	50'142.78	53'384.97	3'242.19

Recalculation Emissions for 2006	HFC			PFC			SF <sub>6</sub>			Sum (synthetic gases)		
	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO <sub>2</sub> equivalent (Gg)									CO <sub>2</sub> equivalent (Gg)		
2 Ind. Processes (only syn. gases)	617.4	609.5	-7.93	56.2	74.5	18.34	162.2	180.6	18.40	835.81	864.61	28.81

Recalculation Emissions for 2006	Sum (all gases)		
	Prev.	Latest	Differ.
Source and Sink Categories	CO <sub>2</sub> equivalent (Gg)		
<b>Total CO<sub>2</sub> eq Em. with LULUCF</b>	<b>50'978.59</b>	<b>54'249.58</b>	<b>3'270.99</b>
	100.00%	106.42%	6.42%
<b>Total CO<sub>2</sub> eq Em. without LULUCF</b>	<b>53'209.07</b>	<b>53'173.31</b>	<b>-35.76</b>
	100.00%	99.93%	-0.07%

### 9.3. Implications for Emissions Trends, including Time Series Consistency

Due to recalculations, the emission trend 1990–2006 reported in the 2008 submission (FOEN 2008) has slightly changed. Compared to 1990, 2006 emissions (national total without emissions/removals from LULUCF) showed an increase of 0.77% before recalculation (previous submission). After recalculation, the increase turns out to be somewhat larger: 0.88% (latest submission).

Table 9-3 Change of the emission trend 1990–2006 due to recalculation. "Previous" refers to data reported in FOEN (2008), whereas "latest" refers to the present submission.

Recalculation	1990		2006		change 2006/1990	
	previous	latest	previous	latest	previous	latest
Submission						
Unit	CO <sub>2</sub> eq (Gg)				%	
Total excl. LULUCF	52'800.1	52'709.0	53'209.1	53'173.3	0.77%	0.88%

All time series in the present submission are consistent.

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## References to EMIS database comments

Table A - 1 Assignments of NFR Codes to titles of EMIS database comments. These internal documents will be made available, on request, to reviewers by the NIC. Titles in *italics* see References above.

NFR Code	EMIS Title	NFR Code	EMIS Title
1 A 1 a ii	Kehrichtverbrennungsanlagen	3 A	Farben-Anwendung Bau
1 A 1 a ii	Sondermüllverbrennungsanlagen	3 A	Farben-Anwendung Haushalte
1 A 2 a	Eisengiessereien Kupolöfen	3 A	Farben-Anwendung Holz
1 A 2 a	Stahl-Produktion Wärmeöfen	3 B	Chemische Reinigung
1 A 2 b	Buntmetallgiessereien übriger Betrieb	3 B	Elektronik-Reinigung
1 A 2 d	Zellulose-Produktion Feuerung	3 B	Metallreinigung
1 A 2 f	Feinkeramik Produktion	3 B	Reinigung Industrie übrige
1 A 2 f	Glas übrige Produktion	3 C	Druckfarben Produktion
1 A 2 f	Glaswolle Produktion Rohprodukt	3 C	Farben-Produktion
1 A 2 f	Hohlglas Produktion	3 C	Feinchemikalien-Produktion
1 A 2 f	Kalkproduktion, Feuerung	3 C	Gummi-Verarbeitung
1 A 2 f	Mischgut Produktion	3 C	Klebband-Produktion
1 A 2 f	Steinwolle Produktion Rohprodukt	3 C	Klebstoff-Produktion
1 A 2 f	Ziegeleien	3 C	Lösungsmittel-Umschlag und -Lager
1 A 2 f / 2 D 1	Faserplatten Produktion	3 C	Pharmazeutische Produktion
1 A 2 f / 3 D	Steinwolle-Imprägnierung	3 C	Polyester-Verarbeitung
1 A 2 f / 6 B 1 / 6 B 2	Zementwerke Feuerung	3 C	Polystyrol-Verarbeitung
1 A 3 a / 1 A 3 e	Flugverkehr	3 C	Polyurethan-Verarbeitung
1 A 3 b i-viii	Strassenverkehr	3 C	PVC-Verarbeitung
1 A 3 c	Schienerverkehr	3 D	Betonzusatzmittel-Anwendung
1 A 3 d	Off-Road	3 D	Coiffeursalons
1 A 4 c i	Graströcknung	3 D	Druckereien
1 A div.	Energie New	3 D	Entfernung von Farben und Lacken
1 B 2 a iv	Raffinerie, Leckverluste	3 D	Entwachsung von Fahrzeugen
1 B 2 a v	Benzinumschlag Tanklager	3 D	Fahrzeug-Unterbodenschutz
1 B 2 a v	Benzinumschlag Tankstellen	3 D	Feuerwerke
1 B 2 b	Gasverteilung Netzverluste	3 D	Flugzeug-Enteisung
1 B 2 c 2 1	Raffinerie, Abfackelung	3 D	Gas-Anwendung
2 A 1	Zementwerke Rohmaterial	3 D	Gerben von Ledermaterialien
2 A 1	Zementwerke übriger Betrieb	3 D	Gesundheitswesen, übrige
2 A 2	Kalkproduktion, Rohmaterial	3 D	Glaswolle Imprägnierung
2 A 2	Kalkproduktion, übriger Betrieb	3 D	Holzschutzmittel-Anwendung
2 A 5	Dachpappen Produktion Emissionen aus Bitumen	3 D	Klebstoff-Anwendung
2 A 5	Dachpappen Produktion Voranstrich	3 D	Korrosionsschutz im Freien
2 A 5	Dachpappen Verlegung Bitumen	3 D	Kosmetika-Produktion
2 A 5	Dachpappen Verlegung Voranstrich	3 D	Kosmetik-Institute
2 A 6	Strassenbelagsarbeiten Bitumen	3 D	Kühlschmiermittel-Verwendung
2 A 6	Strassenbelagsarbeiten Voranstrich	3 D	Lachgasanwendung Haushalt
2 A 7	Gips-Produktion übriger Betrieb	3 D	Lachgasanwendung Spitäler
2 B 1	Ammoniak-Produktion	3 D	Lösungsmittel-Emissionen IG nicht zugeordnet
2 B 2	Salpetersäure Produktion	3 D	Medizinische Praxen
2 B 4	Graphit und Siliziumkarbid Produktion	3 D	Öl- und Fettgewinnung
2 B 5	Ammoniumnitrat-Produktion	3 D	Papier- und Karton-Produktion
2 B 5	Chlorgas-Produktion	3 D	Parfum- und Aromen-Produktion
2 B 5	Essigsäure-Produktion	3 D	Pflanzenschutzmittel-Verwendung
2 B 5	Ethen-Produktion	3 D	Pharma-Produkte im Haushalt
2 B 5	Formaldehyd-Produktion	3 D	Reinigung Gebäude IGD
2 B 5	PVC-Produktion	3 D	Reinigungs- und Lösemittel; Haushalte
2 B 5	Salzsäure-Produktion	3 D	Schmierstoff-Verwendung
2 B 5	Schwefelsäure-Produktion	3 D	Spraydosen Haushalte
2 C 1	Eisengiessereien Elektroschmelzöfen	3 D	Spraydosen IndustrieGewerbe
2 C 1	Eisengiessereien übriger Betrieb	3 D	Tabakwaren Konsum
2 C 1	Stahl-Produktion Elektroschmelzöfen	3 D	Tabakwaren Produktion
2 C 1	Stahl-Produktion übriger Betrieb	3 D	Textilien-Produktion
2 C 1	Stahl-Produktion Walzwerke	3 D	Wissenschaftliche Laboratorien
2 C 3	Aluminium Produktion	4 div.	Landwirtschaft
2 C 5	Batterie-recycling	4 F	Abfallverbrennung Land- und Forstwirtschaft
2 C 5	Buntmetallgiessereien Elektroöfen	5 E	Blitze
2 C 5	Verzinkereien	5 E	Flüsse
2 D 1	Zellulose Produktion übriger Betrieb	5 E	Laubwald
2 D 2	Bierbrauereien	5 E	Nadelwald
2 D 2	Branntwein Produktion	5 E	Natürliche Grasflächen
2 D 2	Brot Produktion	5 E	Seen
2 D 2	Fleischräuchereien	5 E	Waldbrände
2 D 2	Kaffeeröstereien	5 E	Wildtiere gross
2 D 2	Müllereien	5 E	Wildtiere klein
2 D 2	Wein Produktion	6 A 1	Kehrichtdeponien
2 D 2	Zucker Produktion	6 B 2	Kläranlagen
2 F 1	Kühlanlagen	6 C	Abfallverbrennung illegal
2 F div.	Synthetische Gase	6 C	Kabelabbrand
2 G	Holzbearbeitung	6 C	Klärschlammverbrennung
2 G	Holzkohle Produktion	6 C	Krematorien
2 G	Spanplatten Produktion	6 C	Spitalabfallverbrennung
2 G	Sprengen und Schiessen	6 D	Kompostierung
3 A	Farben-Anwendung andere industrielle	6 D	Shredder Anlagen
3 A	Farben-Anwendung andere nicht industrielle	6 D	Vergärung
3 A	Farben-Anwendung Autoreparatur	7 A 1 - 5	Mensch



## Annexes

### Annex 1: Key Category Analysis (KCA)

#### *A1.1 Methodology*

The key category analysis is performed according to the IPCC Good Practice Guidance (IPCC 2000, chapter 7): A Tier 1 level and trend assessment is applied with the proposed threshold of 95%. A Tier 2 key category analyses has also been carried out for this submission with the proposed threshold of 90% of the sum of all level assessments weighted with their uncertainty. All main source categories have been disaggregated into sub-sources (e.g. 2A, 2B, 2C etc.) and gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, and SF<sub>6</sub>).

For some important sources, an even more detailed level of disaggregation has been used in order to clearly identify and isolate the most important sources.

In the important source category 1A Energy Fuel Combustion sources have been disaggregated further to the level of sub-categories (e.g. 1A1 Fuel Combustion – Energy Industries, 1A2 Fuel Combustion – Manufacturing Industries, etc.) as well as fuels (e.g. gaseous fuels, liquid fuels, etc.). The source Transport (1A3) has been further split into Civil Aviation (1A3a), Road Transportation (1A3b), and Other Transportation (military aviation; 1A3e)

A more detailed disaggregation has been carried out for Other Sectors (1A4) which has been split into Commercial/Institutional (1A4a), Residential (1A4b) and Agriculture/Forestry (1A4c). In Consumption of Halocarbons and SF<sub>6</sub> (2F), HFC from Refrigeration and AC Equipment (2F1-HFC) and SF<sub>6</sub> from Electrical Equipment (2F8-SF<sub>6</sub>) are separated from the rest (2F\_o). In Agricultural Soils (4D), N<sub>2</sub>O from Direct and Indirect Soil Emissions (4D1-N<sub>2</sub>O, 4D3-N<sub>2</sub>O), respectively, are separated from the rest (4D\_o).

For the Tier 2 key category analyses, results from Tier 1 uncertainty analysis were used. In addition to that, CO<sub>2</sub> emissions in 1A Energy were disaggregated based on results of the Tier 2 uncertainty analysis carried out for the previous submission (FOEN 2008). A scaling factor was used to achieve that the uncertainties of CO<sub>2</sub> emissions when combined are identical to the aggregated Tier 1 uncertainties for 1A Energy.

**A1.2 KCA Tier 1 2007 without LULUCF categories.****A1.2.1 Results of Key Category Analysis Tier 1 – Level**

Table A - 2 Key category analysis Tier 1 2007 (without LULUCF) regarding level (year t refers to 2007). Note that the total of emissions shown in this table (52'272 Gg CO<sub>2</sub> eq) is slightly higher than the total in the CRF and the rest of this report (51'265 Gg CO<sub>2</sub> eq), because the key category analysis was carried out before an error was detected and corrected in the CRF tables during the drafting of the report.

IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Cumulative Total Column E-L	Result level assessment
						[Gg CO <sub>2</sub> eq]	[Gg CO <sub>2</sub> eq]			
TOTAL					All	52'271.08	51'272.33	100.00%		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'335.25	10'614.99	20.70%	20.70%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	7'922.91	15.45%	36.12%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'647.42	5'188.33	10.12%	46.27%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'444.11	3'310.50	6.46%	52.73%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	3'339.62	2'572.26	5.02%	57.75%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	2'318.84	4.52%	62.27%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2'162.03	4.22%	66.49%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	1'066.65	2'161.70	4.22%	70.70%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2'141.71	4.18%	74.88%	KC level
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'844.15	3.60%	78.48%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	938.95	1'350.12	2.63%	81.11%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	1'231.47	2.40%	83.51%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	1'387.85	774.46	1.51%	85.02%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	758.97	1.48%	86.50%	KC level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	692.36	1.35%	87.85%	KC level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CO2	443.97	588.91	1.15%	89.00%	KC level
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	568.66	1.11%	90.11%	KC level
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.47	529.32	1.03%	91.14%	KC level
4B	4. Agriculture	B. Manure Management			CH4	557.43	500.85	0.98%	92.12%	KC level
4B	4. Agriculture	B. Manure Management			N2O	448.20	408.39	0.80%	92.92%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	156.87	295.17	0.58%	93.49%	KC level
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	279.30	0.54%	94.04%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	261.50	0.51%	94.55%	KC level
6B	6. Waste	B. Wastewater Handling			N2O	179.35	201.02	0.39%	94.94%	KC level
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	180.11	0.35%	95.29%	KC level
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	179.13	0.35%	95.64%	-
3	3. Solvent and Other Product Use				CO2	357.79	177.11	0.35%	95.99%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CH4	380.46	173.28	0.34%	96.32%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.90	161.21	0.31%	96.64%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	138.39	0.27%	96.91%	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	111.86	115.67	0.23%	97.13%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	115.09	0.22%	97.36%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	112.44	0.22%	97.58%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CO2	139.24	102.65	0.20%	97.78%	-
6D	6. Waste	D. Other			CH4	30.34	99.94	0.19%	97.97%	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	173.76	83.15	0.16%	98.13%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	87.79	81.62	0.16%	98.29%	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	81.55	0.16%	98.45%	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	77.08	0.15%	98.60%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	62.14	0.12%	98.72%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	60.86	0.12%	98.84%	-
3	3. Solvent and Other Product Use				N2O	110.14	53.72	0.10%	98.95%	-
2A o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.21	47.32	0.09%	99.04%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	52.32	42.76	0.08%	99.12%	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	36.49	0.07%	99.19%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	57.10	35.14	0.07%	99.26%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	8.41	31.93	0.06%	99.33%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6			SF6	79.58	31.72	0.06%	99.39%	-
6C	6. Waste	C. Waste Incineration			N2O	14.69	30.75	0.06%	99.45%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	34.26	25.52	0.05%	99.50%	-
6D	6. Waste	D. Other			N2O	6.23	20.47	0.04%	99.54%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.29	20.11	0.04%	99.58%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	20.05	0.04%	99.62%	-

(cont'd next page)

IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Cumulative Total Column E-L	Result level assessment
						[Gg CO2eq]	[Gg CO2eq]			
TOTAL					All	52711.08	51272.33	100.00%		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.32	17.86	0.03%	99.65%	-
6C	6. Waste	C. Waste Incineration			CO2	52.87	15.25	0.03%	99.68%	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	15.21	0.03%	99.71%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	8.14	13.01	0.03%	99.74%	-
6B	6. Waste	B. Wastewater Handling			CH4	4.51	12.53	0.02%	99.76%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	4.29	12.25	0.02%	99.78%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	0.02%	99.80%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.30	8.42	0.02%	99.82%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.24	8.38	0.02%	99.84%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	9.45	6.76	0.01%	99.85%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	N2O	5.13	6.67	0.01%	99.86%	-
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8.16	6.30	0.01%	99.87%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	4.96	5.27	0.01%	99.88%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	2.95	5.22	0.01%	99.89%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.06	0.01%	99.90%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.40	4.95	0.01%	99.91%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	7.31	4.00	0.01%	99.92%	-
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.99	0.01%	99.93%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	0.01%	99.94%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.35	3.79	0.01%	99.94%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	1.60	2.56	0.00%	99.95%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.37	0.00%	99.95%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	0.00%	99.96%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.27	0.00%	99.96%	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.62	1.74	0.00%	99.97%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.41	0.00%	99.97%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.35	0.00%	99.97%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	0.60	1.22	0.00%	99.97%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.21	0.00%	99.98%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CH4	1.23	1.14	0.00%	99.98%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.13	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.96	1.02	0.00%	99.98%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.49	1.01	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.54	0.96	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.85	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.76	0.00%	99.99%	-
2A o	2. Industrial Proc.	A. Mineral Products			CH4	0.94	0.65	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.60	0.00%	99.99%	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.60	0.53	0.00%	99.99%	-
2G	2. Industrial Proc.	G. Other			CO2	1.04	0.44	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.43	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.36	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.33	0.00%	100.00%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.55	0.29	0.00%	100.00%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.27	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.03	0.25	0.00%	100.00%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.22	0.00%	100.00%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.30	0.19	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.15	0.00%	100.00%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.12	0.00%	100.00%	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.13	0.06	0.00%	100.00%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.05	0.00%	100.00%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		N2O	0.03	0.03	0.00%	100.00%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	100.00%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.00%	100.00%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CH4	0.00	0.00	0.00%	100.00%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	NO	NO	0.00%	100.00%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.00%	100.00%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.00%	100.00%	-
2A o	2. Industrial Proc.	A. Mineral Products			N2O	NO	NO	0.00%	100.00%	-
2B	2. Industrial Proc.	B. Chemical Industry			HFC	NO	NO	0.00%	100.00%	-
2B	2. Industrial Proc.	B. Chemical Industry			PFC	NO	NO	0.00%	100.00%	-
2B	2. Industrial Proc.	B. Chemical Industry			SF6	0.00	0.00	0.00%	100.00%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			PFC	0.00	0.00	0.00%	100.00%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CH4	IE,NO	IE,NO	0.00%	100.00%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			N2O	NO	NO	0.00%	100.00%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	NO	0.00%	100.00%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	NO	0.00%	100.00%	-
2D	2. Industrial Proc.	D. Other Production			CO2	NO	NO	0.00%	100.00%	-
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6			CO2	0.00	0.00	0.00%	100.00%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC & 2F8-SF6			CO2	0.00	0.00	0.00%	100.00%	-
2G	2. Industrial Proc.	G. Other			CH4	NO	NO	0.00%	100.00%	-
2G	2. Industrial Proc.	G. Other			N2O	NO	NO	0.00%	100.00%	-
4C	4. Agriculture	C. Rice Cultivation			CH4	NO	NO	0.00%	100.00%	-
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			CH4	NO	NO	0.00%	100.00%	-
4E	4. Agriculture	E. Prescribed Burning of Savannas			CH4	NO	NO	0.00%	100.00%	-
4E	4. Agriculture	E. Prescribed Burning of Savannas			N2O	NO	NO	0.00%	100.00%	-
4G	4. Agriculture	G. Other			CH4	NO	NO	0.00%	100.00%	-
4G	4. Agriculture	G. Other			N2O	NO	NO	0.00%	100.00%	-
6D	6. Waste	D. Other			CO2	NO	NO	0.00%	100.00%	-

(cont'd)

### A1.2.2 Results of Key Category Analysis Tier 1 – Trend

Table A - 3 Key category analysis Tier 1 2007 (without LULUCF) regarding trend (year t refers to 2007).

IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
				[Gg CO2eq]	[Gg CO2eq]						
TOTAL				All	52711.08	51272.33	100.00%	0.288203	100.0%		
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	2847.42	5188.33	10.12%	0.052397	18.2%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Liquid Fuels	10215.56	7922.91	15.45%	0.040379	14.0%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	1066.65	2161.70	4.22%	0.022541	7.8%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Liquid Fuels	4444.11	3310.50	6.46%	0.020298	7.0%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Gaseous Fuels	1406.59	2141.71	4.18%	0.015610	5.4%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	1519.73	2162.03	4.22%	0.013710	4.8%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	3339.62	2572.26	5.02%	0.013558	4.7%	KC level	KC trend
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2		CO2	2524.77	1844.15	3.60%	0.012265	4.3%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	1387.85	774.46	1.51%	0.011539	4.0%	KC level	KC trend
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.02	668.66	1.11%	0.011402	4.0%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	938.95	1350.12	2.63%	0.008758	3.0%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	11335.25	10614.99	20.70%	0.008238	2.9%	KC level	KC trend
6A	6. Waste	A. Solid Waste Disposal on Land		CH4	693.04	279.30	0.54%	0.007917	2.7%	KC level	KC trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	443.97	588.91	1.15%	0.003149	1.1%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	156.87	295.17	0.58%	0.002859	1.0%	KC level	KC trend
4D1	4. Agriculture	D. Agricultural Soils: Direct Soil Emissions		N2O	1389.94	1231.47	2.40%	0.002417	0.8%	KC level	KC trend
4D3	4. Agriculture	D. Agricultural Soils: Indirect Emissions		N2O	818.89	692.36	1.35%	0.002089	0.7%	KC level	KC trend
4A	4. Agriculture	A. Enteric Fermentation		CH4	2474.84	2318.64	4.52%	0.001777	0.6%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	691.23	758.97	1.48%	0.001737	0.6%	KC level	KC trend
4B	4. Agriculture	B. Manure Management		CH4	557.43	500.85	0.98%	0.000829	0.3%	KC level	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	234.93	261.50	0.51%	0.000661	0.2%	KC level	-
4B	4. Agriculture	B. Manure Management		N2O	448.20	408.39	0.80%	0.000553	0.2%	KC level	-
6B	6. Waste	B. Wastewater Handling		N2O	179.35	201.02	0.39%	0.000533	0.2%	KC level	-
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		N2O	200.19	180.11	0.35%	0.000293	0.1%	KC level	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	547.47	529.32	1.03%	0.000064	0.0%	KC level	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CH4	380.46	173.28	0.34%	0.003946	1.4%	-	KC trend
3	3. Solvent and Other Product Use			CO2	357.79	177.11	0.35%	0.003427	1.2%	-	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	46.90	161.21	0.31%	0.002318	0.8%	-	KC trend
1A3a	1. Energy	A. Fuel Combustion	3. Transport: Civil Aviation	CO2	252.55	138.39	0.27%	0.002151	0.7%	-	KC trend
2B	2. Industrial Proc.	B. Chemical Industry		N2O	173.76	83.15	0.16%	0.001722	0.6%	-	KC trend
1A3e	1. Energy	A. Fuel Combustion	3. Transport: Other Transportation (military aviation)	CO2	200.04	115.09	0.22%	0.001594	0.6%	-	KC trend
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		PFC	0.04	77.08	0.15%	0.001545	0.5%	-	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	91.32	17.86	0.03%	0.001423	0.5%	-	KC trend
6D	6. Waste	D. Other		CH4	30.34	99.94	0.19%	0.001412	0.5%	-	KC trend
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CO2	112.45	179.13	0.35%	0.001399	0.5%	-	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	48.42	112.44	0.22%	0.001310	0.5%	-	KC trend
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		SF6	0.00	62.14	0.12%	0.001246	0.4%	-	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	0.00	60.86	0.12%	0.001220	0.4%	-	-
3	3. Solvent and Other Product Use			N2O	110.14	53.72	0.10%	0.001071	0.4%	-	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6		SF6	79.58	31.72	0.06%	0.000916	0.3%	-	-
6C	6. Waste	C. Waste Incineration		CO2	52.87	15.25	0.03%	0.000725	0.3%	-	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CO2	139.24	102.65	0.20%	0.000657	0.2%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	8.41	31.93	0.06%	0.000476	0.2%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Solid Fuels	57.10	35.14	0.07%	0.000409	0.1%	-	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.		SF6	64.04	81.55	0.16%	0.000386	0.1%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Gaseous Fuels	40.29	20.11	0.04%	0.000383	0.1%	-	-
6C	6. Waste	C. Waste Incineration		N2O	14.69	30.75	0.06%	0.000330	0.1%	-	-
6D	6. Waste	D. Other		N2O	6.23	20.47	0.04%	0.000289	0.1%	-	-
6A	6. Waste	A. Solid Waste Disposal on Land		CO2	9.13	0.06	0.00%	0.000177	0.1%	-	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport: Railways	CO2	28.69	36.49	0.07%	0.000172	0.1%	-	-
2A o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2		CO2	40.21	47.32	0.09%	0.000165	0.1%	-	-
6B	6. Waste	B. Wastewater Handling		CH4	4.51	12.53	0.02%	0.000163	0.1%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Biomass	52.32	42.76	0.08%	0.000163	0.1%	-	-

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IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year 1 Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
					[Gg CO2eq]	[Gg CO2eq]					
TOTAL				All	52'711.08	51'272.33	100.00%	0.288203	100.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	4.29	12.25	0.02%	0.000162	0.1%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	34.26	25.52	0.05%	0.000156	0.1%	-	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport, Navigation	CO2	111.86	115.67	0.23%	0.000138	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	8.14	13.01	0.03%	0.000102	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	25.84	20.05	0.04%	0.000102	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport, Road Transportation	Gasoline	87.79	81.62	0.16%	0.000076	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	5.83	2.27	0.00%	0.000068	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	7.31	4.00	0.01%	0.000062	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	2.40	4.95	0.01%	0.000052	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	11.24	8.38	0.02%	0.000051	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	9.45	6.76	0.01%	0.000049	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	2.95	5.22	0.01%	0.000047	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		CO2	13.60	15.21	0.03%	0.000040	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	3.26	5.06	0.01%	0.000038	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	5.13	6.67	0.01%	0.000034	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		CH4	8.16	6.30	0.01%	0.000033	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	10.30	8.42	0.02%	0.000032	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	2.54	0.96	0.00%	0.000030	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	2.35	3.79	0.01%	0.000030	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	3.83	2.36	0.00%	0.000027	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport, Civil Aviation	N2O	2.46	1.35	0.00%	0.000021	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	1.60	2.56	0.00%	0.000020	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	1.96	1.02	0.00%	0.000018	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport, Other Transportation (military aviation)	N2O	1.97	1.13	0.00%	0.000016	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	0.60	1.22	0.00%	0.000013	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	0.25	0.85	0.00%	0.000012	0.0%	-	-
2G	2. Industrial Proc.	G. Other		CO2	1.04	0.44	0.00%	0.000011	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	4.96	5.27	0.01%	0.000009	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	0.79	1.21	0.00%	0.000009	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport, Road Transportation	Diesel	1.49	1.01	0.00%	0.000009	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	2.15	2.37	0.00%	0.000006	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues		CH4	10.00	10.00	0.02%	0.000005	0.0%	-	-
2A o	2. Industrial Proc.	A. Mineral Products		CH4	0.94	0.65	0.00%	0.000005	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport, Road Transportation	Biomass	0.00	0.27	0.00%	0.000005	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	0.10	0.36	0.00%	0.000005	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	0.53	0.76	0.00%	0.000005	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	0.55	0.29	0.00%	0.000005	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	0.03	0.25	0.00%	0.000004	0.0%	-	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	N2O	1.62	1.74	0.00%	0.000003	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	1.62	1.41	0.00%	0.000003	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	0.49	0.33	0.00%	0.000003	0.0%	-	-
6C	6. Waste	C. Waste Incineration		CH4	3.96	3.99	0.01%	0.000003	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	0.30	0.19	0.00%	0.000002	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues		N2O	3.91	3.91	0.01%	0.000002	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	0.36	0.43	0.00%	0.000002	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	0.54	0.60	0.00%	0.000002	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	1.23	1.14	0.00%	0.000001	0.0%	-	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	CH4	0.60	0.53	0.00%	0.000001	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	0.09	0.05	0.00%	0.000001	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport, Other Transportation (military aviation)	CH4	0.16	0.12	0.00%	0.000001	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport, Road Transportation	Biomass	0.00	0.02	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	0.13	0.15	0.00%	0.000000	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport, Civil Aviation	CH4	0.24	0.22	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	0.02	0.01	0.00%	0.000000	0.0%	-	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	N2O	0.03	0.03	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	NO	NO	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-
2A o	2. Industrial Proc.	A. Mineral Products		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		HFC	NO	NO	0.00%	0.000000	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		PFC	NO	NO	0.00%	0.000000	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		SF6	0.00	0.00	0.00%	0.000000	0.0%	-	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		PFC	0.00	0.00	0.00%	0.000000	0.0%	-	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
2C3	2. Industrial Proc.	C. Metal Production, Aluminium Production-CO2		CO2	139.28	NO	0.00%	0.000000	0.0%	-	-
2C3	2. Industrial Proc.	C. Metal Production, Aluminium Production-PFC		PFC	100.17	NO	0.00%	0.000000	0.0%	-	-
2D	2. Industrial Proc.	D. Other Production		CO2	NO	NO	0.00%	0.000000	0.0%	-	-
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6		CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC & 2F6-SF6		CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-
2G	2. Industrial Proc.	G. Other		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
2G	2. Industrial Proc.	G. Other		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
4C	4. Agriculture	C. Rice Cultivation		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
4E	4. Agriculture	E. Prescribed Burning of Savannas		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
4E	4. Agriculture	E. Prescribed Burning of Savannas		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
4G	4. Agriculture	G. Other		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
4G	4. Agriculture	G. Other		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
6D	6. Waste	D. Other		CO2	NO	NO	0.00%	0.000000	0.0%	-	-

(cont'd)

## A1.3 KCA Tier 1 2007 including LULUCF categories

### A1.3.1 Results of Key Category Analysis Tier 1 – Level

Table A - 4 Key category analysis Tier 1 2007 (with LULUCF) regarding level (year t refers to 2007).

IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Cumulative Total Column E-L	Result level assessment
						[Gg CO2eq]	[Gg CO2eq]			
TOTAL					All	57'423.79	54'134.47	100.00%		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'335.25	10'614.99	19.61%	19.61%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	7'922.91	14.64%	34.24%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'647.42	5'188.33	9.58%	43.83%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'444.11	3'310.50	6.12%	49.94%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	3'339.62	2'572.26	4.75%	54.70%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	2'318.64	4.28%	58.98%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2'162.03	3.99%	62.97%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	1'066.65	2'161.70	3.99%	66.97%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2'141.71	3.96%	70.92%	KC level
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'844.15	3.41%	74.33%	KC level
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	3'362.03	1'722.75	3.18%	77.51%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	938.95	1'350.12	2.49%	80.00%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	1'231.47	2.27%	82.28%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	1'387.85	774.46	1.43%	83.71%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	758.97	1.40%	85.11%	KC level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	692.36	1.28%	86.39%	KC level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CO2	443.97	588.91	1.09%	87.48%	KC level
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	568.66	1.05%	88.53%	KC level
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	570.89	559.03	1.03%	89.56%	KC level
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	547.47	529.32	0.98%	90.54%	KC level
4B	4. Agriculture	B. Manure Management			CH4	557.43	500.85	0.93%	91.47%	KC level
4B	4. Agriculture	B. Manure Management			N2O	448.20	408.39	0.75%	92.22%	KC level
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	398.89	301.58	0.56%	92.78%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	156.87	295.17	0.55%	93.32%	KC level
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	279.30	0.52%	93.84%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	261.50	0.48%	94.32%	KC level
6B	6. Waste	B. Wastewater Handling			N2O	179.35	201.02	0.37%	94.69%	KC level
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	180.11	0.33%	95.02%	KC level
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	179.13	0.33%	95.36%	-
3	3. Solvent and Other Product Use				CO2	357.79	177.11	0.33%	95.68%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CH4	380.46	173.28	0.32%	96.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.90	161.21	0.30%	96.30%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	138.39	0.26%	96.56%	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	111.86	115.67	0.21%	96.77%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	115.09	0.21%	96.98%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	112.44	0.21%	97.19%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CO2	139.24	102.65	0.19%	97.38%	-
6D	6. Waste	D. Other			CH4	30.34	99.94	0.18%	97.56%	-
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	39.63	93.55	0.17%	97.74%	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	173.76	83.15	0.15%	97.89%	-
5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	110.35	81.92	0.15%	98.04%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	87.79	81.62	0.15%	98.19%	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	81.55	0.15%	98.34%	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PF6	0.04	77.08	0.14%	98.49%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	62.14	0.11%	98.60%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	60.86	0.11%	98.71%	-
3	3. Solvent and Other Product Use				N2O	110.14	53.72	0.10%	98.81%	-
2A o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.21	47.32	0.09%	98.90%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	52.32	42.76	0.08%	98.98%	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	36.49	0.07%	99.05%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	57.10	35.14	0.06%	99.11%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	8.41	31.93	0.06%	99.17%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6			SF6	79.58	31.72	0.06%	99.23%	-
6C	6. Waste	C. Waste Incineration			N2O	14.69	30.75	0.06%	99.29%	-
5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	3.48	29.21	0.05%	99.34%	-

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IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Cumulative Total Column E-L	Result level assessment
					[Gg CO2eq]	[Gg CO2eq]				
TOTAL					All	57'423.79	54'134.47	100.00%		
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	126.38	28.85	0.05%	99.39%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	34.26	25.52	0.05%	99.44%	-
6D	6. Waste	D. Other			N2O	6.23	20.47	0.04%	99.48%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.29	20.11	0.04%	99.52%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	20.05	0.04%	99.55%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.32	17.86	0.03%	99.59%	-
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	6.85	17.59	0.03%	99.62%	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	36.76	17.16	0.03%	99.65%	-
6C	6. Waste	C. Waste Incineration			CO2	52.87	15.25	0.03%	99.68%	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	15.21	0.03%	99.71%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	8.14	13.01	0.02%	99.73%	-
6B	6. Waste	B. Wastewater Handling			CH4	4.51	12.53	0.02%	99.75%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	4.29	12.25	0.02%	99.78%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	0.02%	99.79%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.30	8.42	0.02%	99.81%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.24	8.38	0.02%	99.82%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	9.45	6.76	0.01%	99.84%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	N2O	5.13	6.67	0.01%	99.85%	-
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8.16	6.30	0.01%	99.86%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	4.96	5.27	0.01%	99.87%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	2.95	5.22	0.01%	99.88%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.06	0.01%	99.89%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.40	4.95	0.01%	99.90%	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	7.12	4.69	0.01%	99.91%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	7.31	4.00	0.01%	99.92%	-
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.99	0.01%	99.92%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	0.01%	99.93%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.35	3.79	0.01%	99.94%	-
5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	15.81	3.09	0.01%	99.94%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	1.60	2.56	0.00%	99.95%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.37	0.00%	99.95%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	0.00%	99.96%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.27	0.00%	99.96%	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.62	1.74	0.00%	99.96%	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	8.19	1.74	0.00%	99.97%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.41	0.00%	99.97%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.35	0.00%	99.97%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	0.60	1.22	0.00%	99.97%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.21	0.00%	99.98%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CH4	1.23	1.14	0.00%	99.98%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.13	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.96	1.02	0.00%	99.98%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.49	1.01	0.00%	99.98%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.54	0.96	0.00%	99.99%	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	4.22	0.90	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.85	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.76	0.00%	99.99%	-
2A o	2. Industrial Proc.	A. Mineral Products			CH4	0.94	0.65	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.60	0.00%	99.99%	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.60	0.53	0.00%	99.99%	-
2G	2. Industrial Proc.	G. Other			CO2	1.04	0.44	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.43	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.36	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.33	0.00%	100.00%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.55	0.29	0.00%	100.00%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.27	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.03	0.25	0.00%	100.00%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.22	0.00%	100.00%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.30	0.19	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.15	0.00%	100.00%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.12	0.00%	100.00%	-
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	22.13	0.08	0.00%	100.00%	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.13	0.06	0.00%	100.00%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.05	0.00%	100.00%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		N2O	0.03	0.03	0.00%	100.00%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	100.00%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.00%	100.00%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CH4	0.00	0.00	0.00%	100.00%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	NO	NO	0.00%	100.00%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.00%	100.00%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.00%	100.00%	-
2A o	2. Industrial Proc.	A. Mineral Products			N2O	NO	NO	0.00%	100.00%	-
2B	2. Industrial Proc.	B. Chemical Industry			HFC	NO	NO	0.00%	100.00%	-
2B	2. Industrial Proc.	B. Chemical Industry			PFC	NO	NO	0.00%	100.00%	-
2B	2. Industrial Proc.	B. Chemical Industry			SF6	0.00	0.00	0.00%	100.00%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			PFC	0.00	0.00	0.00%	100.00%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CH4	IE,NO	IE,NO	0.00%	100.00%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			N2O	NO	NO	0.00%	100.00%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	NO	0.00%	100.00%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	NO	0.00%	100.00%	-
2D	2. Industrial Proc.	D. Other Production			CO2	NO	NO	0.00%	100.00%	-
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6			CO2	0.00	0.00	0.00%	100.00%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC & 2F8-SF6			CO2	0.00	0.00	0.00%	100.00%	-
2G	2. Industrial Proc.	G. Other			CH4	NO	NO	0.00%	100.00%	-
2G	2. Industrial Proc.	G. Other			N2O	NO	NO	0.00%	100.00%	-
4C	4. Agriculture	C. Rice Cultivation			CH4	NO	NO	0.00%	100.00%	-
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			CH4	NO	NO	0.00%	100.00%	-
4E	4. Agriculture	E. Prescribed Burning of Savannas			CH4	NO	NO	0.00%	100.00%	-
4E	4. Agriculture	E. Prescribed Burning of Savannas			N2O	NO	NO	0.00%	100.00%	-
4G	4. Agriculture	G. Other			CH4	NO	NO	0.00%	100.00%	-
4G	4. Agriculture	G. Other			N2O	NO	NO	0.00%	100.00%	-
6D	6. Waste	D. Other			CO2	NO	NO	0.00%	100.00%	-

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## A1.3.2 Results of Key Category Analysis Tier 1 – Trend

Table A - 5 Key category analysis Tier 1 2007 (with LULUCF) regarding trend (year t refers to 2007).

IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
					[Gg CO <sub>2</sub> eq]	[Gg CO <sub>2</sub> eq]						
TOTAL				All	57'423.79	54'134.47	100.00%	0.298384	100.0%			
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	CO <sub>2</sub>	2'647.42	5'188.33	9.58%	0.052761	17.7%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Liquid Fuels	CO <sub>2</sub>	10'215.56	7'922.91	14.64%	0.033458	11.2%	KC level	KC trend
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO <sub>2</sub>	3'362.03	1'722.75	3.18%	0.028348	9.5%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO <sub>2</sub>	1'066.65	2'161.70	3.99%	0.022655	7.6%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Liquid Fuels	CO <sub>2</sub>	4'444.11	3'310.50	6.12%	0.017225	5.8%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Gaseous Fuels	CO <sub>2</sub>	1'406.59	2'141.71	3.96%	0.015983	5.4%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO <sub>2</sub>	1'519.73	2'162.03	3.99%	0.014292	4.8%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO <sub>2</sub>	3'339.62	2'572.26	4.75%	0.011288	3.8%	KC level	KC trend
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> : Refrig. & AC Eq.			HFC	0.02	568.66	1.05%	0.011142	3.7%	KC level	KC trend
2A1	2. Industrial Proc.	A. Mineral Products: Cement Production-CO <sub>2</sub>			CO <sub>2</sub>	2'524.77	1'844.15	3.41%	0.010503	3.5%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO <sub>2</sub>	1'387.85	774.46	1.43%	0.010461	3.5%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	CO <sub>2</sub>	938.95	1'350.12	2.49%	0.009111	3.1%	KC level	KC trend
6A	6. Waste	A. Solid Waste Disposal on Land			CH <sub>4</sub>	693.04	279.30	0.52%	0.007329	2.5%	KC level	KC trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CO <sub>2</sub>	443.97	588.91	1.09%	0.003338	1.1%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO <sub>2</sub>	156.87	295.17	0.55%	0.002886	1.0%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO <sub>2</sub>	691.23	758.97	1.40%	0.002103	0.7%	KC level	KC trend
4D3	4. Agriculture	D. Agricultural Soils: Indirect Emissions			N <sub>2</sub> O	818.89	692.36	1.28%	0.001560	0.5%	KC level	KC trend
4D1	4. Agriculture	D. Agricultural Soils: Direct Soil Emissions			N <sub>2</sub> O	1'389.94	1'231.47	2.27%	0.001545	0.5%	KC level	KC trend
6E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO <sub>2</sub>	398.89	301.58	0.56%	0.001459	0.5%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	CO <sub>2</sub>	11'335.25	10'614.99	19.81%	0.001391	0.5%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO <sub>2</sub>	234.93	261.50	0.48%	0.000784	0.3%	KC level	-
6B	6. Waste	B. Wastewater Handling			N <sub>2</sub> O	179.35	201.02	0.37%	0.000626	0.2%	KC level	-
4B	4. Agriculture	B. Manure Management			CH <sub>4</sub>	557.43	500.85	0.93%	0.000483	0.2%	KC level	-
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO <sub>2</sub>	570.89	559.03	1.03%	0.000409	0.1%	KC level	-
4A	4. Agriculture	A. Enteric Fermentation			CH <sub>4</sub>	2'474.84	2'318.64	4.28%	0.000283	0.1%	KC level	-
4B	4. Agriculture	B. Manure Management			N <sub>2</sub> O	448.20	408.39	0.75%	0.000277	0.1%	KC level	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	CO <sub>2</sub>	547.47	528.32	0.98%	0.000259	0.1%	KC level	-
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N <sub>2</sub> O & 4D3-N <sub>2</sub> O			N <sub>2</sub> O	200.19	180.11	0.33%	0.000169	0.1%	KC level	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CH <sub>4</sub>	380.46	173.28	0.32%	0.003633	1.2%	-	KC trend
3	3. Solvent and Other Product Use				CO <sub>2</sub>	357.79	177.11	0.33%	0.003139	1.1%	-	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO <sub>2</sub>	46.90	161.21	0.30%	0.002292	0.8%	-	KC trend
1A3a	1. Energy	A. Fuel Combustion	3. Transport: Civil Aviation		CO <sub>2</sub>	252.55	138.39	0.26%	0.001954	0.7%	-	KC trend
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO <sub>2</sub>	126.38	28.85	0.05%	0.001769	0.6%	-	KC trend
2B	2. Industrial Proc.	B. Chemical Industry			N <sub>2</sub> O	173.76	83.15	0.15%	0.001580	0.5%	-	KC trend
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub>			PFC	0.04	77.08	0.14%	0.001510	0.5%	-	KC trend
1A3e	1. Energy	A. Fuel Combustion	3. Transport: Other Transportation (military aviation)		CO <sub>2</sub>	200.04	115.09	0.21%	0.001440	0.5%	-	KC trend
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO <sub>2</sub>	112.45	179.13	0.33%	0.001433	0.5%	-	KC trend
6D	6. Waste	D. Other			CH <sub>4</sub>	30.34	99.94	0.18%	0.001398	0.5%	-	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	CH <sub>4</sub>	91.32	17.86	0.03%	0.001337	0.4%	-	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N <sub>2</sub> O	48.42	112.44	0.21%	0.001309	0.4%	-	KC trend
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF <sub>6</sub>	0.00	62.14	0.11%	0.001218	0.4%	-	KC trend
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> without 2F1-HFC			HFC	0.00	90.86	0.11%	0.001192	0.4%	-	KC trend
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO <sub>2</sub>	39.63	93.55	0.17%	0.001101	0.4%	-	-
3	3. Solvent and Other Product Use				N <sub>2</sub> O	110.14	53.72	0.10%	0.000982	0.3%	-	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> without 2F8-SF <sub>6</sub>			SF <sub>6</sub>	79.58	31.72	0.06%	0.000848	0.3%	-	-
6C	6. Waste	C. Waste Incineration			CO <sub>2</sub>	52.87	15.25	0.03%	0.000678	0.2%	-	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CO <sub>2</sub>	139.24	102.65	0.19%	0.000561	0.2%	-	-
6E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO <sub>2</sub>	3.48	29.21	0.05%	0.000508	0.2%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	N <sub>2</sub> O	8.41	31.93	0.06%	0.000470	0.2%	-	-
5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO <sub>2</sub>	110.35	81.92	0.15%	0.000433	0.1%	-	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> : Electrical Eq.			SF <sub>6</sub>	64.04	81.55	0.15%	0.000415	0.1%	-	-
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO <sub>2</sub>	22.13	0.08	0.00%	0.000407	0.1%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Solid Fuels	CO <sub>2</sub>	57.10	35.14	0.06%	0.000366	0.1%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Gaseous Fuels	CO <sub>2</sub>	40.29	20.11	0.04%	0.000350	0.1%	-	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO <sub>2</sub>	36.76	17.16	0.03%	0.000343	0.1%	-	-
6C	6. Waste	C. Waste Incineration			N <sub>2</sub> O	14.69	30.75	0.06%	0.000331	0.1%	-	-
6D	6. Waste	D. Other			N <sub>2</sub> O	6.23	20.47	0.04%	0.000286	0.1%	-	-
5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO <sub>2</sub>	15.81	3.09	0.01%	0.000232	0.1%	-	-
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO <sub>2</sub>	6.85	17.59	0.03%	0.000218	0.1%	-	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport: Navigation		CO <sub>2</sub>	111.86	115.67	0.21%	0.000200	0.1%	-	-

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IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year 1 Estimate	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment	
					[Gg CO2eq]	[Gg CO2eq]						
TOTAL				All	57'423.79	54'134.47	100.00%	0.298384	100.0%			
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	CO2	28.89	36.49	0.07%	0.000185	0.1%	-	-	
2A o	2. Industrial Proc.	A. Mineral Products	A. Mineral Products without Cement Production-CO2	CO2	40.21	47.32	0.09%	0.000185	0.1%	-	-	
6A	6. Waste	A. Solid Waste Disposal on Land		CO2	9.13	0.06	0.00%	0.000167	0.1%	-	-	
6B	6. Waste	B. Wastewater Handling		CH4	4.51	12.53	0.02%	0.000162	0.1%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	4.29	12.25	0.02%	0.000161	0.1%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	34.26	25.52	0.05%	0.000133	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	52.32	42.76	0.08%	0.000128	0.0%	-	-	
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	CH4	8.19	1.74	0.00%	0.000117	0.0%	-	-	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	8.14	13.01	0.02%	0.000105	0.0%	-	-	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	20.05	0.04%	0.000084	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.27	0.00%	0.000063	0.0%	-	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	N2O	4.22	0.90	0.00%	0.000060	0.0%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	7.31	4.00	0.01%	0.000057	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.40	4.95	0.01%	0.000053	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	2.95	5.22	0.01%	0.000048	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		CO2	13.60	15.21	0.03%	0.000047	0.0%	-	-	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.24	8.38	0.02%	0.000043	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	9.45	6.76	0.01%	0.000042	0.0%	-	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland	N2O	7.12	4.69	0.01%	0.000039	0.0%	-	-	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.06	0.01%	0.000039	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	N2O	5.13	6.67	0.01%	0.000036	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.35	3.79	0.01%	0.000031	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.54	0.95	0.00%	0.000028	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		CH4	8.16	6.30	0.01%	0.000027	0.0%	-	-	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.30	8.42	0.02%	0.000025	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	0.00%	0.000025	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	87.79	81.62	0.15%	0.000022	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	1.60	2.56	0.00%	0.000021	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation	N2O	2.46	1.35	0.00%	0.000019	0.0%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.96	1.02	0.00%	0.000016	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)	N2O	1.97	1.13	0.00%	0.000014	0.0%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	0.60	1.22	0.00%	0.000013	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.85	0.00%	0.000012	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	4.96	5.27	0.01%	0.000012	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues		CH4	10.00	10.00	0.02%	0.000011	0.0%	-	-	
2G	2. Industrial Proc.	G. Other		CO2	1.04	0.44	0.00%	0.000011	0.0%	-	-	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.21	0.00%	0.000009	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.49	1.91	0.00%	0.000009	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.37	0.00%	0.000007	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.27	0.00%	0.000005	0.0%	-	-
6C	6. Waste	C. Waste Incineration		CH4	3.96	3.99	0.01%	0.000005	0.0%	-	-	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.76	0.00%	0.000005	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.36	0.00%	0.000005	0.0%	-	-
2A o	2. Industrial Proc.	A. Mineral Products		CH4	0.94	0.65	0.00%	0.000005	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.03	0.25	0.00%	0.000004	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues		N2O	3.91	3.91	0.01%	0.000004	0.0%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.55	0.29	0.00%	0.000004	0.0%	-	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	N2O	1.62	1.74	0.00%	0.000004	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.33	0.00%	0.000003	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.41	0.00%	0.000002	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.30	0.19	0.00%	0.000002	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.43	0.00%	0.000002	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.60	0.00%	0.000002	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.05	0.00%	0.000001	0.0%	-	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	CH4	0.60	0.53	0.00%	0.000001	0.0%	-	-	
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)	CH4	0.16	0.12	0.00%	0.000001	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.15	0.00%	0.000000	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CH4	1.23	1.14	0.00%	0.000000	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	0.000000	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation	CH4	0.24	0.22	0.00%	0.000000	0.0%	-	-	
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	N2O	0.03	0.03	0.00%	0.000000	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	NO	NO	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
2A o	2. Industrial Proc.	A. Mineral Products		N2O	NO	NO	0.00%	0.000000	0.0%	-	-	
2B	2. Industrial Proc.	B. Chemical Industry		HFC	NO	NO	0.00%	0.000000	0.0%	-	-	
2B	2. Industrial Proc.	B. Chemical Industry		PFC	NO	NO	0.00%	0.000000	0.0%	-	-	
2B	2. Industrial Proc.	B. Chemical Industry		SF6	0.00	0.00	0.00%	0.000000	0.0%	-	-	
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		PFC	0.00	0.00	0.00%	0.000000	0.0%	-	-	
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CH4	IE.NO	IE.NO	0.00%	0.000000	0.0%	-	-	
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		N2O	NO	NO	0.00%	0.000000	0.0%	-	-	
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2		CO2	139.26	NO	0.00%	0.000000	0.0%	-	-	
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC		PFC	100.17	NO	0.00%	0.000000	0.0%	-	-	
2D	2. Industrial Proc.	D. Other Production		CO2	NO	NO	0.00%	0.000000	0.0%	-	-	
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6		CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-	
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC & 2F8-SF6		CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-	
2G	2. Industrial Proc.	G. Other		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
2G	2. Industrial Proc.	G. Other		N2O	NO	NO	0.00%	0.000000	0.0%	-	-	
4C	4. Agriculture	C. Rice Cultivation		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
4E	4. Agriculture	E. Prescribed Burning of Savannas		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
4E	4. Agriculture	E. Prescribed Burning of Savannas		N2O	NO	NO	0.00%	0.000000	0.0%	-	-	
4G	4. Agriculture	G. Other		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
4G	4. Agriculture	G. Other		N2O	NO	NO	0.00%	0.000000	0.0%	-	-	
6D	6. Waste	D. Other		CO2	NO	NO	0.00%	0.000000	0.0%	-	-	

(cont'd)

**A1.4 KCA Tier 2 2007 without LULUCF categories.****A1.4.1 Results of Key Category Analysis Tier 2 – Level**

Table A - 6 Key category analysis Tier 2 2007 (without LULUCF) regarding level (year t refers to 2007).

IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment, with Uncertainty	Cumulative Total Column E-L	Result level assessment
					[Gg CO2eq]	[Gg CO2eq]			
TOTAL				All	52'711.08	51'272.33	15.70%		
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	818.89	692.36	2.15%	2.15%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N2O	1'389.94	1'231.47	1.84%	3.99%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	1'519.73	2'162.03	1.40%	5.38%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	11'335.25	10'614.99	0.86%	6.25%	KC level
4A	4. Agriculture	A. Enteric Fermentation		CH4	2'474.84	2'318.64	0.83%	7.08%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	10'215.56	7'922.91	0.77%	7.85%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	1'066.65	2'161.70	0.57%	8.42%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	1'406.59	2'141.71	0.56%	8.98%	KC level
4B	4. Agriculture	B. Manure Management		CH4	557.43	500.85	0.53%	9.51%	KC level
4B	4. Agriculture	B. Manure Management		N2O	448.20	408.39	0.50%	10.01%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	1'387.85	774.46	0.48%	10.50%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	2'647.42	5'188.33	0.42%	10.92%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	156.87	295.17	0.41%	11.32%	KC level
6B	6. Waste	B. Wastewater Handling		N2O	179.35	201.02	0.39%	11.72%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	938.95	1'350.12	0.35%	12.07%	KC level
6A	6. Waste	A. Solid Waste Disposal on Land		CH4	693.04	279.30	0.33%	12.40%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	4'444.11	3'310.50	0.32%	12.72%	KC level
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		N2O	200.19	180.11	0.26%	12.98%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	3'339.62	2'572.26	0.25%	13.23%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	87.79	81.62	0.24%	13.47%	KC level
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2		CO2	2'524.77	1'844.15	0.23%	13.70%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	48.42	112.44	0.18%	13.88%	KC level
3	3. Solvent and Other Product Use			CO2	357.79	177.11	0.17%	14.05%	KC level
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CH4	380.46	173.28	0.17%	14.22%	KC level
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.02	568.66	0.15%	14.37%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CO2	112.45	179.13	0.14%	14.51%	-
6D	6. Waste	D. Other		CH4	30.34	99.94	0.10%	14.61%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	8.41	31.93	0.09%	14.70%	-
3	3. Solvent and Other Product Use			N2O	110.14	53.72	0.08%	14.78%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	46.90	161.21	0.08%	14.87%	-
2B	2. Industrial Proc.	B. Chemical Industry		N2O	173.76	83.15	0.07%	14.94%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	547.47	529.32	0.05%	14.99%	-
6C	6. Waste	C. Waste Incineration		N2O	14.69	30.75	0.05%	15.04%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	443.97	588.91	0.05%	15.08%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	691.23	758.97	0.04%	15.13%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	234.93	261.50	0.04%	15.17%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	34.26	25.52	0.04%	15.21%	-
6D	6. Waste	D. Other		N2O	6.23	20.47	0.03%	15.24%	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.		SF6	64.04	81.55	0.03%	15.27%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	25.84	20.05	0.03%	15.31%	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		PFC	0.04	77.08	0.03%	15.34%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	0.00	60.86	0.03%	15.38%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	52.32	42.76	0.03%	15.39%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		SF6	0.00	62.14	0.02%	15.41%	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	CO2	111.86	115.67	0.02%	15.43%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	91.32	17.86	0.02%	15.45%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CO2	139.24	102.65	0.02%	15.47%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	4.29	12.25	0.02%	15.49%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	10.30	8.42	0.01%	15.51%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	11.24	8.38	0.01%	15.52%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6		SF6	79.58	31.72	0.01%	15.53%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues		CH4	10.00	10.00	0.01%	15.54%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues		N2O	3.91	3.91	0.01%	15.56%	-

(cont'd next page)

IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment, with Uncertainty	Cumulative Total Column E-L	Result level assessment
					[Gg CO <sub>2</sub> e]	[Gg CO <sub>2</sub> e]			
TOTAL				All	52'711.08	51'272.33	15.70%		
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation	CO <sub>2</sub>	252.55	138.39	0.01%	15.57%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	9.45	6.76	0.01%	15.58%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	5.13	6.67	0.01%	15.59%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)	CO <sub>2</sub>	200.04	115.09	0.01%	15.60%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	4.96	5.27	0.01%	15.61%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	8.14	13.01	0.01%	15.61%	-
6B	6. Waste	B. Wastewater Handling		CH <sub>4</sub>	4.51	12.53	0.01%	15.62%	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	CO <sub>2</sub>	28.69	36.49	0.01%	15.63%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	57.10	35.14	0.01%	15.63%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	7.31	4.00	0.01%	15.64%	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	N <sub>2</sub> O	1.62	1.74	0.01%	15.65%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	1.60	2.56	0.00%	15.65%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation	N <sub>2</sub> O	2.46	1.35	0.00%	15.65%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	2.15	2.37	0.00%	15.66%	-
2B	2. Industrial Proc.	B. Chemical Industry		CH <sub>4</sub>	8.16	6.30	0.00%	15.66%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)	N <sub>2</sub> O	1.97	1.13	0.00%	15.66%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	2.95	5.22	0.00%	15.67%	-
6C	6. Waste	C. Waste Incineration		CO <sub>2</sub>	52.87	15.25	0.00%	15.67%	-
2B	2. Industrial Proc.	B. Chemical Industry		CO <sub>2</sub>	13.60	15.21	0.00%	15.67%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	3.26	5.06	0.00%	15.68%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	2.40	4.95	0.00%	15.68%	-
6C	6. Waste	C. Waste Incineration		CH <sub>4</sub>	3.96	3.99	0.00%	15.68%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	2.35	3.79	0.00%	15.68%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	0.60	1.22	0.00%	15.69%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	0.79	1.21	0.00%	15.69%	-
2A o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO <sub>2</sub>		CO <sub>2</sub>	40.21	47.32	0.00%	15.69%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	3.83	2.36	0.00%	15.69%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	0.25	0.85	0.00%	15.69%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	5.83	2.27	0.00%	15.69%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	0.53	0.76	0.00%	15.69%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	1.49	1.01	0.00%	15.70%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	1.62	1.41	0.00%	15.70%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	40.29	20.11	0.00%	15.70%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	0.00	0.27	0.00%	15.70%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	1.23	1.14	0.00%	15.70%	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	CH <sub>4</sub>	0.60	0.53	0.00%	15.70%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	1.96	1.02	0.00%	15.70%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	2.54	0.96	0.00%	15.70%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	0.03	0.25	0.00%	15.70%	-
2A o	2. Industrial Proc.	A. Mineral Products		CH <sub>4</sub>	0.94	0.65	0.00%	15.70%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	0.54	0.80	0.00%	15.70%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	0.30	0.19	0.00%	15.70%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation	CH <sub>4</sub>	0.24	0.22	0.00%	15.70%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	0.36	0.43	0.00%	15.70%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	0.13	0.15	0.00%	15.70%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	0.10	0.36	0.00%	15.70%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	0.49	0.33	0.00%	15.70%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	0.55	0.29	0.00%	15.70%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)	CH <sub>4</sub>	0.16	0.12	0.00%	15.70%	-
2G	2. Industrial Proc.	G. Other		CO <sub>2</sub>	1.04	0.44	0.00%	15.70%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	N <sub>2</sub> O	0.03	0.03	0.00%	15.70%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	0.09	0.05	0.00%	15.70%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	0.00	0.02	0.00%	15.70%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	0.02	0.01	0.00%	15.70%	-
6A	6. Waste	A. Solid Waste Disposal on Land		CO <sub>2</sub>	9.13	0.06	0.00%	15.70%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	0.00	0.00	0.00%	15.70%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	0.00	0.00	0.00%	15.70%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	NO	NO	0.00%	15.70%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH <sub>4</sub>	0.00	0.00%	15.70%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N <sub>2</sub> O	0.00	0.00%	15.70%	-
2A o	2. Industrial Proc.	A. Mineral Products		N <sub>2</sub> O	NO	NO	0.00%	15.70%	-
2B	2. Industrial Proc.	B. Chemical Industry		HFC	NO	NO	0.00%	15.70%	-
2B	2. Industrial Proc.	B. Chemical Industry		PFC	NO	NO	0.00%	15.70%	-
2B	2. Industrial Proc.	B. Chemical Industry		SF <sub>6</sub>	0.00	0.00	0.00%	15.70%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		PFC	0.00	0.00	0.00%	15.70%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CH <sub>4</sub>	IE,NO	IE,NO	0.00%	15.70%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		N <sub>2</sub> O	NO	NO	0.00%	15.70%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO <sub>2</sub>		CO <sub>2</sub>	139.26	NO	0.00%	15.70%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC		PFC	100.17	NO	0.00%	15.70%	-
2D	2. Industrial Proc.	D. Other Production		CO <sub>2</sub>	NO	NO	0.00%	15.70%	-
2E	2. Industrial Proc.	E. Production of Halocarbons and SF <sub>6</sub>		CO <sub>2</sub>	0.00	0.00	0.00%	15.70%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> without 2F1-HFC & 2F8-SF <sub>6</sub>		CO <sub>2</sub>	0.00	0.00	0.00%	15.70%	-
2G	2. Industrial Proc.	G. Other		CH <sub>4</sub>	NO	NO	0.00%	15.70%	-
2G	2. Industrial Proc.	G. Other		N <sub>2</sub> O	NO	NO	0.00%	15.70%	-
4C	4. Agriculture	C. Rice Cultivation		CH <sub>4</sub>	NO	NO	0.00%	15.70%	-
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N <sub>2</sub> O & 4D3-N <sub>2</sub> O		CH <sub>4</sub>	NO	NO	0.00%	15.70%	-
4E	4. Agriculture	E. Prescribed Burning of Savannas		CH <sub>4</sub>	NO	NO	0.00%	15.70%	-
4E	4. Agriculture	E. Prescribed Burning of Savannas		N <sub>2</sub> O	NO	NO	0.00%	15.70%	-
4G	4. Agriculture	G. Other		CH <sub>4</sub>	NO	NO	0.00%	15.70%	-
4G	4. Agriculture	G. Other		N <sub>2</sub> O	NO	NO	0.00%	15.70%	-
6D	6. Waste	D. Other		CO <sub>2</sub>	NO	NO	0.00%	15.70%	-

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## A1.4.2 Results of Key Category Analysis Tier 2 – Trend

Table A - 7 Key category analysis Tier 2 2007 (without LULUCF) regarding trend (year t refers to 2007).

IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment, with Uncertainty	Trend Assessment, with Uncertainty	% Contribution in Trend with Uncertainty	Result level assessment	Result trend assessment	
					[Gg CO2eq]	[Gg CO2eq]						
<b>TOTAL</b>				All	52'711.08	51'272.33	15.70%	0.049934	100.0%			
6A	6. Waste	A. Solid Waste Disposal on Land		CH4	693.04	279.30	0.33%	0.004750	9.5%	KC level	KC trend	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	1'519.73	2'162.03	1.40%	0.004549	9.1%	KC level	KC trend	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	1'387.85	774.46	0.48%	0.003702	7.4%	KC level	KC trend	
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	818.89	692.36	2.15%	0.003324	6.7%	KC level	KC trend	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	1'066.65	2'161.70	0.57%	0.003025	6.1%	KC level	KC trend	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	2'647.42	5'188.33	0.42%	0.002186	4.4%	KC level	KC trend	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	1'406.59	2'141.71	0.56%	0.002082	4.2%	KC level	KC trend	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	10'215.56	7'922.91	0.77%	0.002021	4.0%	KC level	KC trend	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	156.87	295.17	0.41%	0.002013	4.0%	KC level	KC trend	
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CH4	380.46	173.28	0.17%	0.001973	4.0%	KC level	KC trend	
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N2O	1'389.94	1'231.47	1.84%	0.001849	3.7%	KC level	KC trend	
3	3. Solvent and Other Product Use			CO2	357.79	177.11	0.17%	0.001714	3.4%	KC level	KC trend	
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.02	568.66	0.15%	0.001576	3.2%	KC level	KC trend	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	938.95	1'350.12	0.35%	0.001176	2.4%	KC level	KC trend	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	48.42	112.44	0.18%	0.001056	2.1%	KC level	KC trend	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	4'444.11	3'310.50	0.32%	0.001016	2.0%	KC level	KC trend	
3	3. Solvent and Other Product Use			N2O	110.14	53.72	0.08%	0.000857	1.7%	-	KC trend	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	91.32	17.86	0.02%	0.000854	1.7%	-	KC trend	
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2		CO2	2'524.77	1'844.15	0.23%	0.000776	1.6%	KC level	KC trend	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	8.41	31.93	0.09%	0.000714	1.4%	-	KC trend	
2B	2. Industrial Proc.	B. Chemical Industry		N2O	173.76	83.15	0.07%	0.000710	1.4%	-	KC trend	
6D	6. Waste	D. Other		CH4	30.34	99.94	0.10%	0.000706	1.4%	-	KC trend	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	3'339.62	2'572.26	0.25%	0.000678	1.4%	KC level	KC trend	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	46.90	161.21	0.08%	0.000603	1.2%	-	KC trend	
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CO2	112.45	179.13	0.14%	0.000560	1.1%	-	KC trend	
6B	6. Waste	B. Wastewater Handling		N2O	179.35	201.02	0.39%	0.000533	1.1%	KC level	KC trend	
4B	4. Agriculture	B. Manure Management		CH4	557.43	500.85	0.53%	0.000452	0.9%	KC level	-	
4B	4. Agriculture	B. Manure Management		N2O	448.20	408.39	0.50%	0.000349	0.7%	KC level	-	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	11'335.25	10'614.99	0.86%	0.000344	0.7%	KC level	-	
4A	4. Agriculture	A. Enteric Fermentation		CH4	2'474.94	2'318.64	0.83%	0.000326	0.7%	KC level	-	
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		PFC	0.04	77.08	0.03%	0.000309	0.6%	-	-	
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	0.00	60.86	0.03%	0.000267	0.5%	-	-	
6C	6. Waste	C. Waste Incineration		N2O	14.69	30.75	0.05%	0.000264	0.5%	-	-	
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		SF6	0.00	62.14	0.02%	0.000249	0.5%	-	-	
6D	6. Waste	D. Other		N2O	6.23	20.47	0.03%	0.000231	0.5%	-	-	
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		N2O	200.19	180.11	0.26%	0.000220	0.4%	KC level	-	
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6		SF6	79.58	31.72	0.01%	0.000183	0.4%	-	-	
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	443.97	588.91	0.05%	0.000131	0.3%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	4.29	12.25	0.02%	0.000130	0.3%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	34.26	25.52	0.04%	0.000125	0.3%	-	-	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	87.79	81.62	0.24%	0.000113	0.2%	KC level	-	
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation	CO2	252.55	138.39	0.01%	0.000090	0.2%	-	-	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	20.05	0.03%	0.000082	0.2%	-	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.		SF6	64.04	81.55	0.03%	0.000077	0.2%	-	-	
6C	6. Waste	C. Waste Incineration		CO2	52.87	15.25	0.00%	0.000073	0.1%	-	-	
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)	CO2	200.04	115.09	0.01%	0.000067	0.1%	-	-	
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CO2	139.24	102.65	0.02%	0.000066	0.1%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	261.50	0.04%	0.000056	0.1%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	758.97	0.04%	0.000052	0.1%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	7.31	4.00	0.01%	0.000050	0.1%	-	-
6B	6. Waste	B. Wastewater Handling		CH4	4.51	12.53	0.01%	0.000049	0.1%	-	-	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	52.32	42.76	0.03%	0.000049	0.1%	-	-	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.24	8.38	0.01%	0.000041	0.1%	-	-

(cont'd next page)

IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year 1 Estimate	Level Assessment, with Uncertainty	Trend Assessment, with Uncertainty	% Contribution in Trend with Uncertainty	Result level assessment	Result trend assessment
					[Gg CO2eq]	[Gg CO2eq]					
<b>TOTAL</b>				All	52'711.08	51'272.33	15.70%	0.049934	100.0%		
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	57.10	35.14	0.01%	0.000041	0.1%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	9.45	6.76	0.01%	0.000039	0.1%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation	N2O	2.46	1.35	0.00%	0.000031	0.1%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	8.14	13.01	0.01%	0.000031	0.1%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	5.13	6.67	0.01%	0.000027	0.1%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	10.30	8.42	0.01%	0.000026	0.1%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)	N2O	1.97	1.13	0.00%	0.000024	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	5.83	2.27	0.00%	0.000020	0.0%	-	-
6A	6. Waste	A. Solid Waste Disposal on Land		CO2	9.13	0.06	0.00%	0.000018	0.0%	-	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways	CO2	28.69	36.49	0.01%	0.000017	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	1.60	2.56	0.00%	0.000016	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	2.40	4.95	0.00%	0.000016	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	2.95	5.22	0.00%	0.000014	0.0%	-	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation	CO2	111.86	115.67	0.02%	0.000014	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	3.26	5.06	0.00%	0.000011	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	0.60	1.22	0.00%	0.000010	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		CH4	8.16	6.30	0.00%	0.000010	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	0.25	0.85	0.00%	0.000010	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	2.54	0.96	0.00%	0.000009	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	2.35	3.79	0.00%	0.000009	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	3.83	2.36	0.00%	0.000008	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	0.00	0.27	0.00%	0.000008	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	40.29	20.11	0.00%	0.000008	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	4.96	5.27	0.01%	0.000007	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	0.79	1.21	0.00%	0.000007	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	1.96	1.02	0.00%	0.000005	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	1.49	1.01	0.00%	0.000005	0.0%	-	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	N2O	1.62	1.74	0.01%	0.000005	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	2.15	2.37	0.00%	0.000004	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		CO2	13.60	15.21	0.00%	0.000004	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	0.53	0.76	0.00%	0.000004	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	0.03	0.25	0.00%	0.000004	0.0%	-	-
2A o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2		CO2	40.21	47.32	0.00%	0.000003	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues		CH4	10.00	10.00	0.01%	0.000003	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	547.47	629.32	0.05%	0.000003	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues		N2O	3.91	3.91	0.01%	0.000003	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	0.30	0.19	0.00%	0.000002	0.0%	-	-
2A o	2. Industrial Proc.	A. Mineral Products		CH4	0.94	0.65	0.00%	0.000002	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	0.10	0.36	0.00%	0.000002	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	0.55	0.29	0.00%	0.000001	0.0%	-	-
2G	2. Industrial Proc.	G. Other		CO2	1.04	0.44	0.00%	0.000001	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	1.62	1.41	0.00%	0.000001	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	0.49	0.33	0.00%	0.000001	0.0%	-	-
6C	6. Waste	C. Waste Incineration		CH4	3.96	3.99	0.00%	0.000001	0.0%	-	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	CH4	0.60	0.53	0.00%	0.000001	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	0.36	0.43	0.00%	0.000001	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	0.54	0.60	0.00%	0.000000	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)	CH4	0.16	0.12	0.00%	0.000000	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	1.23	1.14	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	0.13	0.15	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	0.09	0.05	0.00%	0.000000	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	0.00	0.02	0.00%	0.000000	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation	CH4	0.24	0.22	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	0.02	0.01	0.00%	0.000000	0.0%	-	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	N2O	0.03	0.03	0.00%	0.000000	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	NO	NO	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-
2A o	2. Industrial Proc.	A. Mineral Products		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		HFC	NO	NO	0.00%	0.000000	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		PFC	NO	NO	0.00%	0.000000	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		SF6	0.00	0.00	0.00%	0.000000	0.0%	-	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		PFC	0.00	0.00	0.00%	0.000000	0.0%	-	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CH4	IE.NO	IE.NO	0.00%	0.000000	0.0%	-	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2		CO2	139.26	NO	0.00%	0.000000	0.0%	-	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC		PFC	100.17	NO	0.00%	0.000000	0.0%	-	-
2D	2. Industrial Proc.	D. Other Production		CO2	NO	NO	0.00%	0.000000	0.0%	-	-
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6		CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC & 2F6-SF6		CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-
2G	2. Industrial Proc.	G. Other		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
2G	2. Industrial Proc.	G. Other		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
4C	4. Agriculture	C. Rice Cultivation		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
4E	4. Agriculture	E. Prescribed Burning of Savannas		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
4E	4. Agriculture	E. Prescribed Burning of Savannas		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
4G	4. Agriculture	G. Other		CH4	NO	NO	0.00%	0.000000	0.0%	-	-
4G	4. Agriculture	G. Other		N2O	NO	NO	0.00%	0.000000	0.0%	-	-
6D	6. Waste	D. Other		CO2	NO	NO	0.00%	0.000000	0.0%	-	-

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## A1.5 KCA Tier 2 2007 including LULUCF categories

### A1.5.1 Results of Key Category Analysis Tier 2 – Level

Table A - 8 Key category analysis Tier 2 2007 (with LULUCF) regarding level (year t refers to 2007).

IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment, with Uncertainty	Cumulative Total Column E-L	Result level assessment	
					[Gg CO <sub>2</sub> e]	[Gg CO <sub>2</sub> e]				
TOTAL				All	57'423.79	54'134.47	17.12%			
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N <sub>2</sub> O	818.89	692.36	2.03%	2.03%	KC level	
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N <sub>2</sub> O	1'389.94	1'231.47	1.74%	3.78%	KC level	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO <sub>2</sub>	1'519.73	2'162.03	1.33%	5.10%	KC level
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO <sub>2</sub>	3'362.03	1'722.75	1.28%	6.38%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO <sub>2</sub>	11'335.25	10'614.99	0.82%	7.20%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH <sub>4</sub>	2'474.84	2'318.64	0.79%	7.99%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO <sub>2</sub>	10'215.56	7'922.91	0.73%	8.72%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO <sub>2</sub>	1'066.65	2'161.70	0.54%	9.25%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO <sub>2</sub>	1'406.59	2'141.71	0.53%	9.79%	KC level
4B	4. Agriculture	B. Manure Management			CH <sub>4</sub>	557.43	500.85	0.50%	10.29%	KC level
4B	4. Agriculture	B. Manure Management			N <sub>2</sub> O	448.20	408.39	0.48%	10.77%	KC level
1A4	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO <sub>2</sub>	1'387.85	774.46	0.46%	11.23%	KC level
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO <sub>2</sub>	570.89	559.03	0.40%	11.63%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO <sub>2</sub>	2'647.42	5'188.33	0.40%	12.03%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO <sub>2</sub>	156.87	295.17	0.38%	12.41%	KC level
6B	6. Waste	B. Wastewater Handling			N <sub>2</sub> O	179.35	201.02	0.37%	12.78%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO <sub>2</sub>	938.95	1'350.12	0.33%	13.12%	KC level
6A	6. Waste	A. Solid Waste Disposal on Land			CH <sub>4</sub>	693.04	279.30	0.31%	13.43%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO <sub>2</sub>	4'444.11	3'310.50	0.31%	13.73%	KC level
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO <sub>2</sub>	398.89	301.58	0.30%	14.03%	KC level
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N <sub>2</sub> O & 4D3-N <sub>2</sub> O			N <sub>2</sub> O	200.19	180.11	0.25%	14.28%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO <sub>2</sub>	3'339.62	2'572.26	0.24%	14.52%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N <sub>2</sub> O	87.79	81.62	0.23%	14.75%	KC level
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO <sub>2</sub>			CO <sub>2</sub>	2'524.77	1'844.15	0.22%	14.96%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N <sub>2</sub> O	48.42	112.44	0.17%	15.13%	KC level
3	3. Solvent and Other Product Use				CO <sub>2</sub>	357.79	177.11	0.16%	15.29%	KC level
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CH <sub>4</sub>	380.46	173.28	0.16%	15.45%	KC level
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> ; Refrig. & AC Eq.			HFC	0.02	568.66	0.15%	15.60%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO <sub>2</sub>	112.45	179.13	0.13%	15.73%	-
6D	6. Waste	D. Other			CH <sub>4</sub>	30.34	99.94	0.09%	15.82%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N <sub>2</sub> O	8.41	31.93	0.09%	15.91%	-
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO <sub>2</sub>	39.63	93.55	0.09%	16.00%	-
5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO <sub>2</sub>	110.35	81.92	0.08%	16.08%	-
3	3. Solvent and Other Product Use				N <sub>2</sub> O	110.14	53.72	0.08%	16.16%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO <sub>2</sub>	46.90	161.21	0.08%	16.24%	-
2B	2. Industrial Proc.	B. Chemical Industry			N <sub>2</sub> O	173.76	83.15	0.06%	16.30%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO <sub>2</sub>	547.47	529.32	0.05%	16.35%	-
6C	6. Waste	C. Waste Incineration			N <sub>2</sub> O	14.69	30.75	0.05%	16.40%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CO <sub>2</sub>	443.97	588.91	0.05%	16.44%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO <sub>2</sub>	691.23	758.97	0.04%	16.48%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO <sub>2</sub>	234.93	261.50	0.04%	16.52%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N <sub>2</sub> O	34.26	25.52	0.04%	16.56%	-
6D	6. Waste	D. Other			N <sub>2</sub> O	6.23	20.47	0.03%	16.59%	-
5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO <sub>2</sub>	3.48	29.21	0.03%	16.62%	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> ; Electrical Eq.			SF <sub>6</sub>	64.04	81.55	0.03%	16.65%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N <sub>2</sub> O	25.84	20.05	0.03%	16.68%	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub>			PFC	0.04	77.08	0.03%	16.71%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> without 2F1-HFC			HFC	0.00	60.86	0.02%	16.73%	-
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO <sub>2</sub>	126.38	28.85	0.02%	16.76%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH <sub>4</sub>	52.32	42.76	0.02%	16.78%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF <sub>6</sub>	0.00	62.14	0.02%	16.80%	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO <sub>2</sub>	111.86	115.67	0.02%	16.83%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH <sub>4</sub>	91.32	17.86	0.02%	16.85%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CO <sub>2</sub>	139.24	102.65	0.02%	16.87%	-
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO <sub>2</sub>	6.85	17.59	0.02%	16.88%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N <sub>2</sub> O	4.29	12.25	0.02%	16.90%	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO <sub>2</sub>	36.76	17.16	0.01%	16.92%	-

(cont'd next page)

IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment, with Uncertainty	Cumulative Total Column E-L	Result level assessment
						[Gg CO <sub>2</sub> e]	[Gg CO <sub>2</sub> e]			
TOTAL					All	57'423.79	54'134.47	17.12%		
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.30	8.42	0.01%	16.93%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.24	8.38	0.01%	16.94%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6			SF6	79.58	31.72	0.01%	16.95%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	0.01%	16.96%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	0.01%	16.97%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	138.39	0.01%	16.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	9.45	6.76	0.01%	16.99%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	N2O	5.13	6.67	0.01%	17.00%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	115.09	0.01%	17.01%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	4.96	5.27	0.01%	17.02%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	8.14	13.01	0.01%	17.03%	-
6B	6. Waste	B. Wastewater Handling			CH4	4.51	12.53	0.01%	17.04%	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	28.69	36.49	0.01%	17.04%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	57.10	35.14	0.01%	17.05%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	7.31	4.00	0.01%	17.05%	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.62	1.74	0.00%	17.06%	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	7.12	4.69	0.00%	17.06%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	1.60	2.56	0.00%	17.07%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.35	0.00%	17.07%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.37	0.00%	17.07%	-
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8.16	6.30	0.00%	17.08%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.13	0.00%	17.08%	-
5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	15.81	3.09	0.00%	17.08%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	2.95	5.22	0.00%	17.09%	-
6C	6. Waste	C. Waste Incineration			CO2	52.87	15.25	0.00%	17.09%	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	15.21	0.00%	17.09%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.06	0.00%	17.10%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.40	4.95	0.00%	17.10%	-
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.99	0.00%	17.10%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.35	3.79	0.00%	17.10%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	0.60	1.22	0.00%	17.10%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.21	0.00%	17.11%	-
2A o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.21	47.32	0.00%	17.11%	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	8.19	1.74	0.00%	17.11%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	0.00%	17.11%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.85	0.00%	17.11%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.27	0.00%	17.11%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.76	0.00%	17.11%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.49	1.01	0.00%	17.12%	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	4.22	0.90	0.00%	17.12%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.41	0.00%	17.12%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.29	20.11	0.00%	17.12%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	N2O	0.00	0.27	0.00%	17.12%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CH4	1.23	1.14	0.00%	17.12%	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.60	0.53	0.00%	17.12%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.96	1.02	0.00%	17.12%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.54	0.96	0.00%	17.12%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.03	0.25	0.00%	17.12%	-
2A o	2. Industrial Proc.	A. Mineral Products			CH4	0.94	0.65	0.00%	17.12%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.60	0.00%	17.12%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.30	0.19	0.00%	17.12%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.22	0.00%	17.12%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.43	0.00%	17.12%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.15	0.00%	17.12%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.36	0.00%	17.12%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.33	0.00%	17.12%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.55	0.29	0.00%	17.12%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.12	0.00%	17.12%	-
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	22.13	0.08	0.00%	17.12%	-
2G	2. Industrial Proc.	G. Other			CO2	1.04	0.44	0.00%	17.12%	-
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		N2O	0.03	0.03	0.00%	17.12%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.05	0.00%	17.12%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Biomass	CH4	0.00	0.02	0.00%	17.12%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	17.12%	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.13	0.06	0.00%	17.12%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.00%	17.12%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CH4	0.00	0.00	0.00%	17.12%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CO2	NO	NO	0.00%	17.12%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.00%	17.12%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.00%	17.12%	-
2A o	2. Industrial Proc.	A. Mineral Products			N2O	NO	NO	0.00%	17.12%	-
2B	2. Industrial Proc.	B. Chemical Industry			HFC	NO	NO	0.00%	17.12%	-
2B	2. Industrial Proc.	B. Chemical Industry			PF6	NO	NO	0.00%	17.12%	-
2B	2. Industrial Proc.	B. Chemical Industry			SF6	0.00	0.00	0.00%	17.12%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			PF6	0.00	0.00	0.00%	17.12%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CH4	IE,NO	IE,NO	0.00%	17.12%	-
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production			N2O	NO	NO	0.00%	17.12%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	NO	0.00%	17.12%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PF6	100.17	NO	0.00%	17.12%	-
2D	2. Industrial Proc.	D. Other Production			CO2	NO	NO	0.00%	17.12%	-
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6			CO2	0.00	0.00	0.00%	17.12%	-
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC & 2F8-SF6			CO2	0.00	0.00	0.00%	17.12%	-
2G	2. Industrial Proc.	G. Other			CH4	NO	NO	0.00%	17.12%	-
2G	2. Industrial Proc.	G. Other			N2O	NO	NO	0.00%	17.12%	-
4C	4. Agriculture	C. Rice Cultivation			CH4	NO	NO	0.00%	17.12%	-
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			CH4	NO	NO	0.00%	17.12%	-
4E	4. Agriculture	E. Prescribed Burning of Savannas			CH4	NO	NO	0.00%	17.12%	-
4E	4. Agriculture	E. Prescribed Burning of Savannas			N2O	NO	NO	0.00%	17.12%	-
4G	4. Agriculture	G. Other			CH4	NO	NO	0.00%	17.12%	-
4G	4. Agriculture	G. Other			N2O	NO	NO	0.00%	17.12%	-
6D	6. Waste	D. Other			CO2	NO	NO	0.00%	17.12%	-

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## A1.5.2 Results of Key Category Analysis Tier 2 – Trend

Table A - 9 Key category analysis Tier 2 2007 (with LULUCF) regarding trend (year t refers to 2007).

IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment, with Uncertainty	Trend Assessment, with Uncertainty	% Contribution in Trend	Result level assessment	Result trend assessment	
					[Gg CO <sub>2</sub> e]	[Gg CO <sub>2</sub> e]						
TOTAL				All	57'423.79	54'134.47	17.1246%	0.060869	100.0%			
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	CO2	3'362.03	1'722.75	1.28%	0.011427	18.8%	KC level	KC trend	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	1'519.73	2'162.03	1.33%	0.004741	7.8%	KC level	KC trend	
6A	6. Waste	A. Solid Waste Disposal on Land		CH4	693.04	279.30	0.31%	0.004398	7.2%	KC level	KC trend	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	1'387.85	774.46	0.46%	0.003356	5.5%	KC level	KC trend	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	1'066.65	2'161.70	0.54%	0.003041	5.0%	KC level	KC trend	
4D3	4. Agriculture	D. Agricultural Soils: Indirect Emissions		N2O	818.89	692.36	2.03%	0.002482	4.1%	KC level	KC trend	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	2'647.42	5'188.33	0.40%	0.002202	3.6%	KC level	KC trend	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	1'406.59	2'141.71	0.53%	0.002145	3.5%	KC level	KC trend	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	156.87	295.17	0.38%	0.002033	3.3%	KC level	KC trend	
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CH4	380.46	173.28	0.16%	0.001816	3.0%	KC level	KC trend	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	10'215.56	7'922.91	0.73%	0.001674	2.8%	KC level	KC trend	
3	3. Solvent and Other Product Use			CO2	357.79	177.11	0.16%	0.001569	2.5%	KC level	KC trend	
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	2.02	568.66	0.15%	0.001540	2.5%			
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	938.95	1'350.12	0.33%	0.001223	2.0%	KC level	KC trend	
4D1	4. Agriculture	D. Agricultural Soils: Direct Soil Emissions		N2O	1'389.94	1'231.47	1.74%	0.001182	1.9%	KC level	KC trend	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	48.42	112.44	0.17%	0.001055	1.7%	KC level	KC trend	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	4'444.11	3'310.50	0.31%	0.000862	1.4%	KC level	KC trend	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	91.32	17.86	0.02%	0.000802	1.3%	-	-	
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land	CO2	126.38	28.85	0.02%	0.000791	1.3%	-	-	
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements	CO2	398.89	301.58	0.30%	0.000786	1.3%	KC level	KC trend	
3	3. Solvent and Other Product Use			N2O	110.14	53.72	0.08%	0.000786	1.3%	-	-	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	8.41	31.93	0.09%	0.000706	1.2%	-	-	
6D	6. Waste	D. Other		CH4	30.34	99.94	0.09%	0.000699	1.1%	-	-	
2A1	2. Industrial Proc.	A. Mineral Products: Cement Production-CO2		CO2	2'524.77	1'844.15	0.22%	0.000664	1.1%	KC level	KC trend	
2B	2. Industrial Proc.	B. Chemical Industry		N2O	173.76	83.15	0.06%	0.000652	1.1%	-	-	
6B	6. Waste	B. Wastewater Handling		N2O	179.35	201.02	0.37%	0.000626	1.0%	KC level	KC trend	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	48.90	161.21	0.08%	0.000596	1.0%	-	-	
2C	2. Industrial Proc.	C. Metal Production without Aluminium Production		CO2	112.45	179.13	0.13%	0.000574	0.9%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	3'339.62	2'572.26	0.24%	0.000565	0.9%	KC level	KC trend	
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland	CO2	39.63	93.55	0.09%	0.000553	0.9%	-	-	
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland	CO2	22.13	0.08	0.00%	0.000375	0.6%	-	-	
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6		PFC	0.04	77.08	0.03%	0.000302	0.5%	-	-	
5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements	CO2	3.48	29.21	0.03%	0.000284	0.5%	-	-	
6C	6. Waste	C. Waste Incineration		N2O	14.69	30.75	0.05%	0.000265	0.4%	-	-	
4B	4. Agriculture	B. Manure Management		CH4	557.43	500.85	0.50%	0.000263	0.4%	KC level	-	
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	0.00	60.86	0.02%	0.000261	0.4%	-	-	
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		SF6	0.00	62.14	0.02%	0.000244	0.4%	-	-	
5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land	CO2	110.35	81.92	0.08%	0.000233	0.4%	-	-	
6D	6. Waste	D. Other		N2O	6.23	20.47	0.03%	0.000229	0.4%	-	-	
4B	4. Agriculture	B. Manure Management		N2O	448.20	408.39	0.48%	0.000175	0.3%	KC level	-	
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6		SF6	79.58	31.72	0.01%	0.000170	0.3%	-	-	
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland	CO2	570.89	559.03	0.40%	0.000160	0.3%	KC level	-	
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland	CO2	36.76	17.16	0.01%	0.000153	0.3%	-	-	
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	443.97	588.91	0.05%	0.000139	0.2%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	4.29	12.25	0.02%	0.000129	0.2%	-	-	
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		N2O	200.19	180.11	0.25%	0.000127	0.2%	KC level	-	
5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands	CO2	15.81	3.09	0.00%	0.000125	0.2%	-	-	
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands	CO2	6.85	17.59	0.02%	0.000122	0.2%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	34.26	25.52	0.04%	0.000106	0.2%	-	-	
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.		SF6	64.04	81.55	0.03%	0.000083	0.1%	-	-	
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	138.39	0.01%	0.000082	0.1%	-	-
6C	6. Waste	C. Waste Incineration		CO2	52.87	15.25	0.00%	0.000068	0.1%	-	-	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	25.94	20.05	0.03%	0.000068	0.1%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	234.93	261.50	0.04%	0.000066	0.1%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	691.23	758.97	0.04%	0.000063	0.1%	-	-	

(cont'd next page)

IPCC Source Categories (and fuels if applicable)				Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment, with Uncertainty	Trend Assessment, with Uncertainty	% Contribution in Trend	Result level assessment	Result trend assessment	
					[Gg CO2eq]	[Gg CO2eq]						
TOTAL				All	57'423.79	54'134.47	17.1246%	0.060869	100.0%			
1A3e	1. Energy	A. Fuel Combustion	3. Transport: Other Transportation (military aviation)	CO2	200.04	115.09	0.01%	0.000060	0.1%	-	-	
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	CH4	8.19		0.00%	0.000060	0.1%	-	-	
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	11'335.25	10'614.99	0.82%	0.000058	0.1%	KC level	-	
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	CO2	139.24	102.65	0.02%	0.000056	0.1%	-	-	
4A	4. Agriculture	A. Enteric Fermentation		CH4	2'474.84	2'318.64	0.79%	0.000052	0.1%	KC level	-	
6B	6. Waste	B. Wastewater Handling		CH4	4.51	12.53	0.01%	0.000049	0.1%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	7.31	4.00	0.01%	0.000045	0.1%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Biomass	CH4	52.32	42.76	0.02%	0.000039	0.1%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Solid Fuels	CO2	57.10	35.14	0.01%	0.000037	0.1%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Liquid Fuels	N2O	11.24	8.38	0.01%	0.000035	0.1%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	9.45	6.76	0.01%	0.000034	0.1%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	N2O	87.79	81.62	0.23%	0.000033	0.1%	KC level	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Biomass	CH4	8.14	13.01	0.01%	0.000031	0.1%	-	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	N2O	4.22	0.90	0.00%	0.000031	0.1%	-	-	
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	N2O	5.13	6.67	0.01%	0.000029	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport: Civil Aviation	N2O	2.46	1.35	0.00%	0.000029	0.0%	-	-	
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Other Transportation (military aviation)	Gaseous Fuels	CO2	1.97	1.13	0.00%	0.000021	0.0%	-	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland	N2O	7.12	4.69	0.00%	0.000021	0.0%	-	-	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Biomass	N2O	10.30	8.42	0.01%	0.000020	0.0%	-	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport: Navigation	CO2	111.86	115.67	0.02%	0.000020	0.0%	-	-	
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Liquid Fuels	CH4	5.83	2.27	0.00%	0.000019	0.0%	-	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport: Railways	CO2	28.69	36.49	0.01%	0.000019	0.0%	-	-	
6A	6. Waste	A. Solid Waste Disposal on Land		CO2	9.13	0.06	0.00%	0.000017	0.0%	-	-	
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Biomass	N2O	1.60	2.56	0.00%	0.000016	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.40	4.95	0.00%	0.000016	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	2.95	5.22	0.00%	0.000014	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	CO2	547.47	529.32	0.05%	0.000013	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Gaseous Fuels	CH4	3.26	5.06	0.00%	0.000012	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	0.60	1.22	0.00%	0.000010	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.85	0.00%	0.000010	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	N2O	4.96	5.27	0.01%	0.000009	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	CH4	2.35	3.79	0.00%	0.000009	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Liquid Fuels	CH4	2.54	0.96	0.00%	0.000008	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		CH4	8.16	6.30	0.00%	0.000008	0.0%	-	-	
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Biomass	N2O	0.00	0.27	0.00%	0.000008	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Solid Fuels	CH4	3.83	2.36	0.00%	0.000007	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Gaseous Fuels	N2O	0.79	1.21	0.00%	0.000007	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Gaseous Fuels	CO2	40.29	20.11	0.00%	0.000007	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues		CH4	10.00	10.00	0.01%	0.000007	0.0%	-	-	
4F	4. Agriculture	F. Field Burning of Agricultural Residues		N2O	3.91	3.91	0.01%	0.000007	0.0%	-	-	
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	N2O	1.62	1.74	0.00%	0.000006	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.37	0.00%	0.000005	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.96	1.02	0.00%	0.000005	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry		CO2	13.60	15.21	0.00%	0.000005	0.0%	-	-	
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	CH4	1.49	1.01	0.00%	0.000005	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.76	0.00%	0.000004	0.0%	-	-
2A o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2		CO2	40.21	47.32	0.00%	0.000004	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.03	0.25	0.00%	0.000004	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Solid Fuels	N2O	0.30	0.19	0.00%	0.000002	0.0%	-	-
6C	6. Waste	C. Waste Incineration		CH4	3.96	3.99	0.00%	0.000002	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.36	0.00%	0.000002	0.0%	-	-
2A o	2. Industrial Proc.	A. Mineral Products		CH4	0.94	0.65	0.00%	0.000001	0.0%	-	-	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.55	0.29	0.00%	0.000001	0.0%	-	-
2G	2. Industrial Proc.	G. Other		CO2	1.04	0.44	0.00%	0.000001	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.33	0.00%	0.000001	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	CH4	1.62	1.41	0.00%	0.000001	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.43	0.00%	0.000001	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.60	0.00%	0.000001	0.0%	-	-
1A3 o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e	CH4	0.60	0.53	0.00%	0.000000	0.0%	-	-	
1A3e	1. Energy	A. Fuel Combustion	3. Transport: Other Transportation (military aviation)	CH4	0.16	0.12	0.00%	0.000000	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.15	0.00%	0.000000	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Biomass	CH4	0.00	0.02	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.05	0.00%	0.000000	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Gaseous Fuels	N2O	0.02	0.01	0.00%	0.000000	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CH4	1.23	1.14	0.00%	0.000000	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport: Civil Aviation	CH4	0.24	0.22	0.00%	0.000000	0.0%	-	-	
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas	N2O	0.03	0.03	0.00%	0.000000	0.0%	-	-	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Solid Fuels	CO2	NO	NO	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Solid Fuels	CH4	0.00	0.00	0.00%	0.000000	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Solid Fuels	N2O	0.00	0.00	0.00%	0.000000	0.0%	-	-
2A o	2. Industrial Proc.	A. Mineral Products		NO	NO	NO	0.00%	0.000000	0.0%	-	-	
2B	2. Industrial Proc.	B. Chemical Industry		HFC	NO	NO	0.00%	0.000000	0.0%	-	-	
2B	2. Industrial Proc.	B. Chemical Industry		PFC	NO	NO	0.00%	0.000000	0.0%	-	-	
2B	2. Industrial Proc.	B. Chemical Industry		SF6	0.00	0.00	0.00%	0.000000	0.0%	-	-	
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		PFC	0.00	0.00	0.00%	0.000000	0.0%	-	-	
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		CH4	IE.NO	IE.NO	0.00%	0.000000	0.0%	-	-	
2C o	2. Industrial Proc.	C. Metal Production without Aluminium Production		N2O	NO	NO	0.00%	0.000000	0.0%	-	-	
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2		CO2	139.26	NO	0.00%	0.000000	0.0%	-	-	
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC		PFC	100.17	NO	0.00%	0.000000	0.0%	-	-	
2D	2. Industrial Proc.	D. Other Production		CO2	NO	NO	0.00%	0.000000	0.0%	-	-	
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6		CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-	
2F o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC & 2F8-SF6		CO2	0.00	0.00	0.00%	0.000000	0.0%	-	-	
2G	2. Industrial Proc.	G. Other		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
2G	2. Industrial Proc.	G. Other		N2O	NO	NO	0.00%	0.000000	0.0%	-	-	
4C	4. Agriculture	C. Rice Cultivation		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
4D o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
4E	4. Agriculture	E. Prescribed Burning of Savannas		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
4E	4. Agriculture	E. Prescribed Burning of Savannas		N2O	NO	NO	0.00%	0.000000	0.0%	-	-	
4G	4. Agriculture	G. Other		CH4	NO	NO	0.00%	0.000000	0.0%	-	-	
4G	4. Agriculture	G. Other		N2O	NO	NO	0.00%	0.000000	0.0%	-	-	
6D	6. Waste	D. Other		CO2	NO	NO	0.00%	0.000000	0.0%	-	-	

(cont'd)

## Annex 2: Detailed discussion of methodology and data for estimating CO<sub>2</sub> emissions from fossil fuel combustion

### A2.1 Carbon Dioxide (CO<sub>2</sub>)

The main sources for calculating CO<sub>2</sub> emissions of Switzerland are the

- net calorific values NCV of the fuels (SFOE 2001, Intertek 2008)
- CO<sub>2</sub> emission factors of the fuels (SFOE 2001, Intertek 2008)
- Swiss overall energy statistics 2007 (SFOE 2008).

#### A2.1.1 Net calorific values and densities of fuels

All parameters of fuels are assumed to be constant for the period 1990 to 2007.

Table A - 10 NCV, densities and data sources of fossil and biofuels.

Fuels	Net calorific values (NCV)		Density	data sources
	GJ / t	GJ / volume	t / volume	
<b>Fossil fuels</b>				
Diesel Oil	42.8	35.5 GJ / 1000 lt	0.830 t / 1000 lt	SFOE (2001), Intertek (2008)
Gas Oil	42.6	36.0 GJ / 1000 lt	0.845 t / 1000 lt	SFOE (2001), Intertek (2008)
Gasoline	42.5	31.7 GJ / 1000 lt	0.745 t / 1000 lt	SFOE (2001), Intertek (2008)
Hard Coal	26.3	---	---	SFOE (2001)
Jet Kerosene	43.0	34.4 GJ / 1000 lt	0.800 t / 1000 lt	SFOE (2001), Intertek (2008)
Lignite	20.1	---	---	SFOE (2001)
Natural Gas	46.5	36.3 GJ / 1000 Nm <sup>3</sup>	0.780 t / 1000 Nm <sup>3</sup>	SFOE (2001)
Propane/Butane (LPG)	46.0	---	---	SFOE (2001)
Residual Fuel Oil	41.2	39.1 GJ / 1000 lt	0.950 t / 1000 lt	SFOE (2001), Intertek (2008)
<b>Biofuels</b>		<b>GJ / volume</b>		
Biodiesel		32.7 GJ / 1000 lt		EMIS (2009/1A3b)
Bioethanol		21.1 GJ / 1000 lt		EMIS (2009/1A3b)
Biogas		36.3 GJ / 1000 Nm <sup>3</sup>		EMIS (2009/1A3b)
Vegetable oil		34.6 GJ / 1000 lt		EMIS (2009/1A3b)

Note that the NCV have been taken from SFOE (2001). An extended measurement campaign, commissioned by FOEN and carried out by Intertek (2008) compared measured values with former measurements (EMPA 1999) and showed that the **assumption of constant NCV is widely fulfilled for fuels sold in Switzerland**. The authors write in their report, that only small deviations were found, which are hardly larger than the uncertainties of the measurements<sup>25</sup>.

<sup>25</sup> „Im Vergleich mit der letzten grösseren Heizwert-Untersuchung von 1998 (EMPA Prüfbericht Nr. 172853) können nur einige kleine Änderungen beobachtet werden, die aber kaum grösser als die Messungenauigkeit sind“ (Intertek 2008, p. 5)

## A2.1.2 CO<sub>2</sub> emission factors of fuels

Table A - 11 CO<sub>2</sub> emission factors (SFOE 2001). The value for natural gas also holds for CNG (compressed natural gas). The CO<sub>2</sub> emission factor of fossil fuels is assumed to be constant from 1990 to 2007.

Fuels	CO <sub>2</sub> Emission Factors 1990-2007			
	t CO <sub>2</sub> / TJ	t CO <sub>2</sub> / t	t CO <sub>2</sub> / volume	data sources
<b>Fossil fuels</b>				
Diesel Oil	73.6	3.15	2.61t / 1000 liter	SFOE (2001), Intertek (2008)
Gas Oil	73.7	3.14	2.65t / 1000 liter	SFOE (2001), Intertek (2008)
Gasoline	73.9	3.14	2.34t / 1000 liter	SFOE (2001), Intertek (2008)
Hard Coal	94.0	2.47	---	SFOE (2001)
Jet Kerosene	73.2	3.15	2.52t / 1000 liter	SFOE (2001), Intertek (2008)
Lignite	104.0	2.09	---	SFOE (2001)
Natural Gas	55.0	2.56	2.00t / 1000 Nm <sup>3</sup>	SFOE (2001)
Propane/Butane (LPG)	65.5	---	---	SFOE (2001)
Residual Fuel Oil	77.0	3.17	3.01t / 1000 liter	SFOE (2001), Intertek (2008)
<b>Biofuels</b>	t CO <sub>2</sub> / TJ			
Biodiesel	73.6			EMIS (2009/1A3b)
Bioethanol	73.9			EMIS (2009/1A3b)
Biogas	55.0			EMIS (2009/1A3b)
Vegetable oil	73.6			EMIS (2009/1A3b)

## A2.2 Sulphur Dioxide (SO<sub>2</sub>)

Table A - 12 Sulphur content and SO<sub>2</sub> emission factors. For explanations see next page.

year	maximum legal limit of sulphur content					
	Diesel oil ppm	Gasoline ppm	Gas oil ppm	Natural gas ppm	Res. fuel oil %	Coal %
1990	1400	200	2000	190	1.0	1.0
1991	1300	200	2000	190	1.0	1.0
1992	1200	200	2000	190	1.0	1.0
1993	1000	200	2000	190	1.0	1.0
1994	500	200	2000	190	1.0	1.0
1995	500	200	2000	190	1.0	1.0
1996	500	200	2000	190	1.0	1.0
1997	500	200	2000	190	1.0	1.0
1998	500	200	2000	190	1.0	1.0
1999	500	200	2000	190	1.0	1.0
2000	350	150	2000	190	1.0	1.0
2001	350	150	2000	190	1.0	1.0
2002	350	150	2000	190	1.0	1.0
2003	350	150	2000	190	1.0	1.0
2004	350	150	2000	190	1.0	1.0
2005-2007	50	50	2000	190	1.0	1.0

year	Effective sulphur content					
	Diesel oil ppm	Gasoline ppm	Gas oil ppm	Natural gas ppm	Res. fuel oil %	Coal %
1990	1400	200	1600	11.6	0.97	0.9
1991	1300	200	1300	11.6	0.89	0.9
1992	1200	200	1200	11.6	0.86	0.9
1993	1000	200	1000	11.6	0.87	0.9
1994	434	200	1350	11.6	0.77	0.9
1995	341	200	1170	11.6	0.78	0.9
1996	372	200	1160	11.6	0.78	0.9
1997	353	200	1250	11.6	0.70	0.9
1998	402	200	926	11.6	0.83	0.9
1999	443	200	650	11.6	0.62	0.9
2000	272	142	680	11.6	0.66	0.9
2001	250	121	830	11.6	0.82	0.9
2002	235	101	798	11.6	0.82	0.9
2003	200	81	700	11.6	0.79	0.9
2004	10.0	8.0	700	11.6	0.76	0.9
2005-2007	10.0	8.0	700	11.6	0.76	0.9

year	Effective SO <sub>2</sub> emission factor					
	Diesel oil	Gasoline	Gas oil	Natural gas	Res. fuel oil	Coal
kg/TJ						
1990	65.4	9.4	75.1	0.50	473	350
1991	60.7	9.4	61.0	0.50	432	350
1992	56.1	9.4	56.3	0.50	417	350
1993	46.7	9.4	46.9	0.50	422	350
1994	20.3	9.4	63.4	0.50	374	350
1995	15.9	9.4	54.9	0.50	377	350
1996	17.4	9.4	54.5	0.50	379	350
1997	16.5	9.4	58.7	0.50	340	350
1998	18.8	9.4	43.5	0.50	403	350
1999	20.7	9.4	30.5	0.50	301	350
2000	12.7	6.7	31.9	0.50	320	350
2001	11.7	5.7	39.0	0.50	398	350
2002	11.0	4.8	37.5	0.50	398	350
2003	9.3	3.8	32.9	0.50	383	350
2004	0.47	0.38	32.9	0.50	369	350
2005-2007	0.47	0.38	32.9	0.50	369	350

**Explanation to Table A - 12**

- For liquid and solid fuels the SO<sub>2</sub> emission factors are determined by the sulphur content. The upmost lines in Table A - 12 “maximum legal limit on sulphur content” show the maximum values due to the Federal Ordinance on Air Pollution Control OAPC (Swiss Confederation 1985).
- The lines in the middle part of Table A - 12 contain the effective sulphur contents. They are based on measurements: Summary and annual reports of the Swiss Petroleum Association (EV), reports by the Federal Administration of Customs (OZD) since 2000.
- The lines at the bottom part of Table A - 12 give the emission factors in kg/TJ. They are calculated from the sulphur content S, the net calorific value NCV and the quotient of the molar masses of S and SO<sub>2</sub>

$$\frac{M_{SO_2}}{M_S} \frac{S}{NCV} = 2 \frac{S}{NCV}$$

- Coal: Note that the legal limit of sulphur content depends on the size of the heat capacity of the combustion system. The value shown in the table above (1%, 350 kg/TJ SO<sub>2</sub>) holds for heat capacity below 1 MW; see OAPC Annex 4, §513 (Swiss Confederation 1985). For larger capacities the value is 3% (OAPC Annex 5, §2, Swiss Confederation 1985). For industrial combustion plants, the limit value for the exhaust emissions actually limits the maximum sulphur content corresponding to 1.4% (500 kg/TJ).
- Residual fuel oil: OAPC Annex 5, §11, lit.2 sets 2.8% for the legal limit. Simultaneously, OAPC dispenses from emission control measurements if residual fuel oil is used with sulphur content of maximum 1% (see OAPC Annex 3, §421, lit. 2, Swiss Confederation 1985), which holds for most combustion plants.

# Annex 3: Other detailed methodological descriptions for individual source or sink categories

## A3.1 Sector Energy

### A3.1.1 Swiss Energy Flux

The diagrams show a summary of the Swiss energy flux 2007 and 1990 as published by the Swiss Federal Office of Energy (SFOE 2008). Diagram languages are German and French.

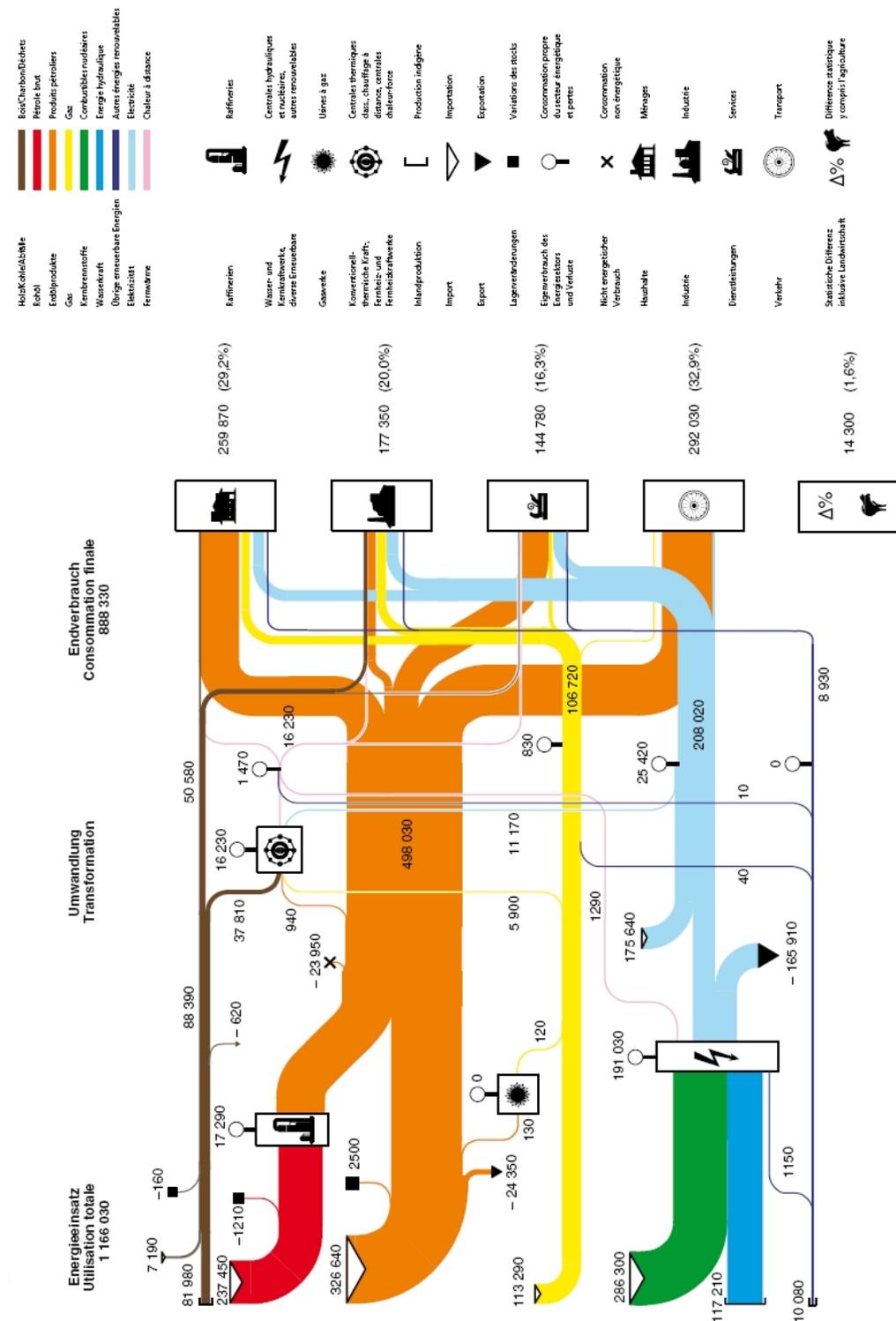


Figure A - 1 Energy flux in Switzerland 2007 (SFOE 2008)

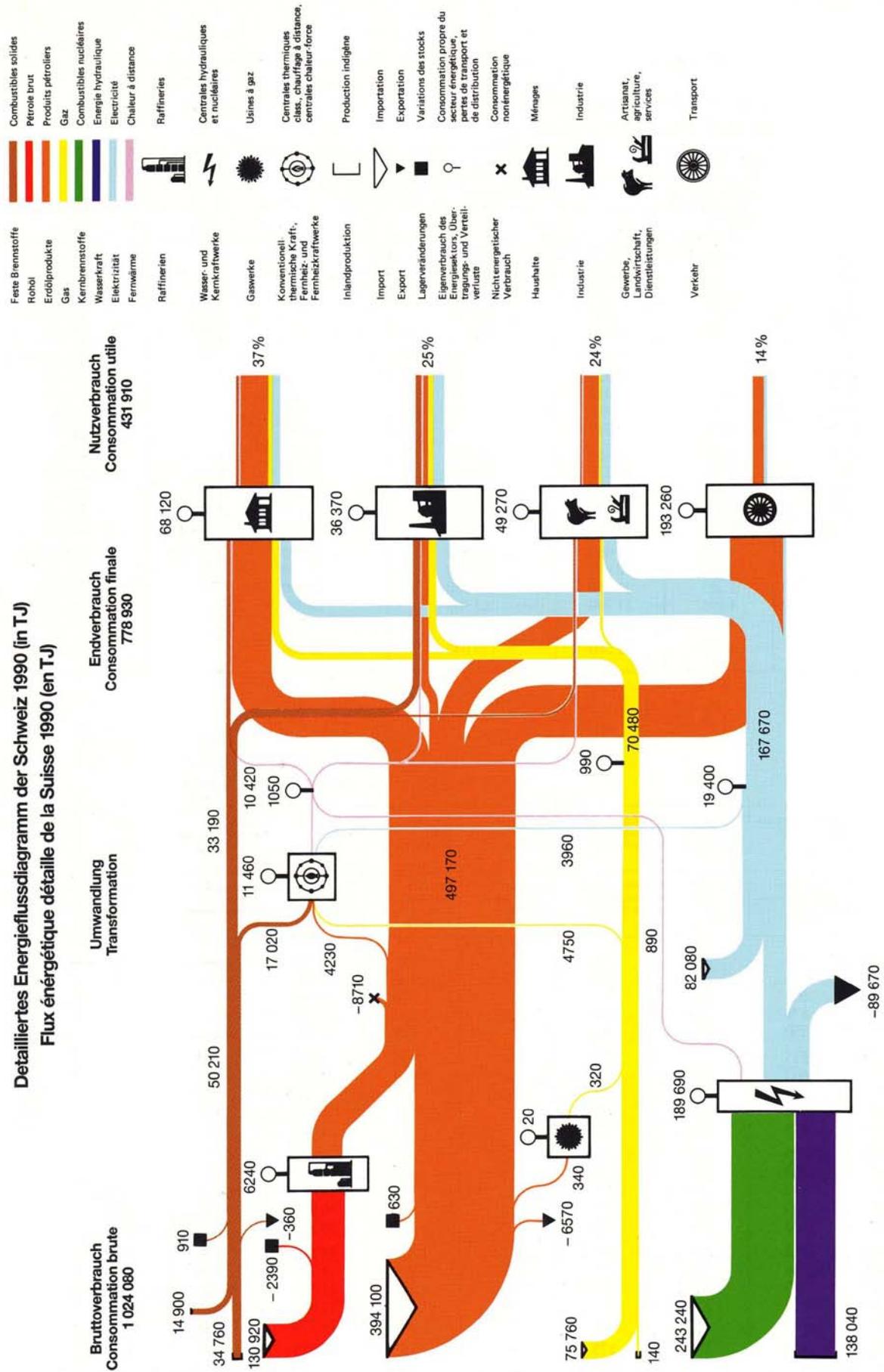


Figure A - 2 Energy flux in Switzerland 1990 (SFOE 1991)

### A3.1.2 Emissions from Fuel Consumption: Disaggregation of Fuel Consumption

#### Swiss overall energy statistics 2007

The consumption of Solid, Liquid, Gaseous and Other Fuels in the Swiss overall energy statistics 2007 (SFOE 2008) are the basis for the calculations of GHG emissions in source category 1A "Energy". The statistics provide annual aggregated consumption data for different fuels for categories of sources. The categories in the Swiss overall energy statistics are more aggregated than in CRF (e.g. the energy statistics provide data for "industry" as a whole, whereas the CRF differentiate between different industrial activities in source categories 1A2a to 1A2f).

The aggregated data on fuel consumption in the Swiss overall energy statistics are derived from the following sources:

- "Carbura" and Swiss Petroleum Association for data on import, export, sales, stocks of oil products and for processing of crude oil in refineries
- Annual import data for natural gas from Swiss gas industry association
- Annual customs import data for coal
- Measurements and data provided by industry associations

For a first disaggregation of fuel consumption data in the three categories (i) Energy Industries, (ii) industry, services and institutional and (iii) households, estimates based on selected surveys in industry and households, modelling, and expert judgments are used, including

- Survey on consumption of light fuel oil ("Erdöl Panel"); based on the survey, stocks are estimated; however, larger uncertainties about stock changes remain.
- Survey on consumption of natural gas to differentiate the consumption for heat, power and co-generation purposes.
- Survey with suppliers on amount and type of newly installed wood boilers and data on buildings. This data is then fed into a model that provides estimates of annual wood consumption.

#### Models for fuel consumption in industry and services/institutional

As the Swiss overall energy statistics provide only the sum of the combined fuel consumption in industry, services and institutional sector, SAEFL/FOEN mandated the companies/institutions *Basics* and *CEPE* to model the disaggregation and to estimate consumption in source categories 1A2a-f and 1A4a.

##### *Modelling of fuel consumption in Manufacturing Industries and Construction (Basics)*

The modelling of fuel consumption in Manufacturing Industries and Construction in Switzerland from 1990 to 2007 of Basics (Basics 2008) is based on several long- and short-term bottom-up energy-economic models. Starting from individual industrial processes, the fuel consumption of 16 branches of industry is calculated as the product of activity data (e.g. tons of chocolate produced) and a specific fuel consumption factor (e.g. kWh natural gas per ton of chocolate). The model is adjusted and scaled to fit available energy data and statistics, including the Swiss overall energy statistics, the statistics of the large energy consumers (Energiekonsumenten-Verband EKV; for 1990-1998), data from soundings of Helbling Ltd. (since 1999), data from Cemsuisse (2008a) for 1990 and 2000 to 2007, industry data from annual reports, fuel supply data from CARBURA for 1985 to 2007, data on full-time-jobs and on industrial production from SFSO, as well as expert estimates.

For the context of the Swiss GHG inventory, the Basics-model output provides annual consumption (in TJ) for light fuel oil (gas oil), heavy fuel oil, coal, natural gas, and biomass in the source categories 1A2a to 1A2f:

$F_{1A2a}^{Model}$ ,  $F_{1A2b}^{Model}$ ,  $F_{1A2c}^{Model}$ ,  $F_{1A2d}^{Model}$ ,  $F_{1A2e}^{Model}$ ,  $F_{1A2f}^{Model}$ , and total consumption  $F_{1A2}^{Model} = \sum_{i=a}^f F_{1A2i}^{Model}$ .

### Modelling of fuel consumption in services/institutional (CEPE)

Modelling work at the Centre for Energy Policy and Economics in Zürich (CEPE 2008) provided the basis to estimate the fuel consumption of the services and institutional sector in Switzerland from 1990 to 2007. The model calculates heat and electricity demand on the basis of heated building area. Seven fuels/heating systems are distinguished: Light fuel oil (gas oil), natural gas, electric heaters, fuel wood, district heating, electric heat pumps, and solar energy. When estimating the specific heat demand for different branches, the following factors are taken into account: changes in the cohort of buildings, changes in the efficiency of heating systems, substitution between fuels (e.g. fuel oil vs. natural gas), as well as changes in the typical behaviour of users.

For the context of the Swiss GHG inventory, the CEPE-model output provides annual consumption (in TJ) for light fuel oil, natural gas, and biomass in the source category "Services/Institutional" 1A4a:

$$F_{1A4a}^{Model}$$

### Application of model results to disaggregate fuel consumption between industry and services/institutional

With the exception of the year 2004, for which the models have been normalized, the total annual fuel consumption resulting from the two models do not exactly tally with the corresponding actual fuel consumption data in the Swiss overall energy statistics. The model output is used as a proxy to distribute the total consumption from the Swiss overall energy statistics between CRF source categories in the following steps:

1. The Swiss overall energy statistics provide the aggregated fuel consumption in industries (1A2) and in the services/institutional sector (1A4a) in TJ,  $F_{1A2+4a}$ .
2. The aggregated fuel consumption in the statistics,  $F_{1A2+4a}$ , are distributed proportional to the model outputs between the categories Industries (1A2) and Services/Institutional (1A4a):

$$(1) \quad F_{1A2} = F_{1A2+4a} \cdot \frac{F_{1A2}^{Model}}{F_{1A2}^{Model} + F_{1A4a}^{Model}}$$

$$(2) \quad F_{1A4a} = F_{1A2+4a} \cdot \frac{F_{1A4a}^{Model}}{F_{1A2}^{Model} + F_{1A4a}^{Model}}$$

3. The following equations have been used to disaggregate emissions related to the combustion of light fuel oil, natural gas, biomass, residual fuel oil and coal from Manufacturing Industries based on the outputs of the Basics-model:

$$(3) \quad F_{1A2a} = F_{1A2a}^{Model}; \quad F_{1A2b} = F_{1A2b}^{Model}; \quad F_{1A2c} = F_{1A2c}^{Model}; \quad F_{1A2d} = F_{1A2d}^{Model};$$

$$F_{1A2e} = F_{1A2e}^{Model}$$

$$(4) \quad F_{1A2f} = F_{1A2} - \sum_{i=a}^e F_{1A2i}^{Model}$$

I.e. source category 1A2f "Other" serves as a buffer to offset inconsistencies between the statistical data and the model outputs. With this, the overall consumption of light fuel oil, residual fuel oil, coal, natural gas, and biomass reported in 1A2 is consistent with the Swiss overall energy statistics.

### A3.1.3 Civil Aviation

This paragraph contains further information to the emission modelling. More complete information will be available in FOCA (2006, 2007, 2008) and on request for reviewers by FOCA.

#### Emission factors

Table A - 13 Aircraft cruise factors, used for cruise emission calculation (extract of list of 843 aircraft)  
GKL\_ICAO = ICAO seat categories. Mass emissions are given in kilograms or grams per nautical mile (NM).

Aircraft Cruise_Factors						
Aircraft_ICAO	GKL_ICAO	Cruise_D_Source	kg_fuel_NM	kg_NOx_NM	g_VOC_NM	g_CO_NM
AA1	0	P002FOCA	0.21	0.0098	1.79	61.7
AA5	0	P002FOCA	0.21	0.0098	1.79	61.7
AC11	0	P002FOCA	0.21	0.0098	1.79	61.7
AC14	0	P002FOCA	0.21	0.0098	1.79	61.7
AC50	0	P001FOCA	0.77	0.021	4.14	364.17
AC68	0	P001FOCA	0.77	0.0075	4.14	364.17
AC6T	1	FOCAINV95-03.2T	1.58	0.021	0.87	2.9
AC90	1	FOCAINV95-03.2T	1.58	0.021	0.87	2.9
AC95	1	FOCAINV95-03.2T	1.58	0.021	0.87	2.9
AEST	0	P001FOCA	0.77	0.021	4.14	364.17
AJET	0	FOCAEDBJ014	2.92	0.0146	8.53	63
ALO2	0	FOCAHeli	1.91	0.024	0.42	2.1
ALO3	0	FOCAHeli	1.91	0.024	0.42	2.1
AN12	0	AN26*2	5.36	0.0062	143	348
AN2	0	FOCA/91/DC3	0.82	0.0002	13.7	1000
AN22	6	FOCAINV95-03.2T*2	3.16	0.042	1.74	5.8
AN24	2	AN26	2.68	0.0031	71.7	174
AN26	1	500	2.68	0.0031	71.7	174
AN72	2	FOCAINV95-03.2J	6.4	0.1	0.83	10
AR7	0	P002FOCA	0.21	0.0098	1.79	61.7
AR7A	0	P002FOCA	0.21	0.0098	1.79	61.7
AS02	0	P002FOCA	0.21	0.0098	1.79	61.7
AS16	0	P002FOCA	0.21	0.0098	1.79	61.7
AS20	0	P002FOCA	0.21	0.0098	1.79	61.7
AS24	0	P002FOCA	0.21	0.0098	1.79	61.7
AS25	0	P002FOCA	0.21	0.0098	1.79	61.7
AS26	0	P002FOCA	0.21	0.0098	1.79	61.7
AS2T	0	FOCAEDBT758	0.95	0.005	1.8	12
AS30	0	FOCAHeli*2	3.82	0.048	0.82	4.2
AS32	1	FOCAHeli*2	3.82	0.048	0.82	4.2
AS33	0	FOCAHeli*2	3.82	0.048	0.82	4.2
AS35	0	FOCAHeli	1.91	0.024	0.42	2.1
AS50	0	FOCAHeli*2	3.82	0.048	0.82	4.2
AS55	0	FOCAHeli*2	3.82	0.048	0.82	4.2
AS65	0	FOCAHeli*2	3.82	0.048	0.82	4.2
ASK1	0	P002FOCA	0.21	0.0098	1.79	61.7
ASTA	0	FOCAINV95-03.B	3.016	0.046	0.3	2.8
ASTR	0	FOCAINV95-03.B	3.016	0.046	0.3	2.8
ASTRA	0	FOCAINV95-03.B	3.016	0.046	0.3	2.8
AT42	1	FOCAINV95-03.2T	1.58	0.021	0.87	2.9
AT43	1	500	1.6	0.013	0	15

## Activity data

Table A - 14 LTO-cycle times (minutes). ICAO standard cycle times were originally designed for emissions certification, not for emissions modelling. Today, they do generally not match real world aircraft LTO operations. Swiss FOCA has therefore adjusted some of the ICAO standard cycle times for different aircraft categories. For jets, the mean time for taxi-in and taxi-out at Swiss airports has been determined 20 minutes instead of the standard 26 minutes. For jets, business jets, turboprops, piston engines and helicopters, the times in mode are shown in the table and are based on ICAO, US EPA and Swiss FOCA data "Type" is a classification variable. J = Jet, T = Turboprop, P = Piston, H = Helicopter, B = Business jet, SJ = Supersonic Jet. The number in "Type" stands for the number of engines. For Jet Aircraft, the cycle times and associated thrust settings still lead to an overestimation of LTO emissions (FOCA 2007b).

LTO Cycle				
Type	Time_Take_Off	Time_Climbout	Time_Approach	Zeit_Taxi
1J	0.7	2.2	4	20
1T	0.5	2.5	4.5	13
1P	0.3	2.5	3	12
1H	0	6.5	6.5	7
2B	0.4	0.5	1.6	13
3B	0.4	0.5	1.6	13
2T	0.5	2.5	4.5	13
4T	0.5	2.5	4.5	13
2J	0.7	2.2	4	20
3J	0.7	2.2	4	20
4J	0.7	2.2	4	20
2P	0.3	2.5	3	12
3P	0.3	2.5	3	12
4P	0.3	2.5	3	12
2H	0	6.5	6.5	7
4SJ	1.2	2	2.3	20
3H	0	6.5	6.5	7
4H	0	6.5	6.5	7
4B	0.4	0.5	1.6	13

Table A - 15 Aircraft-Engine Combinations and associated codes for SWISS FOCA emissions database. (Extract from list of more than 23'000 individual aircraft)

Aircraft Engine Combinations							
Engine Name	Aircraft Name	Aircraft Registr.	No. Eng.	Code	Type	Aircr. ICAO	Source
V2527-A5	AIRBUS A320-232	ECHXA	2	J220	2J	A320	1IA003
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECHXM	2	J090	2J	CRJ2	1GE034
CFM56-3C1	BOEING 737-4K5	ECHXT	2	J022	2J	B734	1CM007
TPE331-11U-611G	FAIRCHILD (SWEARIN-GEN) SA227AC METR	ECHXY	2	T310	2T	SW4	FOI
CFM56-5B4/P	AIRBUS A320-214	ECHYC	2	J067	2J	A320	3CM026
CFM56-5B4/P	AIRBUS A320-214	ECHYD	2	J067	2J	A320	3CM026
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECHYG	2	J090	2J	CRJ2	1GE034
CFEC-FE738-1-1B	DASSAULT FALCON 2000	ECHYI	2	B130	2B	F2TH	FOI-Honeywell
GA TPE331-11U-612G		ECHZH	2	T310	2T	FA3	FOI
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECHZR	2	J090	2J	CRJ2	1GE034
CFM56-7B27B1	BOEING 737-86Q (WINGLETS)	ECHZS	2	J075	2J	B738	3CM034
CFM56-5B4/P	AIRBUS A320-214	ECHZU	2	J067	2J	A320	3CM026
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECIAA	2	J090	2J	CRJ2	1GE034
FJ44-1A	CESSNA 525 CITATIONJET	ECIAB	2	B001	2B	C525	FOCA
CFM56-5B4/P	AIRBUS A320-214	ECIAG	2	J067	2J	A320	3CM026
V2527-A5	AIRBUS A320-232	ECIAZ	2	J220	2J	A320	1IA003

BRBR700-710A2-20	BOMBARDIER BD-700-1A10 GLOBAL EX-PRE	ECIBD	2	J854	2J	GLEX	4BR009
PT6A-60A	BEECH-CRAFT KING AIR 350 (RAYTHEON B	ECIBK	2	T738	2T	B350	FOI
CF34-3B1	BOMBARDIER CRJ200ER (CL-600-2B19)	ECIBM	2	J090	2J	CRJ2	1GE034
CFM56-7B27B1	BOEING 737-81Q (WINGLETS)	ECICD	2	J075	2J	B738	3CM034
CFM56-5B4/P	AIRBUS A320-214	ECICK	2	J067	2J	A320	3CM026

## Emissions

The output of the FOCA emission modelling consists of tables with the following structure:

Table A - 16 Extract of the output file of FOCA emission and fuel consumption modelling. Upper part: LTO, lower part: cruise (example for 2004). Emissions and fuel consumption in tons.

Airport	Distance	Type Traffic	Movements	Type	Aircraft ICAO	Engine Name	Fuel (LTO) tons	Emissions (LTO) in tons					
	Km		No.					CO <sub>2</sub>	H <sub>2</sub> O	SO <sub>2</sub>	NO <sub>x</sub>	VOC	CO
LSGG	181501.69	Taxi	165	2B	C550	JT15D-4	5673.492	17871.5	6978.395	5.673	26.04	139	359.2
LSGG	164165.197	Taxi	77	2J	B752	RB211-535E4	47470.5	149532.1	58388.72	47.47	554.91	0	361.47
LSGG	133166.837	Taxi	118	2B	F2TH	CFE738-1-1B	6164.2728	19417.46	7582.056	6.164	87.539	40.59	185.53
LSGG	117228.943	Taxi	99	3B	F900	TFE731-60-1C	5668.542	17855.91	6972.307	5.669	46.937	28.13	163.44
LSGG	114258.902	Taxi	134	2B	LJ45	TFE731-20R	4725.108	14884.09	5811.883	4.725	31.31	53.62	169.01
LSGG	112510.267	Taxi	100	2B	F2TH	CFE738-1-1B	5223.96	16455.47	6425.471	5.224	74.186	34.4	157.23
LSGG	107945.477	Taxi	96	2B	C560	JT15D-5D	3795.3216	11955.26	4668.246	3.795	16.959	271.6	287.98
Airport	Distance km	Type Traffic	Movements	Type	Aircraft ICAO	Engine Name	Fuel (cruise) tons	Emissions (cruise) in tons					
LSGG	181501.69	Taxi	165	2B	C550	JT15D-4	307732.68	969357.9	378511.2	307.7	4513	29.43	274.71
LSGG	164165.197	Taxi	77	2J	B752	RB211-535E4	673698.47	2122150	828649.1	673.7	7986.4	647.8	1038.2
LSGG	133166.837	Taxi	118	2B	F2TH	CFE738-1-1B	225781.85	711212.8	277711.7	225.8	3311.2	21.59	201.55
LSGG	117228.943	Taxi	99	3B	F900	TFE731-60-1C	298139.18	939138.4	366711.2	298.1	4372.3	28.52	266.14
LSGG	114258.902	Taxi	134	2B	LJ45	TFE731-20R	193723.81	610230	238280.3	193.7	2841	18.53	172.93
LSGG	106761.289	Taxi	100	2B	F2TH	CFE738-1-1B	181011.75	570187	222644.4	181	2654.6	17.31	161.58
LSGG	103217.159	Taxi	96	2B	C560	JT15D-5D	175002.74	551258.6	215253.4	175	2566.5	16.74	156.22

### A3.1.4 Road Transportation

#### Emission factors

The derivation of the emission factors for road vehicles is described in detail in INFRAS 2004 (Passenger cars and light duty vehicles) and in Hausberger et al. 2002 (heavy duty vehicles). Both reports are in English. A similar report for two-wheelers exists but is available in German only (RWTÜV 2003). Some important features of the emission factor methodologies are summarised in this paragraph.

The emission factors have to be differentiated according to the vehicle categories. Each category contains a number vehicle classes, which differ by emission concepts. The next table illustrates the classes of the passenger cars. Similar "segmentations" hold for the other vehicle categories too. Emission factors for vehicle classes are combined to average emission factors for vehicles categories weighted according to the fleet composition, which varies from year to year (see below).

Table A - 17 Vehicle segmentation of the passenger cars. Each class (segment) is subdivided into three cubic capacities: <1.4 litre, 1.4-2.0 litres, > 2.0 litres (INFRAS 2004).

Fuel	Vehicle class
Gasoline	<ECE
	ECE 15'00
	ECE 15'01-02
	ECE 15'03
	ECE 15'04
	AGV82
	Conc.div.
	unreg.Cat.
	closed L.Cat. <87
	closed L.Cat. 87-90
	closed L.Cat. 91-95(CH)
	EURO1
	EURO2
	EURO3
EURO4	
Diesel	<1986
	1986-88
	EURO1
	EURO2
	EURO3
	EURO4

The emission factors published in the handbook (CD ROM, SAEFL 2004a) are classified by "traffic situations." A traffic situation is primarily characterised by the type of road which induces a typical driving behaviour. (Because driving behaviour is not independent of the amount of traffic on that particular road, on the same segment different driving patterns may exist.) For the handbook several typical traffic situations have been defined, based on driving behaviour studies in Germany and in Switzerland (see e.g. SAEFL 1995, chap. 4).

Table A - 18 Traffic situations ("TS name") in Switzerland (SAEFL 1995, SAEFL 2004a). Every traffic situation is either equal to a driving pattern or equal to a linear combination of several driving patterns (see table below).

Traffic Situations in Switzerland							
TS Name	Description	gradient -3% to +3%	V (km/h)	gradient <-3%	V (km/h)	gradient >3%	V (km/h)
Highway							
Highway_120	Highway, Speed limit 120, >=2 lanes/direction (avg. speed v (PC)=116 km/h, v (HDV)=86 km/h)	$0.67 \cdot AE1 + 0.33 \cdot AE2$	116	$0.5 \cdot AG1 + 0.5 \cdot AG2$	118	$0.75 \cdot AS1 + 0.25 \cdot AS2$	113
Highway_100	Highway, Speed limit 100, >=2 lanes/direction (avg. speed v (PC)=103 km/h, v (HDV)=86 km/h)	$0.25 \cdot (AE1, AE2, A3, A4)$	103	$0.5 \cdot AG2 + 0.5 \cdot AGV$	112	AS2	102.8
Highway_80	Highway, Speed limit 80, >=2 lanes/direction (avg. speed v (PC)=87 km/h, v (HDV)=86 km/h)	A4	87	A4	87	A4	87
Highway_100/1 lane	Highway, Speed limit 100, 1 lane/direction (avg. speed v (PC)=103 km/h, v (HDV)=86 km/h)	$0.25 \cdot (AE1, AE2, A3, A4)$	103				
Highway_80 /1 lane	Highway, Speed limit 80, 1 lane/direction (avg. speed v (PC)=87 km/h, v (HDV)=83 km/h)	A4	87	A4	87	A4	87
rural							
Rural_1	well developed, straight (v (PC)=77 km/h,	LE1	77	LG1	61	LS1	60
Rural_2	well developed, even bends (v (PC)=66 km/h,	LE2s	66	LG1	61	$0.5 \cdot LS1 + 0.5 \cdot LS2$	55
Rural_3	uneven bends (avg. speed v (PC)=63 km/h,	LE2u	63	LG2	51	LS2	49
Rural_4	small roads, uneven bends	LE2u	63	LG2	51	LS2	49
urban							
Urban_M1	Main road, right of way, minimal hold-ups	LE3	53	LE3	53	LE3	53
Urban_M2	Main road, right of way, medium hold-ups	$0.5 \cdot LE3 + 0.5 \cdot LE5$	42	$0.5 \cdot LE3 + 0.5 \cdot LE5$	42	$0.5 \cdot LE3 + 0.5 \cdot LE5$	42
Urban_M3	Main road, right of way, major hold-ups	LE5	31	LE5	31	LE5	31
Urban_L1	Main road, with traffic light syst, minimall hold-ups	$0.25 \cdot LE3 + 0.5 \cdot LE5 + 0.25 \cdot LE6$	34	$0.25 \cdot LE3 + 0.5 \cdot LE5 + 0.25 \cdot LE6$	34	$0.25 \cdot LE3 + 0.5 \cdot LE5 + 0.25 \cdot LE6$	34
Urban_L2	Main road, with traffic light system, medium hold-ups	$0.67 \cdot LE5 + 0.33 \cdot LE6$	28	$0.67 \cdot LE5 + 0.33 \cdot LE6$	28	$0.67 \cdot LE5 + 0.33 \cdot LE6$	28

Urban_L3	Main road, with traffic light system, major hold-ups	$0.33 \cdot LE5 + 0.67 \cdot LE6$	24	$0.33 \cdot LE5 + 0.67 \cdot LE6$	24	$0.33 \cdot LE5 + 0.67 \cdot LE6$	24
Urban_Centre	Urban roads, in city centre	LE6	20	LE6	21	LE6	21
X:Urban_Side roads_dense	Side roads, self-contained development	LE6	21	LE6	21	LE6	21
X:Urban_Side roads_light	Side roads, light development	LE5	31	LE5	31	LE5	31
X:Urban_Stop+Go	Urban roads, Stop+Go	STGOio	5	STGOio	5	STGOio	5

Traffic situations are defined independently of vehicle categories (LDV, HDV, 2-wheelers). But behind the same traffic situation each vehicle category may know its own “driving pattern” which may be expressed as a speed curve (i.e. speed time series). Emission factors originally are derived for these underlying driving patterns based on measurements performed on laboratory test benches. Emission factors per traffic situation then are calculated by combining and weighting the emission factors of these driving patterns. In fact, the handbook provides emission factors per traffic situation which are linear combinations of emission factors per driving pattern. In the following table the driving patterns are given.

Table A - 19 Driving patterns in Switzerland (INFRAS 2004). "T" stands for tempo (speed) limit: T120 specifies a road with maximum velocity of 120 km/h. "v" is the average velocity driven on a road.

Driving Patterns	
A3	T 80-100, medium/heavy traffic; v=95.3 km/h
A4	T 80, 1-3 lanes, heavy traffic; v=86.6 km/h
A5	T 60-80, 1-3 lanes, heavy traffic; v=75.8 km/h
AB	T 80-120, 2-3 lanes, heavy traffic; v=100.2 km/h
AE1	T 120, 2-3 lanes, low traffic; v=117.8 km/h
AE2	T 100-120, 2-3 lanes; v=111.9 km/h
AG1	T 120, 2-3 lanes; v=120.1 km/h
AG2	T 100-120, 2-3 lanes; v=111.9 km/h
AGV	T 80-100; v=112 km/h
AS1	T 120
AS2	T 80-120
AV	T 80-120, 2-3 lanes, heavy traffic; v=104 km/h
K	city centre; v=19.9 km/h
LB2	continuous, acceleration phase after crossings, with priority
LB3	acceleration phase after crossings; with priority v=57 km/h
LB4	acceleration phase after settlements; v=45.4 km/h
LE1	continuous; v=77 km/h
LE2s	continuous flow; v=66 km/h
LE2u	discontinuous flow; v=62.6 km/h
LE3	with priority, undisturbed traffic flow v=53.1 km/h
LE5	traffic lights, heavily interrupted traffic flow; with priority v=31.1 km/h
LE6	traffic lights, heavily interrupted traffic flow; v=20.7 km/h
LG1	slope, continuous to narrow, v = 60.9 km/h
LG2	slope, narrow to changeable, v = 51.2 km/h
LG3	slope, changeable, v = 49.9 km/h
LS1	incline, continuous to narrow, v = 59.8 km/h
LS2	incline, narrow, changeable, v = 49.2 km/h
LS3	incline, continuous to changeable, v = 46.2 km/h
LV1	continuous, deceleration phase at settlements; v=72.9 km/h
LV2	continuous, deceleration phase at crossings; v=66.2 km/h
LV4	deceleration phase at settlements; v=43.6 km/h
STGOAB	stop and go (Highway); v=9.4 km/h
STGOio	stop and go (urban); v=5.3 km/h

Emission factors for Switzerland are shown in the next table (SAEFL 2004). They represent weighted averages over all traffic situations. The year indicates the date when the corresponding vehicle class appears in the market. E.g. "Euro-3" standard came into force on Jan 1, 2001, but the first vehicles with Euro-3 standard already appeared in 1999.

Table A - 20 Mean emission factors of passenger cars (PC), light duty vehicles (LDV), heavy duty vehicles (HDV), urban busses (Buses) and 2-wheelers. further abbr. P gasoline (petrol), D diesel oil, LMC light motorcycles, MP moped (SAEFL 2004).

Vehicle type	Gas	Concept	1990	1995	2000	2005	2010
Pass. cars	CO2	PC/P/Euro-1/FAV1		215.4	214.6	214.3	217.4
Pass. cars	CO2	PC/P/Euro-2			202.5	201.8	201.5
Pass. cars	CO2	PC/P/Euro-3			200.6	196.9	196.2
Pass. cars	CO2	PC/P/Euro-4			200.0	194.6	187.6
Pass. cars	CO2	PC/P/RCat<91	213.8	213.9	215.0	219.0	224.8
Pass. cars	CO2	PC/P/conv	222.1	224.5	229.5	237.0	240.4
Pass. cars	CO2	PC/D/Euro-2		207.6	198.5	193.6	192.4
Pass. cars	CO2	PC/D/Euro-3			182.3	177.1	176.7
Pass. cars	CO2	PC/D/Euro-4				174.3	169.2
Pass. cars	CO2	PC/D/conv	217.4	218.5	220.4	226.6	230.0
Pass. cars	CO2	PC/D/XXIII/FAV1	210.2	209.6	210.4	211.5	214.2
Pass. cars	CH4	PC/P/Euro-1/FAV1		0.0048	0.0050	0.0052	0.0053
Pass. cars	CH4	PC/P/Euro-2			0.0044	0.0046	0.0047
Pass. cars	CH4	PC/P/Euro-3			0.0008	0.0008	0.0008
Pass. cars	CH4	PC/P/Euro-4			0.0006	0.0006	0.0006
Pass. cars	CH4	PC/P/RCat<91	0.0122	0.0145	0.0162	0.0175	0.0191
Pass. cars	CH4	PC/P/conv	0.0476	0.0449	0.0446	0.0483	0.0535
Pass. cars	CH4	PC/D/Euro-2		0.0012	0.0012	0.0012	0.0012
Pass. cars	CH4	PC/D/Euro-3			0.0010	0.0009	0.0009
Pass. cars	CH4	PC/D/Euro-4				0.0008	0.0008
Pass. cars	CH4	PC/D/conv	0.0034	0.0031	0.0028	0.0027	0.0029
Pass. cars	CH4	PC/D/XXIII/FAV1	0.0016	0.0016	0.0016	0.0016	0.0016
Pass. cars	N2O	PC/P/Euro-1/FAV1		0.014	0.014	0.014	0.014
Pass. cars	N2O	PC/P/Euro-2			0.006	0.006	0.006
Pass. cars	N2O	PC/P/Euro-3			0.003	0.003	0.003
Pass. cars	N2O	PC/P/Euro-4			0.001	0.001	0.001
Pass. cars	N2O	PC/P/RCat<91	0.014	0.014	0.014	0.014	0.014
Pass. cars	N2O	PC/P/conv	0.000	0.000	0.000	0.000	0.000
Pass. cars	N2O	PC/D/Euro-2		0.005	0.005	0.005	0.005
Pass. cars	N2O	PC/D/Euro-3			0.006	0.006	0.006
Pass. cars	N2O	PC/D/Euro-4				0.006	0.006
Pass. cars	N2O	PC/D/conv	0.000	0.000	0.000	0.000	0.000
Pass. cars	N2O	PC/D/XXIII/FAV1	0.000	0.000	0.000	0.000	0.000
LDV	CO2	LDV/P/Euro-1/FAV1		256.5	255.4	256.3	258.9
LDV	CO2	LDV/P/Euro-2			219.3	219.4	222.6
LDV	CO2	LDV/P/Euro-3			210.1	204.7	202.8
LDV	CO2	LDV/P/Euro-4				199.8	192.6
LDV	CO2	LDV/P/RCat<91	254.1	255.9	256.7	258.0	259.7
LDV	CO2	LDV/P/conv	294.3	282.2	281.1	274.9	273.9
LDV	CO2	LDV/D/Euro-1/FAV1		313.7	306.7	306.1	308.3
LDV	CO2	LDV/D/Euro-2			289.2	281.0	281.8
LDV	CO2	LDV/D/Euro-3			274.1	264.8	263.1
LDV	CO2	LDV/D/Euro-4					250.9
LDV	CO2	LDV/D/conv	351.7	324.7	314.0	314.0	317.5
LDV	CH4	LDV/P/Euro-1/FAV1		0.021	0.024	0.026	0.028
LDV	CH4	LDV/P/Euro-2			0.011	0.012	0.013
LDV	CH4	LDV/P/Euro-3			0.007	0.008	0.008
LDV	CH4	LDV/P/Euro-4				0.005	0.005
LDV	CH4	LDV/P/RCat<91	0.009	0.010	0.011	0.011	0.012
LDV	CH4	LDV/P/conv	0.115	0.123	0.123	0.121	0.119
LDV	CH4	LDV/D/Euro-1/FAV1		0.002	0.002	0.002	0.002
LDV	CH4	LDV/D/Euro-2			0.001	0.001	0.001
LDV	CH4	LDV/D/Euro-3			0.001	0.001	0.001
LDV	CH4	LDV/D/Euro-4					0.001
LDV	CH4	LDV/D/conv	0.010	0.005	0.004	0.003	0.003
LDV	N2O	LDV/P/Euro-1/FAV1		0.014	0.014	0.014	0.014
LDV	N2O	LDV/P/Euro-2			0.006	0.006	0.006
LDV	N2O	LDV/P/Euro-3			0.003	0.003	0.003
LDV	N2O	LDV/P/Euro-4				0.001	0.001
LDV	N2O	LDV/P/RCat<91	0.000	0.000	0.000	0.000	0.000
LDV	N2O	LDV/P/conv	0.008	0.010	0.010	0.010	0.010
LDV	N2O	LDV/D/Euro-1/FAV1		0.003	0.003	0.003	0.003
LDV	N2O	LDV/D/Euro-2			0.005	0.005	0.005
LDV	N2O	LDV/D/Euro-3			0.006	0.006	0.006
LDV	N2O	LDV/D/Euro-4					0.006
LDV	N2O	LDV/D/conv	0.000	0.000	0.000	0.000	0.000
HDV	CO2	HMV/1960s	870.8	874.1			
HDV	CO2	HMV/1970s	839.5	843.4	830.6	830.6	823.0
HDV	CO2	HMV/1980s	794.2	802.3	797.9	789.6	786.7
HDV	CO2	HMV/Euro-1		748.1	729.3	722.6	711.8
HDV	CO2	HMV/Euro-2			707.5	744.2	730.8
HDV	CO2	HMV/Euro-3			761.9	772.1	759.5
HDV	CO2	HMV/Euro-4				777.3	764.5
HDV	CO2	HMV/Euro-5					788.5
HDV	CH4	HMV/1960s	0.032	0.033			
HDV	CH4	HMV/1970s	0.026	0.027	0.027	0.028	0.028
HDV	CH4	HMV/1980s	0.021	0.021	0.021	0.023	0.022
HDV	CH4	HMV/Euro-1		0.017	0.017	0.016	0.016

Vehicle type	Gas	Concept	1990	1995	2000	2005	2010
HDV	CH4	HMV/Euro-2			0.010	0.010	0.010
HDV	CH4	HMV/Euro-3			0.009	0.009	0.009
HDV	CH4	HMV/Euro-4				0.011	0.011
HDV	CH4	HMV/Euro-5					0.011
HDV	N2O	HMV/1960s	0.012	0.012			
HDV	N2O	HMV/1970s	0.012	0.012	0.012	0.012	0.012
HDV	N2O	HMV/1980s	0.012	0.012	0.012	0.012	0.012
HDV	N2O	HMV/Euro-1		0.012	0.012	0.012	0.012
HDV	N2O	HMV/Euro-2			0.012	0.012	0.012
HDV	N2O	HMV/Euro-3			0.007	0.007	0.007
HDV	N2O	HMV/Euro-4				0.007	0.007
HDV	N2O	HMV/Euro-5					0.007
Buses	CO2	HMV/1960s	1272	1276			
Buses	CO2	HMV/1970s	1249	1263	1288	1264	1266
Buses	CO2	HMV/1980s	1165	1182	1204	1206	1203
Buses	CO2	HMV/Euro-1		1040	1039	1039	1040
Buses	CO2	HMV/Euro-2		1055	1030	1053	1056
Buses	CO2	HMV/Euro-3			1135	1096	1098
Buses	CO2	HMV/Euro-4				1104	1106
Buses	CO2	HMV/Euro-5					1143
Buses	CH4	HMV/1960s	0.085	0.087			
Buses	CH4	HMV/1970s	0.065	0.065	0.069	0.071	0.071
Buses	CH4	HMV/1980s	0.056	0.055	0.054	0.054	0.054
Buses	CH4	HMV/Euro-1		0.024	0.024	0.024	0.024
Buses	CH4	HMV/Euro-2		0.014	0.014	0.014	0.014
Buses	CH4	HMV/Euro-3			0.013	0.013	0.013
Buses	CH4	HMV/Euro-4				0.015	0.015
Buses	CH4	HMV/Euro-5					0.015
Buses	N2O	HMV/1960s	0.015	0.015			
Buses	N2O	HMV/1970s	0.015	0.015	0.015	0.015	0.015
Buses	N2O	HMV/1980s	0.015	0.015	0.015	0.015	0.015
Buses	N2O	HMV/Euro-1		0.015	0.015	0.015	0.015
Buses	N2O	HMV/Euro-2		0.015	0.015	0.015	0.015
Buses	N2O	HMV/Euro-3			0.008	0.008	0.008
Buses	N2O	HMV/Euro-4				0.008	0.008
Buses	N2O	HMV/Euro-5					0.008
2-wheelers	CO2	LMC/<Euro-1	63.0	63.0	63.0	63.0	63.0
2-wheelers	CO2	LMC/Euro-1	53.7	53.7	53.7	53.7	53.7
2-wheelers	CO2	LMC/Euro-2				45.1	45.1
2-wheelers	CO2	MC/2S/<Euro-1	164.2	164.5	163.8	163.8	164.1
2-wheelers	CO2	MC/2S/Euro-1	112.0	111.9	112.0	112.0	112.0
2-wheelers	CO2	MC/2S/Euro-2				94.8	94.9
2-wheelers	CO2	MC/2S/Euro-3					80.4
2-wheelers	CO2	MC/4S/<Euro-1	99.4	101.4	106.3	113.5	113.6
2-wheelers	CO2	MC/4S/Euro-1	95.8	97.5	96.9	96.9	97.6
2-wheelers	CO2	MC/4S/Euro-2				88.3	88.3
2-wheelers	CO2	MC/4S/Euro-3					85.8
2-wheelers	CO2	MP/ with cat	38.6	38.6	38.6	38.6	38.6
2-wheelers	CO2	MP/ without cat	48.6	48.6	48.6	48.6	48.6
2-wheelers	CH4	LMC/<Euro-1	0.238	0.238	0.238	0.238	0.238
2-wheelers	CH4	LMC/Euro-1	0.180	0.180	0.180	0.180	0.180
2-wheelers	CH4	LMC/Euro-2				0.208	0.208
2-wheelers	CH4	MC/2S/<Euro-1	1.327	1.330	1.322	1.322	1.326
2-wheelers	CH4	MC/2S/Euro-1	0.341	0.341	0.341	0.341	0.341
2-wheelers	CH4	MC/2S/Euro-2				0.582	0.581
2-wheelers	CH4	MC/2S/Euro-3					0.360
2-wheelers	CH4	MC/4S/<Euro-1	0.037	0.038	0.040	0.043	0.043
2-wheelers	CH4	MC/4S/Euro-1	0.033	0.033	0.033	0.033	0.033
2-wheelers	CH4	MC/4S/Euro-2				0.023	0.023
2-wheelers	CH4	MC/4S/Euro-3					0.013
2-wheelers	CH4	MP/ with cat	0.202	0.202	0.202	0.202	0.202
2-wheelers	CH4	MP/ without cat	0.263	0.263	0.263	0.263	0.263
2-wheelers	N2O	LMC/<Euro-1	0.0008	0.0008	0.0008	0.0008	0.0008
2-wheelers	N2O	LMC/Euro-1	0.0008	0.0008	0.0008	0.0008	0.0008
2-wheelers	N2O	LMC/Euro-2				0.0008	0.0008
2-wheelers	N2O	MC/2S/<Euro-1	0.0010	0.0010	0.0010	0.0010	0.0010
2-wheelers	N2O	MC/2S/Euro-1	0.0010	0.0010	0.0010	0.0010	0.0010
2-wheelers	N2O	MC/2S/Euro-2				0.0010	0.0010
2-wheelers	N2O	MC/2S/Euro-3					0.0010
2-wheelers	N2O	MC/4S/<Euro-1	0.0010	0.0010	0.0010	0.0010	0.0010
2-wheelers	N2O	MC/4S/Euro-1	0.0010	0.0010	0.0010	0.0010	0.0010
2-wheelers	N2O	MC/4S/Euro-2				0.0010	0.0010
2-wheelers	N2O	MC/4S/Euro-3					0.0010
2-wheelers	N2O	MP/ with cat	0.0008	0.0008	0.0008	0.0008	0.0008
2-wheelers	N2O	MP/ without cat	0.0008	0.0008	0.0008	0.0008	0.0008

More details concerning the N<sub>2</sub>O emission factors are given in the next table. The factors are taken from recent measurements by the Netherlands Organisation for Applied Scientific Research (Gense and Vermeulen 2002, 2002a; Riemersma et al. 2003). These factors are used for emission modelling in Switzerland. They are typically lower than the default values by IPCC. The vehicle fleet composition in the Netherlands is supposed to be very similar compared to Switzerland, which is one of the reasons why Switzerland uses these factors. Another reason is the year of measurement: The Dutch factors are newer than the ones by IPCC, therefore, vehicle with later emission technology may be modelled in a more representative way.

Table A - 21 N<sub>2</sub>O emission factors of passenger cars (PC), light duty vehicles (LDV), heavy duty vehicles (HDV) and two-wheelers (2-W). From Gense and Vermeulen (2002, 2002a); Riemersma et al. (2003).

Veh category	Fuel	Em. concept	urban	extra-urban	motorway
			N <sub>2</sub> O emission factor (mg/veh-km)		
PC/LDV	Gasoline	conventional	0	0	0
		Euro 0	21	13	8
		Euro 1	21	13	8
		Euro 2	13	4	2
		Euro 3	5	2	1
		Euro 4	2.5	1	0.5
	Diesel	conventional	0	0	0
		Euro 1	2	4	4
		Euro 2	4	6	6
		Euro 3	9	4	4
		Euro 4	9	4	4
HDV	Diesel	Euro 0	16.2	13.6	9.4
		Euro 1	16.2	13.6	9.4
		Euro 2	15.9	13.6	9.4
		Euro 3	8.4	7.8	5.9
		Euro 4	8.4	7.8	5.9
		Euro 5	8.4	7.8	5.9
2-W	2-stroke	conventional	1	1	1
		catalyst	1	1	1
	4-stroke	conventional	1	1	1
		catalyst	1	1	1

## Activity Data

Activity data for the emission model are the mileages of the vehicle categories per traffic situation. To that aim, three steps must be carried out.

1. Vehicle turnover: The vehicle fleet is built up for each year accounting for the stock changes. This vehicle turnover is modelled on the basis of new registrations and by applying survival probabilities. Trends in traffic volume per vehicle category, including structural changes (size distributions, shares of diesel vehicles) are then combined to draw the continual substitution of older technologies by new ones altering constantly the fleet composition or mileage by emission concepts in all vehicle categories (see following figure).
2. The total mileage is calculated by vehicle stock times specific mileage per vehicle and annum. The latter data are derived from household surveys and from specific odometer readings during vehicle inspections (ARE 2002).
3. Assignment of the mileage to the traffic situations for all vehicle categories. This step requires the adoption of the traffic model: Each road segment carries its mileage and its traffic, which allows the assignment sought.

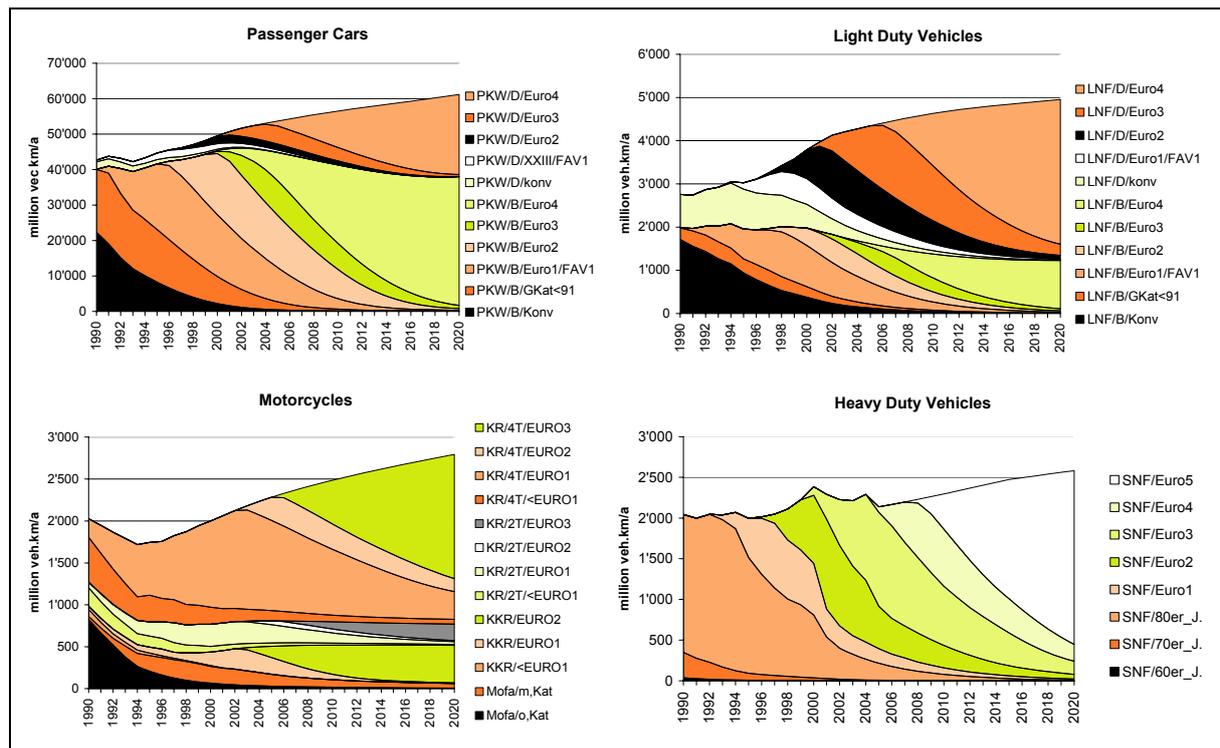


Figure A - 3 Mileage composition by emission concept (in million vehicle kilometres per year), SAEFL 2004.

### Modelling hot exhaust emissions

As a next step in the modelling process, the mileage classified by vehicle segments and traffic situations is multiplied with the emission factors resulting in hot exhaust emissions.

The results do not yet contain the emissions from tank tourism. For this purpose a special procedure is carried out (described in section 3.2.2c), providing the fuel consumption of tank tourism. From that, the emissions are calculated by multiplication with mean emission factors.

### Cold start and evaporative emissions

The handbook also contains emission factors for modelling cold start excess emissions and evaporative emissions (diurnal and hot/warm soak). For a technical description the reader may be referred to INFRAS (2004), SAEFL (1995, 2004).

Results show that for CO<sub>2</sub> the hot exhaust emissions contribute to 95% of the total. Only 5% stem from cold start excess emissions. For CH<sub>4</sub> however, the picture is much different. Only about a fourth of the emission total is hot exhaust. More than 50% are cold start excess emissions, the rest results evaporative emissions. For N<sub>2</sub>O, no cold start emissions nor evaporative emissions are taken into account due to lack of data.

### A3.1.5 Off-road Vehicles

#### Methodology

The emissions of the whole off-road sector have undergone a complete revision. The emissions are calculated with a Tier 2 method. Activity data and emission factors are being updated and the results for the emissions have been used for the current inventory. The modelling is carried out in a database that is structured in analogy to the on-road database (INFRAS 2008).

The modelling of the emission and of the fuel consumption are carried out by using the formula

$$E_{i,j,t,\tau}^g = N_{i,j,t} \cdot T_{i,j,t} \cdot \omega_{t-\tau} \cdot P_{i,j} \cdot L_{i,j} \cdot v_{t-\tau} \cdot \varepsilon_{i,j,\tau}^g$$

E: Emission and fuel consumption

N: number of vehicles

T: average operating hours per year

$\omega$ : age dependency

P: motor power in kW

L: load factor

v: degradation factor (due to aging)

$\varepsilon$ : emission factor in g/kWh

indices: g: gas (CH<sub>4</sub>, N<sub>2</sub>O, CO, NO<sub>x</sub>, SO<sub>2</sub>) and fuel consumption,  
i off-road family (railway, navigation etc.),  
j size class,  
t: year (1980, 1985, 1990, 1995, 2000, ... , 2020)  
 $\tau$ : year of construction (note: t -  $\tau$  = age of vehicle)

Note that the emissions are only calculated in steps of 5 years. Emissions for years in-between like 1991, 1992 etc. are interpolated linearly.

#### Emission and fuel consumption factors for off-road vehicles

The CO<sub>2</sub> emission factors are derived from fuel type and fuel consumption (see tables below). The emission factors for CH<sub>4</sub> and N<sub>2</sub>O are only specified by the fuel type.

Table A - 22 CH<sub>4</sub> and N<sub>2</sub>O emission factors (INFRAS 2008).

Gas	Diesel	Gasoline		CNG
		4-stroke	2-stroke	
mg/kWh				
CH <sub>4</sub>	6	500	4000	10'000/1'000
N <sub>2</sub> O	30	50	50	--

The values differ from default values (IPCC 1996, vol III, tbl 1-7, 1-8, conversion factor used: 1 g/kWh = 278 kg/TJ): For CH<sub>4</sub> IPCC recommends 18 mg/kWh for diesel oil, 72 mg/kWh for gasoline 4-stroke, 210 mg/kWh gasoline 2-stroke. For N<sub>2</sub>O IPCC gives 2 mg/kWh (diesel oil and gasoline 4-stroke) and 6 mg/kWh (gasoline 2-stroke).

Table A - 23 Emission and consumption factors for diesel engines (without ships and rail vehicles). PreEU-A etc. indicate emission standards.

Basic emission factors of diesel engines (g/kWh)					
power class	PreEU-A <1996	PreEU-B 1996	EU-I 2002/2003	EU-II 2003/2004	EU-III A 2007/2008
<b>Carbon monoxide (CO)</b>					
<18 kW	6.71	6.71	2.90	2.90	2.90
18-37 kW	6.71	6.71	2.76	2.42	2.06
37-75 kW	4.68	4.68	1.87	1.63	1.39
75-130 kW	3.62	3.62	1.28	1.01	0.86
>130 kW	3.62	3.62	1.04	0.91	0.77
<b>VOC</b>					
<18 kW	2.28	2.28	1.60	1.00	0.59
18-37 kW	2.41	2.41	0.92	0.56	0.37
37-75 kW	1.33	1.33	0.65	0.46	0.33
75-130 kW	0.91	0.91	0.45	0.35	0.28
>130 kW	0.91	0.91	0.43	0.3	0.22
<b>Nitrogen oxides (NOx)</b>					
<18 kW	10.31	8.2	5.95	5.95	5.95
18-37 kW	10.31	8.2	6.34	6.34	6.34
37-75 kW	12.4	9.87	8.95	6.56	3.90
75-130 kW	12.52	9.96	8.44	5.67	3.32
>130 kW	12.52	9.96	8.19	5.66	3.38
<b>Fuel consumption (FC)</b>					
<18 kW	248	248	248	248	248
18-37 kW	248	248	248	248	248
37-75 kW	248	248	248	248	248
75-130 kW	223	223	223	223	223
>130 kW	223	223	223	223	223

Table A - 24 Emission and consumption factors for gasoline 4-stroke engines. PreEU-A etc. indicate emission standards.

Basic emission factors of equipment with 4-stroke gasoline engines (g/kWh).					
power class	PreEU-A <1995	PreEU-B 1995	PreEU-C 2000	EU-I 2004	EU-II 2005/2007
<b>Carbon monoxide (CO)</b>					
<66 ccm	645	640	620	519	500
66-100 ccm	645	640	600	550	550
100-225 ccm	350	350	350	350	300
>225 ccm	350	350	350	350	350
<b>VOC</b>					
<66 ccm	260	250	150	45	45
66-100 ccm	260	250	150	35	35
100-225 ccm	20	20	20	12	12
>225 ccm	20	20	20	9	8
<b>Nitrogen oxides (NOx)</b>					
<66 ccm	1.5	2	3	5	5
66-100 ccm	1.5	2	3	5	5
100-225 ccm	3.5	3.5	3.5	3.5	3.5
>225 ccm	3.5	3.5	3.5	3.5	3.5
<b>Fuel consumption (FC)</b>					
<66 ccm	678	670	650	640	630
66-100 ccm	678	670	650	640	630
100-225 ccm	460	460	460	460	460
>225 ccm	460	460	460	460	460

Table A - 25 Emission and consumption factors for gasoline 2-stroke engines. PreEU-A etc. indicate emission standards.

<b>Basic emission factors of equipment with 2-stroke gasoline engines (g/kWh)</b>				
<b>gas/fuel consumption</b>	<b>PreEU-A &lt;1995</b>	<b>PreEU-B 1995</b>	<b>PreEU-C 2000</b>	<b>EU-I 2004</b>
<b>Carbon monoxide (CO)</b>	645	640	620	600
<b>VOC</b>	260	250	150	100
<b>Nitrogen oxides (NOx)</b>	1.5	2	3	5
<b>Fuel consumption (FC)</b>	678	670	650	640

Table A - 26 Emission and consumption factors for rail vehicles with diesel engines. PreEU etc. indicate emission standards.

<b>Basic emission factors of rail vehicles (g/kWh)</b>				
<b>power class</b>	<b>PreEU &lt;2000</b>	<b>UIC I 2000</b>	<b>UIC II 2003</b>	<b>EU IIIa 2007/2009</b>
<b>Carbon monoxide (CO)</b>				
<560 kW	3.1	3	2.5	3.5
>560 kW	4	4	3	3
<b>VOC</b>				
<560 kW	1.3	0.8	0.6	0.4
>560 kW	2.5	1.6	0.8	0.8
<b>Nitrogen oxides (NOx)</b>				
<560 kW	14.3	12	6	3.6
>560 kW	20	15	12	9.5
<b>Fuel consumption (FC)</b>				
<560 kW	285	283	283	283
>560 kW	285	285	283	283

Table A - 27 Emission and consumption factors for ships with diesel engines. PreSAV etc. indicate emission standards.

<b>Basic emission factors of diesel engine ships (g/kWh)</b>					
<b>power class</b>	<b>PreSAV &lt;1995</b>	<b>SAV I 1995</b>	<b>SAV II 1997</b>	<b>EU I 2005</b>	<b>EU II 2010</b>
<b>Carbon monoxide (CO)</b>					
<18 kW	5	5	5	2.3	2.3
18-37 kW	5	5	4	1.9	1.9
37-75 kW	5	5	2.2	1.7	2
75-130 kW	5	4.9	1.64	1.7	2
>130 kW	2	2	1.3	1	0.5
<b>VOC</b>					
<18 kW	10	10	10	5	5
18-37 kW	10	10	10	5	5
37-75 kW	10	10	10	5	5
75-130 kW	10	10	10	5	5
>130 kW	5	5	5	5	5
<b>Nitrogen oxides (NOx)</b>					
<18 kW	15	15	10	9.8	5
18-37 kW	15	15	10	9.8	5
37-75 kW	15	15	10	9.8	5
75-130 kW	15	15	10	9.8	5
>130 kW	15	15	10	6.5	4.5
<b>Fuel consumption (FC)</b>					
<18 kW	400	400	400	400	360
18-37 kW	400	380	380	380	360
37-75 kW	380	350	350	350	350
75-130 kW	400	330	330	330	330
>130 kW	300	300	300	300	300

Table A - 28 Emission and consumption factors for boats with diesel engines. PreSAV etc. indicate emission standards.

Basic emission factors of diesel engine boats (g/kWh)					
power class	PreSAV	SAV II	EU	PreSAV	SAV II
	<1995	1995	1997	2005	2010
<b>Carbon monoxide (CO)</b>					
<4.4 kW	5	5	5	2.6	2.6
4.4-7.4 kW	5	5	5	2.3	2.3
7.4-37 kW	5	5	4	1.9	1.9
37-74 kW	5	5	2.2	1.7	2
74-100 kW	5	4.9	1.64	1.7	2
>100 kW	2	2	1.3	1	0.5
<b>VOC</b>					
<100 kW	10	10	10	5	5
>100 kW	5	5	5	5	5
<b>Nitrogen oxides (NOx)</b>					
<100 kW	15	15	10	9.8	5
>100 kW	15	15	10	6.5	4.5
<b>Fuel consumption (FC)</b>					
<4.4 kW	400	400	400	400	360
4.4-7.4 kW	400	400	400	400	360
7.4-37 kW	400	380	380	380	360
37-74 kW	380	350	350	350	350
74-100 kW	400	330	330	330	330
>100 kW	300	300	300	300	300

Table A - 29 Emission and consumption factors for boats with gasoline engines. PreSAV etc. indicate emission standards.

Basic emission factors of gasoline engine boats (g/kWh)						
power class	2-stroke gasoline engine			4-stroke gasoline engine		
	PreSAV <1997	SAV II 1997	EU 2005	PreSAV <1997	SAV II 1997	EU 2005
<b>Carbon monoxide (CO)</b>						
<4.4 kW	650	300	300	300	162	162
4.4-7.4 kW	650	245	245	245	125	125
7.4-37 kW	650	128	128	256	107	107
37-74 kW				80	29.5	29.5
74-100 kW				64.3	21.9	21.9
>100 kW				120	40	40
<b>VOC</b>						
<4.4 kW	250	20	20	20	12	12
4.4-7.4 kW	250	17	17	17	9.3	9.3
7.4-37 kW	250	9.2	9.2	18.4	8	8
37-74 kW				6.1	2.2	2.2
74-100 kW				4.9	1.64	1.64
>100 kW				8.2	2.6	2.6
<b>Nitrogen oxides (NOx)</b>						
<4.4 kW	2	2	2	15	8	5
4.4-7.4 kW	2	2	2	15	7.6	5
7.4-37 kW	2	2	2	30	12.4	10
37-74 kW				15	5.1	5
74-100 kW				15	5.1	5
>100 kW				30	10	10
<b>Fuel consumption (FC)</b>						
<4.4 kW	700	400	400	400	500	500
4.4-7.4 kW	700	400	400	400	500	500
7.4-37 kW	650	380	380	760	980	940
37-74 kW				350	460	440
74-100 kW				330	450	430
>100 kW				600	840	840

Table A - 30 Emission and consumption factors (FC) for ships with steam engines (gas oil). steam 1 etc. indicate emission standards.

Basic emission factors of steam (gas oil) engine ships (g/kWh)							
pollutant	steam 1 <1950	steam 2 1950	steam 3 1980	steam 4 1990	steam 5 1995	steam 6 2005	steam 7 2005
CO	0.3	0.3	0.3	0.09	0.09	0.09	0.09
HC	0.45	0.45	0.45	0.33	0.33	0.33	0.33
NOx	2.34	2.34	2.34	1.77	1.56	1.26	1.03
PM	0.033	0.024	0.015	0.009	0.006	0.006	0.006
FC	1406	1012	787	703	703	703	703

### Activity data off-road vehicles

The activity data are described in detail in INFRAS (2008). Aggregated numbers are shown in the following tables.

Table A - 31 Number of vehicles per off-road family (INFRAS 2008)

Family	1990	1995	2000	2005	2010
	no. of vehicles				
Construction	56'070	52'443	47'995	47'354	45'849
Industry	13'947	18'372	22'748	22'748	22'599
Agriculture	324'567	324'047	337'869	339'948	342'230
Forestry	13'844	13'357	13'055	12'749	11'945
Garden/Hobby	659'828	719'118	779'052	763'881	748'708
Navigation	93'395	89'042	82'674	82'647	82'622
Railway	1'300	1'305	1'255	1'255	1'255
Military	1'340	1'340	1'340	1'340	1'340
<b>Sum</b>	<b>1'164'291</b>	<b>1'219'024</b>	<b>1'285'988</b>	<b>1'271'922</b>	<b>1'256'548</b>

Table A - 32 Operating hours per vehicle per year and (million) operating hours per off-road family (INFRAS 2008).

Family	1990	1995	2000	2005	2010
	operating hours per veh. per year				
Construction	299	353	383	386	387
Industry	628	648	660	660	660
Agriculture	119	118	112	108	104
Forestry	199	201	203	202	202
Garden/Hobby	22	25	27	27	27
Navigation	40	39	40	40	40
Railway	612	627	616	616	616
Military	51	53	54	52	49

Family	1990	1995	2000	2005	2010
	mio. of operating hours				
Construction	16.70	18.50	18.40	18.30	17.80
Industry	8.80	11.90	15.00	15.00	14.90
Agriculture	38.80	38.20	37.70	36.60	35.50
Forestry	2.80	2.70	2.60	2.60	2.40
Garden/Hobby	14.40	17.70	21.10	20.80	20.50
Navigation	3.70	3.50	3.30	3.30	3.30
Railway	0.80	0.82	0.77	0.77	0.77
Military	0.07	0.07	0.07	0.07	0.07
<b>Sum</b>	<b>86.00</b>	<b>93.40</b>	<b>99.00</b>	<b>97.40</b>	<b>95.20</b>

Table A - 33 Fuel consumption of several off-road activities in 1'000 t/a (INFRAS 2008).

Fuel	Family	1990	1995	2000	2005	2010
<b>Fuel consumption in 1000 t/a</b>						
Diesel	Construction	91.1	105.5	112.7	116.9	119.3
Diesel	Industry	33.5	40.6	47.7	48.3	46.6
Diesel	Agriculture	113.8	119.5	124.8	125.8	126.2
Diesel	Forestry	5.6	5.9	6.5	7.6	8.5
Diesel	Navigation	16.5	16.2	17.9	18.4	19.2
Diesel	Railway	9.1	10.3	10.6	11.3	12.0
Diesel	Military	1.1	1.1	1.2	1.1	1.1
<b>Diesel</b>	<b>Sum</b>	<b>270.7</b>	<b>299.2</b>	<b>321.5</b>	<b>329.5</b>	<b>332.8</b>
Gasoline	Construction	3.0	3.1	2.8	2.6	2.4
Gasoline	Industry	1.2	1.7	2.2	2.2	2.1
Gasoline	Agriculture	24.0	22.0	19.8	18.8	18.0
Gasoline	Forestry	3.4	3.2	3.1	2.3	1.9
Gasoline	Garden/Hobby	8.3	10.0	11.5	10.5	9.8
Gasoline	Navigation	16.5	15.4	14.5	14.3	14.3
Gasoline	Military	0.0	0.0	0.0	0.0	0.0
<b>Gasoline</b>	<b>Sum</b>	<b>56.4</b>	<b>55.4</b>	<b>53.7</b>	<b>50.6</b>	<b>48.5</b>
<b>Gas Oil</b>	<b>Navigation</b>	<b>2.6</b>	<b>3.3</b>	<b>3.5</b>	<b>3.8</b>	<b>3.8</b>
<b>CNG</b>	<b>Industry</b>	<b>3.4</b>	<b>5.1</b>	<b>6.8</b>	<b>6.8</b>	<b>6.9</b>

## A3.2 Industrial Processes

### Illustrative Example of modelling Mobile Air-Conditioning / Cars

Table A - 34 Model structure and assumptions for calculating emissions from mobile air conditioning in cars. Note that the **data is taken from 2003** for illustration purposes and does not correspond to current inventory data.

#### Parameters for Car Air-Conditioning

Emission Factor 1995	<b>8.5%</b>	[% of initial charge/a]	Emissions from servicing and disposal are calculated separately
share recharged regularly	<b>6.0%</b>	Note: To correlate the data with import statistics the recharged amount is calculated.	
share not recharged	<b>2.5%</b>	This information is used for verification through Tier 1b.	
<b>all units are imported with refrigerant charged</b>			
Product life	<b>12</b>	[a]	
initial charge 1995 [kg]	<b>0.81</b>	Initial charge 2000	<b>0.78</b> other years are inter-/extrapolated)
charge at end of lifetime	<b>60%</b>	[% of initial charge, as per literature]	
Disposal emissions	<b>100%</b>	up to 2004	
	<b>30%</b>	from 2005	
export of 2nd hand cars	<b>50%</b>		
Servicing emission factor	2 times	<b>10%</b>	of initial charge per lifetime
Market growth rate	<b>1%</b>		

#### Model for Car A/C emissions

Year	new registered cars		Disposed cars	A/C units new cars			Stock of A/C units		Disposed units R134	initial charge kg / car
	(VSAI, EFKO)	(B. f. Statistik)		Car-Input [%]	R134a [%]	Units R134	Stock [%]	units R134		
1989	335'094	2'895'842		5	0	0	0	0	0	0.85
1990	327'456	2'985'399	237'899	6	0	0	0	0	0	0.84
1991	314'824	3'057'800	242'423	7	10	2'204	0	2'204	0	0.83
1992	296'009	3'091'230	262'579	9	30	7'992	0	10'196	0	0.83
1993	262'814	3'109'524	244'520	14	66	24'284	1	34'480	0	0.82
1994	270'009	3'165'043	214'490	19	90	46'172	3	80'652	0	0.82
1995	272'897	3'229'169	208'771	24	100	65'495	5	146'147	0	0.81
1996	269'529	3'268'073	230'625	38	100	102'421	8	248'568	0	0.80
1997	272'441	3'323'421	217'093	52	100	141'669	12	390'237	0	0.80
1998	297'336	3'383'275	237'482	68	100	202'188	18	592'426	0	0.79
1999	317'985	3'467'275	233'985	75	100	238'489	24	830'914	0	0.79
2000	315'398	3'545'247	237'426	77	100	242'856	30	1'073'771	0	0.78
2001	317'126	3'629'713	232'660	85	100	269'557	37	1'343'328	0	0.78
2002	295'109	3'704'822	220'000	87	100	256'745	43	1'600'073	0	0.78
2003	271'541	3'754'000	222'363	89	100	241'671	49	1'840'188	1'557	0.78
2004	274'256	3'791'540	236'716	91	100	249'573	55	2'083'370	6'391	0.78
2005	276'999	3'829'455	239'084	92	100	254'839	60	2'316'117	22'091	0.78
2006	279'769	3'867'750	241'474	92	100	257'387	65	2'532'213	41'292	0.78
2007	282'567	3'906'427	243'889	93	100	262'787	70	2'736'466	58'533	0.78
2008	285'392	3'945'492	246'328	93	100	265'415	74	2'908'277	93'605	0.78
2009	288'246	3'984'947	248'791	94	100	270'951	77	3'049'857	129'371	0.78
2010	291'129	4'024'796	251'279	94	100	273'661	78	3'152'648	170'870	0.78

#### Modelling of car A/C refrigerants

R 134a	Input	Stock	Emissions			Import for
	[t]	[t]	Stock + Servicing	Disposal	Servicing	Servicing
	[t]	[t]	[t]	[t]	[t]	[t]
1990	0	0	0	0.0	0	0
1991	2	2	0	0.0	0	0.1
1992	7	8	0	0.0	0	0.3
1993	20	28	2	0.0	0	1.1
1994	38	64	4	0.0	0	2.8
1995	53	113	8	0.0	0	5.3
1996	82	188	13	0.0	1	9.0
1997	113	287	22	0.0	2	14.3
1998	160	425	34	0.0	4	21.4
1999	187	579	48	0.0	5	30.1
2000	189	720	63	0.0	8	39.0
2001	210	867	79	0.0	11	47.6
2002	200	989	95	0.0	16	55.7
<b>2003</b>	<b>189</b>	<b>1'082</b>	<b>107</b>	<b>0.8</b>	<b>19</b>	<b>62.1</b>
2004	195	1'169	115	3.2	19	67.5
2005	199	1'250	124	3.3	21	72.6
2006	201	1'324	129	6.1	20	77.2
2007	205	1'393	134	8.5	19	81.5
2008	207	1'458	141	13.5	19	85.5
2009	211	1'515	146	18.6	20	89.2
2010	213	1'563	151	24	20	92.3

## A3.3 Agriculture

### Livestock Population Data for N<sub>2</sub>O Emission Calculation

Table A - 35 Livestock population data 2007 for N<sub>2</sub>O calculation.

Animals 2007		Number of animals	kg N per head/year	FracGASM (6)	N volatilized (kg N)
<b>Cattle</b>		<b>1'571'764</b>			<b>31'800'603</b>
Mature dairy and mature non-dairy cattle (1)		708'340	107.5	0.33	24'892'973
Young cattle		863'424	30.4	0.26	6'907'630
	<i>Calves on milk and pre-weaned calves</i>	172'642	13	0.38	846'118
	<i>Breeding cattle 1st year</i>	223'261	25	0.23	1'267'006
	<i>Breeding cattle 2nd year</i>	210'491	40	0.23	1'911'258
	<i>Breeding cattle 3rd year</i>	109'072	55	0.23	1'361'764
	<i>Fattening calves</i>	33'874	8	0.38	102'164
	<i>Fattening cattle</i>	114'084	33	0.38	1'419'319
<b>Sheep</b>		<b>443'584</b>	<b>6.2</b>	<b>0.15</b>	<b>405'694</b>
	<i>Sheep places (4)</i>	229'985	12	0.15	405'694
<b>Goats</b>		<b>79'081</b>	<b>9.4</b>	<b>0.30</b>	<b>220'201</b>
	<i>Goat places (5)</i>	46'339	16	0.30	220'201
<b>Horses</b>		<b>57'720</b>	<b>42.4</b>	<b>0.33</b>	<b>800'053</b>
	<i>Pre-weaned foals</i>	2'950	17	0.33	16'399
	<i>Foals 1 year</i>	i.e.			
	<i>Foals 2 years</i>	i.e.			
	<i>Foals &lt; 3 years</i>	6'692	42	0.33	91'908
	<i>Horses 3 years</i>	i.e.			
	<i>Horses more than 4 years</i>	i.e.			
	<i>Breeding mares and studs</i>	i.e.			
	<i>Other horses</i>	48'078	44	0.33	691'746
<b>Mules and Asses</b>		<b>17'161</b>	<b>25</b>	<b>0.33</b>	<b>140'291</b>
	<i>Mules and asses &lt; 1 year</i>	i.e.			
	<i>Mules and asses &gt; 1 year</i>	i.e.			
<b>Swine</b>		<b>1'573'090</b>	<b>10.4</b>	<b>0.47</b>	<b>7'656'558</b>
	<i>Fattening pig places (2)</i>	877'136	13	0.47	5'325'091
	<i>Breeding pig places (3)</i>	142'641	35	0.47	2'331'467
<b>Poultry</b>		<b>8'221'444</b>	<b>0.5</b>	<b>0.51</b>	<b>2'077'236</b>
	<i>Young hens</i>	901'798	0.3	0.55	167'716
	<i>Laying hens</i>	2'197'685	0.7	0.55	853'515
	<i>Broilers</i>	5'002'357	0.4	0.49	974'459
	<i>Other poultry</i>	119'604	1.4	0.49	81'546
<b>Total</b>		<b>11'963'844</b>			<b>43'100'636</b>

(1) N excretion calculated based on milk production according to Walther et al. 1994 and FAL/RAC 2001.  
(2) One fattening pig place corresponds to one fattening pig over 25 kg, 1/6 fattening pig place to one young pig below 30 kg.  
(3) One breeding pig place corresponds to one sow, 1/2 breeding pig place to one boar.  
(4) One sheep place corresponds to one ewe over one year.  
(5) One goat place corresponds to one goat over 1.5 years.  
(6) Includes ammonia volatilization calculated for each species based on management practice and NO<sub>x</sub> emissions of 0.7% of the excreted N.

## Additional data for estimating enteric fermentation emission factors for cattle

Table A - 36 Data for estimating enteric fermentation emission factors for cattle. Reference: IPCC 1997c, p 4.31 – 4.33

Data for estimating enteric fermentation emission factors for cattle in Switzerland										
Type	Age <sup>a</sup>	Weight <sup>a</sup> kg	Weight Gain <sup>a</sup> kg/day	Feeding Situation / <sup>a</sup>	Milk <sup>b</sup> kg/day	Work hrs/day	Pregnant <sup>a</sup> %	Digestibility of CH <sub>4</sub> Conversion <sup>d</sup> Feed % <sup>d</sup>	Em. Factor kg/head/year <sup>e</sup>	
Mature dairy cattle	n.a.	650	0		13.5 – 15.8 <sup>c</sup>	0	305 days of lactation	60%	110.78	
Mature non-dairy cattle	n.a.	550	0		6.8 <sup>a</sup>	0	305 days of lactation	60%	80.71	
Calves on milk	0-98 days	60-200	1.43	Rations of unskimmed milk and supplement feed when life weight	0	0	0%	65%	0	
Pre-weaned calves	0-10 month	60-325	1	"Natura beef" production, milk from mother cow and additional feed.	0	0	0%	65%	21.93	
Breeding calves	0-4 month	50-120	0.8	Feeding plan for a dismission with 14 to 15 Weeks. Milk, feed concentrate (100kg in total), hay (80 kg in total).	0	0	0%	65%	10.58	
Breeding cattle 1	4-12 month	120-300	0.8	Premature race (Milk-race)	0	0	0%	60%	35.12	
Breeding cattle 2	12-28/30 month	300-600	0.8	Premature race (Milk-race)	0	0	0%	60%	50.79	
Fattening calves	0-4 month	70-175	0.86	Diet based on milk or milk-powder and feed concentrate, hay and/or silage.	0	0	0%	65%	21.87	
Fattening cattle	4-12 month	175-550	1.3	Feeding recommendations for fattening steers	0	0	0%	60%	49.03	

<sup>a</sup> data source: RAP 1999 and calculations according to Soliva 2006

<sup>b</sup> Milk production in kg/day is calculated by dividing the average annual milk production per head by 365 days.

<sup>c</sup> data source: Swiss farmers union (SBV 2008).

<sup>d</sup> data source: IPCC 1997c and IPCC 2000

<sup>e</sup> For better comparability emission factors of young cattle have been converted to kg/head/year although the time span of most of the individual categories is less than 365 days.

### Additional data for estimating manure management CH<sub>4</sub> emission factors

Table A - 37 Data for estimating manure management CH<sub>4</sub> emission factors. Reference: IPCC 1997c, Tables B-1-B-7.

Data for estimating Manure Management CH <sub>4</sub> emission factors in Switzerland							
Type	Weight kg <sup>a</sup>	Digestibility of Feed % <sup>b</sup>	Energy Intake MJ/day	Feed Intake kg/day	% Ash Dry Basis <sup>b</sup>	VS kg/head/day	B <sub>0</sub> m <sup>3</sup> CH <sub>4</sub> /kg VS <sup>b</sup>
Mature dairy cattle	650	60	260-282	15.07 <sup>c</sup>	8	5.17-5.62	0.24
Mature non-dairy cattle	550	60	205.09	10.96 <sup>c</sup>	8	4.09	0.24
Calves on milk	60 – 200	65	47.62	2.02 <sup>a</sup>	8	0.83	0.17
Pre-weaned calves	60 – 325	65	55.73	2.98 <sup>a</sup>	8	0.97	0.17
Breeding calves	50 – 120	65	26.88	1.5 <sup>a</sup>	8	0.47	0.17
Breeding cattle 1	120 – 300	60	89.24	4.88 <sup>a</sup>	8	1.78	0.17
Breeding cattle 2	300 – 600	60	129.07	7.78 <sup>a</sup>	8	2.57	0.17
Fattening calves	70 – 175	65	55.58	3.27 <sup>a</sup>	8	0.97	0.17
Fattening cattle	175 – 550	60	124.59	6.82 <sup>a</sup>	8	2.48	0.17
Sheep	Not determined	60	21-24	1.06-1.15 <sup>c</sup>	8	0.40 <sup>b</sup>	0.19
Goats	Not determined	60	29-35	1.08-1.13 <sup>c</sup>	8	0.28 <sup>b</sup>	0.17
Horses	Not determined	70	132-177	7.12-7.94 <sup>c</sup>	4	1.72 <sup>b</sup>	0.33
Mules and Asses	Not determined	70	85-165	Not estimated	4	0.94 <sup>b</sup>	0.33
Swine	Not determined	75	35-40	Not estimated	2	0.50 <sup>b</sup>	0.45
Poultry	Not determined	Not estimated	1.5-1.9	Not estimated	Not estimated	0.10 <sup>b</sup>	0.32

<sup>a</sup> RAP 1999  
<sup>b</sup> IPCC 1997c and IPCC 2000  
<sup>c</sup> FAL/RAC 2001

## Additional Data for N<sub>2</sub>O Emission Calculation of Agricultural Soils

Table A - 38 Additional data for N<sub>2</sub>O emission calculation of agricultural soils.

2007	Total crop production Crop(O) and Crop(BF) (kg DM)	Nitrogen incorporated with crop residues F(CR) (t N)	N <sub>2</sub> O emissions from crop residues (t N <sub>2</sub> O)	N fixed per kg crop (kg N/kg crop)	N fixed (kg N)	N <sub>2</sub> O emissions from N fixation (t N <sub>2</sub> O)
<b>1. Cereals</b>						
Wheat	455'260'000	3'392	67			
Barley	179'265'000	1'019	20			
Maize	153'765'000	1'289	25			
Oats	8'585'000	64	1			
Rye	8'585'000	70	1			
<i>Other (please specify)</i>						
Triticale	48'960'000	576	11			
Spelt	8'840'000	79	2			
Mix of fodder cereals	850'000	5	0			
Mix of bread cereals	170'000	1	0			
<b>2. Pulse</b>						
Dry bean	569'500	23	0	0.0443	29'648	0.6
Eiweisserbsen/peas	15'410'500	363	7	0.0330	598'290	11.8
Soybeans	2'550'000	106	2	0.0571	171'360	3.4
<i>Other (please specify)</i>						
Leguminous vegetables	2'820'420	289	6	0.0177	277'703	5.5
<b>3. Tuber and Root</b>						
Potatoes	107'800'000	469	9			
<i>Other (please specify)</i>						
Fodder beet	17'490'000	163	3			
Sugar beet	346'043'500	3'267	64			
<b>5. Other (please specify)</b>						
Grass	6'237'628'497	22'267	437	0.0051	31'638'570	621.5
Silage corn	1'954'700'000	341	7			
Green corn	332'299'000	49	1			
Fruit	56'012'382	224	4			
Vine	26'367'400	158	3			
Renewable energy crops	5'994'000	93	2			
Non-leguminous vegetables	59'541'600	930	18			
Sunflowers	10'965'000	232	5			
Tobacco	1'050'000	27	1			
Rape	50'850'000	791	16			
<b>Total Non-leguminous</b>	<b>3'833'392'882</b>	<b>13'240</b>	<b>260</b>		<b>0</b>	<b>0</b>
<b>Total Leguminous</b>	<b>21'350'420</b>	<b>780</b>	<b>15</b>		<b>1'077'000</b>	<b>21.2</b>
<b>Total excluding grass</b>	<b>3'854'743'302</b>	<b>14'020</b>	<b>275</b>		<b>1'077'000</b>	<b>21.2</b>
<b>Total including grass</b>	<b>10'092'371'799</b>	<b>36'286</b>	<b>713</b>		<b>32'715'571</b>	<b>642.6</b>

## **Annex 4: CO<sub>2</sub> Reference Approach and comparison with Sectoral Approach, and relevant information on the national energy balance**

No supplementary information to the statements given in Chapter 3.6 Comparison of Sectoral Approach with Reference Approach.

## **Annex 5: Assessment of completeness and (potential) sources and sinks of greenhouse gas emissions and removals excluded**

No supplementary information to the statements given in Chapter 1.8 Completeness Assessment.

## **Annex 6: Additional information to be considered as part of the NIR submission (where relevant) or other useful reference information**

No supplementary information.

## Annex 7: Supplementary Information to the Uncertainty Analysis

### A7.1 Uncertainty Evaluation Tier 1

The uncertainty analysis presented in this paragraph is based on the data of the present GHG inventory (FOEN 2009). Here, the Tier 1 estimated uncertainties are presented for emissions which are not CO<sub>2</sub> emissions from Fuel Combustion and which are not key categories.

Table A - 39 Estimated uncertainties for emissions which are not CO<sub>2</sub> emissions from Fuel Combustion and which are not key categories

IPCC Source Categories (and fuels if applicable)					Gas	Base year emissions 1990	Year 2007 emissions	estimated emission uncertainty for year 2007
						[Gg CO <sub>2</sub> eq]	[Gg CO <sub>2</sub> eq]	
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH <sub>4</sub>	0.54	0.60	30%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH <sub>4</sub>	0.49	0.33	30%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH <sub>4</sub>	0.10	0.36	30%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH <sub>4</sub>	0.36	0.43	30%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	C Gaseous Fuels	CH <sub>4</sub>	2.40	4.95	30%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	C Liquid Fuels	CH <sub>4</sub>	1.96	1.02	30%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	C Solid Fuels	CH <sub>4</sub>	0.55	0.29	30%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	C Biomass	CH <sub>4</sub>	2.95	5.22	30%
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH <sub>4</sub>	0.60	0.53	60%
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH <sub>4</sub>	0.24	0.22	60%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Diesel	CH <sub>4</sub>	1.49	1.01	60%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Biomass	CH <sub>4</sub>	0.00	0.02	60%
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation	(military aviation)	CH <sub>4</sub>	0.16	0.12	60%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Gaseous Fuels	CH <sub>4</sub>	2.35	3.79	30%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Liquid Fuels	CH <sub>4</sub>	2.54	0.96	30%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Biomass	CH <sub>4</sub>	8.14	13.01	30%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH <sub>4</sub>	3.26	5.06	30%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH <sub>4</sub>	5.83	2.27	30%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH <sub>4</sub>	3.83	2.36	30%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH <sub>4</sub>	52.32	42.76	30%
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/For	Gaseous Fuels	CH <sub>4</sub>	0.09	0.05	30%
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/For	Liquid Fuels	CH <sub>4</sub>	1.62	1.41	30%
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH <sub>4</sub>	1.23	1.14	30%
2A_o	2. Industrial Proc.	A. Mineral Products			CH <sub>4</sub>	0.94	0.65	30%
2B	2. Industrial Proc.	B. Chemical Industry			CH <sub>4</sub>	8.16	6.30	30%
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH <sub>4</sub>	10.00	10.00	60%
6B	6. Waste	B. Wastewater Handling			CH <sub>4</sub>	4.51	12.53	30%
6C	6. Waste	C. Waste Incineration			CH <sub>4</sub>	3.96	3.99	30%
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CO <sub>2</sub>	139.24	102.65	10%
2A_o	2. Industrial Proc.	A. Mineral Products without Cement Production	CO <sub>2</sub>		CO <sub>2</sub>	40.21	47.32	2%
2B	2. Industrial Proc.	B. Chemical Industry			CO <sub>2</sub>	13.60	15.21	10%
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production	CO <sub>2</sub>		CO <sub>2</sub>	139.26	NO	30%
2E	2. Industrial Proc.	E. Production of Halocarbons and SF <sub>6</sub>			CO <sub>2</sub>	0.00	0.00	40%
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> without 2F1-HFC & 2F8-SF <sub>6</sub>			CO <sub>2</sub>	0.00	0.00	10%
2G	2. Industrial Proc.	G. Other			CO <sub>2</sub>	1.04	0.44	10%
6A	6. Waste	A. Solid Waste Disposal on Land			CO <sub>2</sub>	9.13	0.06	10%
6C	6. Waste	C. Waste Incineration			CO <sub>2</sub>	52.87	15.25	10%
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> without 2F1-HFC			HFC	0.00	60.86	22%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N <sub>2</sub> O	0.13	0.15	80%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N <sub>2</sub> O	2.15	2.37	80%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N <sub>2</sub> O	0.25	0.85	80%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N <sub>2</sub> O	0.03	0.25	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	C Gaseous Fuels	N <sub>2</sub> O	0.60	1.22	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	C Liquid Fuels	N <sub>2</sub> O	9.45	6.76	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	C Solid Fuels	N <sub>2</sub> O	7.31	4.00	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	C Biomass	N <sub>2</sub> O	4.29	12.25	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and	C Other Fuels	N <sub>2</sub> O	34.26	25.52	80%
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N <sub>2</sub> O	1.62	1.74	150%
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N <sub>2</sub> O	2.46	1.35	150%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Diesel	N <sub>2</sub> O	8.41	31.93	150%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Gasoline	N <sub>2</sub> O	87.79	81.62	150%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Biomass	N <sub>2</sub> O	0.00	0.27	150%
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation	(military aviation)	N <sub>2</sub> O	1.97	1.13	150%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Gaseous Fuels	N <sub>2</sub> O	0.53	0.76	80%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Liquid Fuels	N <sub>2</sub> O	11.24	8.38	80%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Biomass	N <sub>2</sub> O	1.60	2.56	80%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N <sub>2</sub> O	0.79	1.21	80%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N <sub>2</sub> O	25.84	20.05	80%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N <sub>2</sub> O	0.30	0.19	80%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N <sub>2</sub> O	10.30	8.42	80%
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/For	Gaseous Fuels	N <sub>2</sub> O	0.02	0.01	80%
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/For	Liquid Fuels	N <sub>2</sub> O	4.96	5.27	80%
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N <sub>2</sub> O	5.13	6.67	80%
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		N <sub>2</sub> O	0.03	0.03	80%
3	3. Solvent and Other Product Use				N <sub>2</sub> O	110.14	53.72	80%
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N <sub>2</sub> O	3.91	3.91	150%
6C	6. Waste	C. Waste Incineration			N <sub>2</sub> O	14.69	30.75	80%
6D	6. Waste	D. Other			N <sub>2</sub> O	6.23	20.47	80%
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			PFC	0.00	0.00	20%
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production	PFC		PFC	100.17	NO	49%
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF <sub>6</sub>	0.00	62.14	20%
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> without 2F8-SF <sub>6</sub>			SF <sub>6</sub>	79.58	31.72	20%
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> ; Electrical Eq.			SF <sub>6</sub>	64.04	81.55	20%
<b>TOTAL</b>						<b>1'116.19</b>	<b>872.41</b>	<b>17%</b>

## **A7.2 Uncertainty Evaluation Tier 2 (Monte Carlo Simulation)**

Methods (Table A - 40 to Table A - 43) and results (Table A - 44 to Table A - 47) of the uncertainty analysis presented in this paragraph is based on the data of the **previous GHG inventory for 1990 and 2006** (FOEN 2008). Please note: The Tier 2 uncertainty analysis will not be updated every year.

The Monte Carlo Simulation includes all emission source categories, i.e. key categories **and** non-key categories. However, both groups were treated slightly differently for the simulation:

**Key categories:** For all categories for which information was available, the uncertainties of both activity data and emission factors are taken into account for the simulation. For all key categories, it was checked whether correlations with other categories exist (on the level of the activity data and/or the emission factor and/or the emissions).

**Non-key categories:** Only the uncertainty of the emissions is considered.

There were five non-key categories which contributed largely to the total level uncertainty of the inventory 2006 as published in FOEN (2008).

- 1A3b Road Transportation, diesel oil N<sub>2</sub>O;
- 1A3b Road Transportation, gasoline N<sub>2</sub>O;
- 2B Chemical Industry N<sub>2</sub>O;
- 3 Solvent and Other Product Use N<sub>2</sub>O;
- 4D2 Agricultural Soils: Pasture, Range and Paddock Manure, N<sub>2</sub>O.

The five categories are treated like key categories: If available, individual uncertainties are used and if correlations to key sources exist, they are implemented.

## Assumptions for probability distribution and correlations

Table A - 40 Probability distribution assigned to activity data, emission factors and emissions (1990 and 2006) of key categories and the non-key categories whose uncertainty contributes in a large extend to the total uncertainty. For the remaining categories, normal probability distributions have been assigned to the emission uncertainties.

IPCC Source Category	Fuel/ Specification	Gas	Probability Distribution		
			AD	EF	Emission
Key Categories:					
1A1 1. Energy Industries	Gaseous Fuels	CO2	normal	normal	---
1A1 1. Energy Industries	Liquid Fuels	CO2	normal	normal	---
1A1 1. Energy Industries	Other Fuels	CO2	normal	lognormal	---
1A1 1. Energy Industries	Solid Fuels	CO2	normal	normal	---
1A1 1. Energy Industries	Other Fuels	N2O	normal	normal	---
1A2 2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	normal	normal	---
1A2 2. Manufacturing Industries and Construction	Liquid Fuels	CO2	normal	normal	---
1A2 2. Manufacturing Industries and Construction	Other Fuels	CO2	normal	lognormal	---
1A2 2. Manufacturing Industries and Construction	Solid Fuels	CO2	normal	normal	---
1A3a 3. Transport; Civil Aviation		CO2	normal	normal	---
1A3b 3. Transport; Road Transportation	Diesel	CO2	normal	normal	---
1A3b 3. Transport; Road Transportation	Gasoline	CO2	normal	normal	---
1A3b 3. Transport; Road Transportation	Gasoline	CH4	normal	normal	---
1A3e 3. Transport; Other Transportation (military aviation)		CO2	normal	normal	---
1A4a 4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	normal	normal	---
1A4a 4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	normal	normal	---
1A4b 4. Other Sectors; Residential	Gaseous Fuels	CO2	normal	normal	---
1A4b 4. Other Sectors; Residential	Liquid Fuels	CO2	normal	normal	---
1A4c 4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	normal	normal	---
1A5 5. Other	Liquid Fuels	CO2	normal	normal	---
1A5 5. Other	Gaseous Fuels	CO2	normal	normal	---
1B2 2. Oil and Natural Gas		CH4	---	---	normal
2A1 A. Mineral Products; Cement Production-CO2		CO2	normal	normal	---
2C_o C. Metal Production without Aluminium Production		CO2	---	---	normal
2C3 C. Metal Production; Aluminium Production-CO2		CO2	normal	normal	---
2C3 C. Metal Production; Aluminium Production-PFC		PFC	---	---	normal
2F_o F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	---	---	normal
2F1 F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	---	---	normal
3 Solvent and Other Product Use		CO2	---	---	normal
4A A. Enteric Fermentation		CH4	---	---	normal
4B B. Manure Management		CH4	---	---	normal
4B B. Manure Management	liquid	N2O	normal	triangle	---
4B B. Manure Management	solid	N2O	normal	triangle	---
4D1 D. Agricultural Soils; Direct Soil Emissions	fertilizer	N2O	normal	normal	---
4D1 D. Agricultural Soils; Direct Soil Emissions	organic soil	N2O	normal	lognormal	---
4D3 D. Agricultural Soils; Indirect Emissions	deposition	N2O	normal	lognormal	---
4D3 D. Agricultural Soils; Indirect Emissions	leaching and runoff	N2O	normal	lognormal	---
6A A. Solid Waste Disposal on Land		CH4	---	---	normal
6B B. Wastewater Handling		N2O	---	---	normal
6D D. Other		CH4	---	---	normal
Non key categories whose uncertainty contributes in a large extend to the total uncertainty:					
1A3b 3. Transport; Road Transportation	Diesel	N2O	normal	lognormal	---
1A3b 3. Transport; Road Transportation	Gasoline	N2O	normal	lognormal	---
2B B. Chemical Industry		N2O	---	---	normal
3 Solvent and Other Product Use		N2O	---	---	normal
4D2 D. Agricultural Soils; Pasture, Range and Paddock Manure		N2O	normal	triangle	---

Table A - 41 Estimated correlation coefficients of activity data (for a better readability, categories without any correlations have been hidden)

Activity Data		Gas	11	12	13	19	20	25	26	32	33	34	35	36	37	41	42	43
1A3b	A. Fuel Combustion	Diesel	1															
1A3b	A. Fuel Combustion	Gasoline		1														
1A3b	A. Fuel Combustion	Gasoline			1													
1A4c	A. Fuel Combustion	Liquid Fuels	-0.5			1												
1A5	A. Fuel Combustion	Liquid Fuels	-0.5	-0.1	-0.1		1											
2C3	C. Metal Production; Aluminium Production-CO2							1										
2C3	C. Metal Production; Aluminium Production-PFC								1									
4B	B. Manure Management	liquid								1								
4B	B. Manure Management	solid								-1	1							
4D1	D. Agricultural Soils; Direct Soil Emissions	fertilizer								0.3	0.3	1						
4D1	D. Agricultural Soils; Direct Soil Emissions	organic soil										1						
4D3	D. Agricultural Soils; Indirect Emissions	deposition								0.2	0.2	0.7	1					
4D3	D. Agricultural Soils; Indirect Emissions	leaching and runoff								0.2	0.2	0.7	0.5	1				
1A3b	A. Fuel Combustion	Diesel	1													1		
1A3b	A. Fuel Combustion	Gasoline		1	-0.1													1
4D2	D. Agricultural Soils; Pasture, Range and Paddock Manure									0.5	0.5			0.3	0.3			



Table A - 43 Estimated correlation coefficients of emissions (for a better readability, categories without any correlations have been hidden).

Emissions							
IPCC Source Category		Gas	27	28	29	30	31
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC	HFC	27	1		
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	28	-0.5	1	
3	3. Solvent and Other Product Use		CO2	29		1	
4A	4. Agriculture	A. Enteric Fermentation	CH4	30			1
4B	4. Agriculture	B. Manure Management	CH4	31			0.5

In the modelling of the **trend uncertainty** note that

- the emission factors of each source are fully correlated ( $r = 1$ ) between 1990 and 2006.
- Also, the activity data of each source is positively correlated between 1990 and 2006 ( $r = 0.8$ ).
- For sources for which no separate emission factor and activity data is available, the emissions between 1990 and 2006 are correlated with  $r = 0.9$ .

### Derivation of Uncertainties for Sector 1A Energy

#### Notations

$V$  denotes the Variation coefficient,  $s$  the standard deviation,  $AD$  the mean activity data and  $U$  the relative uncertainty

$$V = \frac{s}{AD}, \quad (1)$$

$[AD] = [s] = 1 \text{ TJ/a}$ ; for normal distributions,

$$U = t_{95\%} \frac{s}{AD}; \quad t_{95\%} \approx 2 \quad (1a)$$

#### Activity Data

The total AD of each fuel type is derived based on the following key source categories

gaseous:  $AD_{1A}^g = AD_{1A1} + AD_{1A2} + AD_{1A4a} + AD_{1A4b} + AD_{1A5}$

liquid (stationary):  $AD_{1A}^{ls} = AD_{1A1} + AD_{1A2} + AD_{1A4a} + AD_{1A4b} + AD_{1A4c}$  (2)

liquid (mobile):  $AD_{1A}^{lm} = AD_{1A3a} + AD_{1A3b} + AD_{1A3e} + AD_{1A5}$

solid:  $AD_{1A}^s = AD_{1A1} + AD_{1A2}$

other fuels:  $AD_{1A}^o = AD_{1A1} + AD_{1A2}$

This approach applies only for key categories. Therefore, non-key categories like 1Ac Railways, 1A3d Navigation are excluded from these considerations. For non-key categories, semi-quantitative estimates of uncertainties were carried out (see Section 1.7.2).

#### Uncertainties

Uncertainties are set equal to twice the standard deviation. For the total activity data  $AD_{1A}$ , the following uncertainty values were found for Switzerland (import statistics):

$$U_{1A}^g = 2V_{1A}^g = 5\%, \quad U_{1A}^{ls} = U_{1A}^{lm} = 2V_{1A}^{ls} = 2V_{1A}^{lm} = 1.4\%, \quad U_{1A}^o = 2V_{1A}^o = 10\% \quad (3)$$

For sub-sector 1A1 Energy Industries the consumption is recorded by the industries owners. The uncertainties are therefore set equal to the uncertainties of the sector 1A Energy.

$$U_{1A1}^g = 5\%, \quad U_{1A1}^{ls} = U_{1A1}^{lm} = 1.4\%, \quad U_{1A1}^o = 10\% \quad (4)$$

The activity data (energy consumption) for the other sub-sectors are not known explicitly and have to be derived from the given uncertainties of 1A and some further adequate approach. To that aim, Dr. M.P.J. Pulles, TNO, Netherlands suggested (Pulles 2005), to set the standard deviation proportional to the activity data AD of the sub-sector:

$$s_i^{(f)} = \alpha^{(f)} \cdot AD_i, \quad (5)$$

$f = g, ls, lm, o$  (fuel type). The proportionality constants  $\alpha^{(f)}$  are independent of the sub-sector, assuming that the standard errors for all sub-sectors (other than 1A1) are equal. This may be considered as a first and simple approximation. The proportionality constants are by definition equal to the standard deviations of the sub-sectors and correspond to half of the uncertainties

$$\alpha^{(f)} = \frac{s_i^{(f)}}{AD_i^{(f)}} = \frac{s_{1A2}^{(f)}}{AD_{1A2}^{(f)}} = \frac{s_{1A4a}^{(f)}}{AD_{1A4a}^{(f)}} = \dots = V_i^{(f)} = \frac{1}{2} U_i^{(f)} \quad (6)$$

The constants  $\alpha^{(f)}$  can be determined using the formula for simple error propagation (Gauss)

$$s_{1A}^{(f)2} = s_{1A1}^{(f)2} + \sum_i s_i^{(f)2} = s_{1A1}^{(f)2} + \left(\alpha^{(f)}\right)^2 \cdot \sum_i AD_i^{(f)2} \quad (7)$$

With  $V_{1A1}^{(f)} = V_{1A}^{(f)}$  and Equation (6), Equation (7) can be rewritten as

$$\left(\alpha^{(f)}\right)^2 = \left(V_{1A}^{(f)}\right)^2 \cdot \frac{AD_{1A}^{(f)2} - AD_{1A1}^{(f)2}}{\sum_i AD_i^{(f)2}} \quad (8)$$

Applied to the fuel types

$$\begin{aligned} \left(\alpha^g\right)^2 &= \left(V_{1A}^g\right)^2 \cdot \frac{\left(AD_{1A}^g\right)^2 - AD_{1A1}^2}{AD_{1A2}^2 + AD_{1A4a}^2 + AD_{1A4b}^2 + AD_{1A5}^2} \\ \left(\alpha^{ls}\right)^2 &= \left(V_{1A}^{ls}\right)^2 \cdot \frac{\left(AD_{1A}^{ls}\right)^2 - AD_{1A1}^2}{AD_{1A2}^2 + AD_{1A4a}^2 + AD_{1A4b}^2 + AD_{1A4c}^2} \\ \left(\alpha^{lm}\right)^2 &= \left(V_{1A}^{lm}\right)^2 \cdot \frac{\left(AD_{1A}^{lm}\right)^2}{AD_{1A3a}^2 + AD_{1A3b}^2 + AD_{1A3e}^2 + AD_{1A5}^2} \\ \left(\alpha^s\right)^2 &= \left(V_{1A}^s\right)^2 \cdot \frac{\left(AD_{1A}^s\right)^2 - AD_{1A1}^2}{AD_{1A2}^2} \\ \left(\alpha^o\right)^2 &= \left(V_{1A}^o\right)^2 \cdot \frac{\left(AD_{1A}^o\right)^2 - AD_{1A2}^2}{AD_{1A2}^2} \end{aligned} \quad (9)$$

The uncertainties for sub-sectors other than 1A1 may then be derived from Equations (6) and (9). In our case, this yields (see Table A - 44 for input values)

$$U^g = 2\alpha^g = 0.090 = 9.0\%$$

$$U^{ls} = 2\alpha^{ls} = 0.017 = 1.7\%$$

$$U^{lm} = 2\alpha^{lm} = 0.014 = 1.4\%$$

$$U^s = 2\alpha^s = 0.035 = 3.5\%$$

$$U^o = 2\alpha^o = 0.440 = 44.0\%$$

(10)

Table A - 44 Activity data and uncertainties key categories in 1A Fuel Combustion due to the data of inventory submission in April 2008 (FOEN 2008).

Source category	Activity data AD 2006 (TJ)					Uncertainty of activity data $U$				
	gaseous	liquid (s)	liquid (m)	solid (s)	other	gaseous	liquid (s)	liquid (m)	solid(s)	other
1A Fuel Combustion	110'887	236'126	220'310	9'346	54'219	5.0%	1.0%	1.0%	5.7%	10.0%
1A1 En. Industries	5'843	14'949	---	1'995	48'900	5.0%	1.0%	---	5.7%	10.0%
<i>expansion factors</i>						<i>1.80</i>	<i>1.68</i>	<i>1.39</i>	<i>1.24</i>	<i>4.40</i>
1A2 Manufacturing Ind. + Construction	38'089	38'694	---	7'351	5'319	9.0%	1.7%	---	7.1%	44.0%
1A3a Civil Aviation	---	---	1'658	---	---	---	---	1.4%	---	---
1A3b Road Transportation, diesel	---	---	64'417	---	---	---	---	1.4%	---	---
1A3b Road Transportation, gasoline	---	---	144'611	---	---	---	---	1.4%	---	---
1A3e Military Aviation	---	---	1'672	---	---	---	---	1.4%	---	---
1A4a Other sectors Comm./Institutional	25'987	50'897	---	---	---	9.0%	1.7%	---	---	---
1A4b Other sectors Residential	40'649	124'415	---	---	---	9.0%	1.7%	---	---	---
1A4c Other sectors Agriculture	---	7'171	---	---	---	---	1.7%	---	---	---
1A5 Others (Off-road)	318	---	7'952	---	---	9.0%	---	1.4%	---	---

In Table A - 44, "expansion factors"  $\varepsilon^{(f)}$  are given. These factors are used to expand the uncertainties of the aggregated activity data to the uncertainties of the disaggregated activity data and are derived as follows

$$\varepsilon^{(f)} = \frac{U_{1A2}^{(f)}}{U_{1A}^{(f)}} = \frac{U_{1A4a}^{(f)}}{U_{1A}^{(f)}} = \frac{U_{1A4b}^{(f)}}{U_{1A}^{(f)}} \quad (11)$$

## Relation between simulated and inventory values

The Monte Carlo simulation simulates a probability distribution for which all relevant statistical parameters are determined: mean, standard deviation and percentiles. The simulated mean value may slightly differ from the reported CRF value. This occurs due to two reasons: Firstly, lognormal and asymmetric triangular distributions are applied to some categories and secondly, the number of simulations is restricted due to memory overflow. Note that it is not a relevant issue for the uncertainty analysis but may be confusing for readers and reviewers who carefully study the numbers. For transparency reasons, the numbers are explained in Table A - 45

The absolute percentiles generated by the simulation are expressed as relative numbers (the simulated mean is set to 100%). The relative numbers also hold for the emissions as reported in the CRF tables, and they are applied to derive the absolute uncertainties (see Table A - 45).

Table A - 45 Mean values, 2.5% and 97.5% percentiles of the Monte Carlo simulation and corresponding values of the CRF emissions.

Parameters	Unit	Emission (excl. LULUCF)	Lower bound 2.5 percentile	Upper bound 97.5 percentile	Lower uncertainty	Upper uncertainty
<b>simulated values</b>		<b>1990</b>				
absolute	Gg CO <sub>2</sub> eq	52'646	50'661	55'392	-1'985	2'746
relative	%	100.0%	96.2%	105.2%	-3.8%	5.2%
<b>values of CRF</b>						
absolute	Gg CO <sub>2</sub> eq	52'800	50'809	55'554	-1'991	2'754
relative	%	100.0%	96.2%	105.2%	-3.8%	5.2%
<b>simulated values</b>		<b>2006</b>				
absolute	Gg CO <sub>2</sub> eq	53'088	51'254	55'520	-1'834	2'432
relative	%	100.0%	96.5%	104.6%	-3.5%	4.6%
<b>values of CRF</b>						
absolute	Gg CO <sub>2</sub> eq	53'209	51'371	55'647	-1'838	2'438
relative	%	100.0%	96.5%	104.6%	-3.5%	4.6%

### Further Results of the Monte Carlo Uncertainty Analysis

In addition to the results presented in Table 1-15, Table A - 48 shows results for the uncertainties of the key categories. The uncertainty of the emission is only a Monte Carlo result if uncertainty numbers are given in the corresponding columns "uncertainty of activity data" and "uncertainty of emission factors" (e. g. source categories 1A, 2A, 2B, 4D1). In the other cases (2F, 4A etc.), the uncertainty of the emission is an input data for the Monte Carlo simulation.

Table A - 46 Activity data, emission factors, emissions and their corresponding uncertainties of key categories in Monte Carlo simulation (to be compared with Table 1-15) Year t refers to 2006.

IPPC Source Category	Gas	Activity Data year t (2006)	Uncertainty of activity data	Emission factor year t		Uncertainty of emission factor	Emissions year t (Gg CO2 equivalent)	Uncertainty of emissions
					%			
<b>1A A. Fuel Combustion</b>								
1A1 1. Energy Industries	Gaseous Fuels	5843	TJ	4.9	55	t/TJ	321	6.7
1A1 1. Energy Industries	Liquid Fuels	14949	TJ	1.0	61	t/TJ	912	1.1
1A1 1. Energy Industries	Other Fuels	48900	TJ	9.8	45	t/TJ	2181	31.0
1A1 1. Energy Industries	Solid Fuels	1995	TJ	5.6	94	t/TJ	188	7.4
1A1 1. Energy Industries	Other Fuels	48900	TJ	9.8	2	t/TJ	121	79.3
1A2 2. Manufacturing Industries and Construction	Gaseous Fuels	38089	TJ	8.8	55	t/TJ	2095	9.9
1A2 2. Manufacturing Industries and Construction	Liquid Fuels	38694	TJ	1.6	74	t/TJ	2864	1.7
1A2 2. Manufacturing Industries and Construction	Other Fuels	5319	TJ	43.2	58	t/TJ	307	52.8
1A2 2. Manufacturing Industries and Construction	Solid Fuels	7351	TJ	6.9	96	t/TJ	708	8.5
1A3a 3. Transport, Civil Aviation	CO2	1658	TJ	1.4	73	t/TJ	121	1.5
1A3b 3. Transport, Road Transportation	Diesel	64417	TJ	1.4	74	t/TJ	4741	1.5
1A3b 3. Transport, Road Transportation	Gasoline	144611	TJ	1.4	74	t/TJ	10687	1.5
1A3b 3. Transport, Road Transportation	Gasoline	144611	TJ	1.4	0	t/TJ	19	55.9
1A3e 3. Transport, Other Transportation (military aviation)	CO2	1672	TJ	1.4	73	t/TJ	122	1.5
1A4a 4. Other Sectors; Commercial/Institutional	Gaseous Fuels	25987	TJ	8.8	55	t/TJ	1429	9.9
1A4a 4. Other Sectors; Commercial/Institutional	Liquid Fuels	50897	TJ	1.6	74	t/TJ	3741	1.7
1A4b 4. Other Sectors; Residential	Gaseous Fuels	40649	TJ	1.6	55	t/TJ	2236	4.8
1A4b 4. Other Sectors; Residential	Liquid Fuels	124415	TJ	1.6	74	t/TJ	9145	1.7
1A4c 4. Other Sectors; Agriculture/Forestry	Liquid Fuels	7171	TJ	1.6	74	t/TJ	528	1.7
1A5 5. Other	Liquid Fuels	7952	TJ	1.4	74	t/TJ	586	1.5
1A5 5. Other	Gaseous Fuels	318	TJ	8.8	55	t/TJ	18	9.9
<b>1B B. Fugitive Emissions from Fuels</b>								
1B2 2. Oil and Natural Gas	CH4						174	49.0
<b>2 Industrial Processes</b>								
2A1 A. Mineral Products; Cement Production-CO2	CO2	3452	kt	2.0	1	t/t	1813	6.2
2C o C. Metal Production without Aluminium Production	CO2						177	39.2
2C3 C. Metal Production; Aluminium Production-CO2	CO2	12	kt	4.9	2	t/t	19	29.7
2C3 C. Metal Production; Aluminium Production-PFC	PFC						3	44.3
2F o F. Consumption of Halocarbons and SF6 without 2F1-HFC	HFC						69	37.2
2F1 F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC						549	18.0
3 Solvent and Other Product Use	CO2						186	49.0
<b>4 Agriculture</b>								
4A A. Enteric Fermentation	CH4						2303	18.3
4B B. Manure Management	CH4						502	54.5
4B B. Manure Management	N2O	74972190	kgN	28.9	0.00	kgN2O-N	37	50.6
4B B. Manure Management	liquid solid	37644454	kgN	28.9	0.02	kgN2O-N	367	57.3
4D1 D. Agricultural Soils; Direct Soil Emissions	N2O	187097570	kgN	11.1	0.01	kgN2O-N	1139	79.5
4D1 D. Agricultural Soils; Direct Soil Emissions	organic soil	17000	ha	28.8	8.00	kgN2O-N	66	88.1
4D3 D. Agricultural Soils; Indirect Emissions	N2O	48273714	kgN	40.6	0.01	kgN2O-N	235	101.1
4D3 D. Agricultural Soils; Indirect Emissions	leaching and run	36759583	kgN	21.6	0.03	kgN2O-N	448	294.9
<b>6 Waste</b>								
6A A. Solid Waste Disposal on Land	CH4						291	58.8
6B B. Wastewater Handling	N2O						212	98.0
6D D. Other	CH4						97	49.0
Other							1452.8	
Total							53209	4.02

Table A - 47 shows the results of the Tier 2 uncertainty calculation for all emission source categories, including non-key categories. The lower and the upper limit of the 95% confidence interval is given for each category, as well as the uncertainty introduced on the national total in 2006.

Table A - 47: Tier 2 Uncertainty calculation and reporting for all sources, including non-key categories. Year t refers to 2006.

A	IPPC Source Category	B	C	D	E	F	G
	Key Categories						
1A1	1. Energy	A. Fuel Combustion	235	321	93	107	0.040
1A1	1. Energy	A. Fuel Combustion	691	912	99	101	0.019
1A1	1. Energy	A. Fuel Combustion	1520	2181	72	134	1.270
1A1	1. Energy	A. Fuel Combustion	47	188	93	108	0.026
1A1	1. Energy	A. Fuel Combustion	48	121	21	180	0.181
1A2	1. Energy	A. Fuel Combustion	1063	2095	90	110	0.390
1A2	1. Energy	A. Fuel Combustion	3387	2864	98	102	0.094
1A2	1. Energy	A. Fuel Combustion	157	307	53	158	0.305
1A2	1. Energy	A. Fuel Combustion	1388	708	92	109	0.113
1A3a	1. Energy	A. Fuel Combustion	253	121	99	101	0.003
1A3b	1. Energy	A. Fuel Combustion	2624	4741	98.5	101.5	0.131
1A3b	1. Energy	A. Fuel Combustion	11363	10687	98.5	101.5	0.307
1A3b	1. Energy	A. Fuel Combustion	92	19	44	156	0.020
1A3e	1. Energy	A. Fuel Combustion	200	122	99	101	0.003
1A4a	1. Energy	A. Fuel Combustion	942	1429	90	110	0.266
1A4a	1. Energy	A. Fuel Combustion	4392	3741	98	102	0.121
1A4b	1. Energy	A. Fuel Combustion	1407	2236	95	105	0.202
1A4b	1. Energy	A. Fuel Combustion	10216	9145	98	102	0.297
1A4c	1. Energy	A. Fuel Combustion	553	528	99	102	0.017
1A5	1. Energy	A. Fuel Combustion	449	586	98	101	0.016
1A5	1. Energy	A. Fuel Combustion	9	18	90	110	0.003
1B2	1. Energy	B. Fugitive Emissions from Fuels	380	174	51	149	0.161
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO <sub>2</sub>	2525	1813	94	106	0.211
2C.o	2. Industrial Proc.	C. Metal Production without Aluminium Production	112	177	61	139	0.131
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO <sub>2</sub>	139	19	70	130	0.011
2F.o	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> without 2F1-HFC	100	3	56	144	0.002
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF <sub>6</sub> ; Refrig. & AC Eq.	0	69	63	137	0.048
3	3. Solvent and Other Product Use	A. Enteric Fermentation	357	186	51	149	0.171
4A	4. Agriculture	B. Manure Management	2475	2303	82	118	0.794
4B	4. Agriculture	B. Manure Management	557	502	45	155	0.514
4B	4. Agriculture	B. Manure Management	42	37	15	112	0.033
4B	4. Agriculture	B. Manure Management	406	367	38	150	0.386
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions	1324	1139	21	181	1.708
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions	66	66	24	193	0.106
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions	272	235	18	209	0.421
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions	546	448	8	482	1.995
6A	6. Waste	A. Solid Waste Disposal on Land	693	291	41	159	0.321
6B	6. Waste	B. Wastewater Handling	191	212	2	198	0.390
6D	6. Waste	D. Other	30	97	51	149	0.089
	Non Key Categories						
1A1	1. Energy	A. Fuel Combustion	1	1	71	129	0.000
1A1	1. Energy	A. Fuel Combustion	0	0	71	129	0.000
1A1	1. Energy	A. Fuel Combustion	0	0	71	129	0.000
1A1	1. Energy	A. Fuel Combustion	0	0	71	129	0.000
1A1	1. Energy	A. Fuel Combustion	0	0	22	178	0.000
1A1	1. Energy	A. Fuel Combustion	2	3	22	178	0.004

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1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0	1	22	178	0.001
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0	0	22	178	0.000
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CH4	2	5	71	129	0.003
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CH4	2	1	71	129	0.001
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CH4	1	1	129	129	0.000
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	CH4	3	4	71	129	0.002
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	N2O	1	1	22	178	0.002
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	N2O	10	8	22	178	0.011
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	N2O	7	4	22	178	0.005
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	N2O	2	2	22	178	0.005
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	N2O	34	22	22	178	0.033
1A3	0.1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	1	1	41	159	0.001
1A3	0.1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	2	2	-47	247	0.005
1A3a	1. Energy	A. Fuel Combustion	3. Transport: Civil Aviation		CH4	0	0	41	159	0.000
1A3a	1. Energy	A. Fuel Combustion	3. Transport: Civil Aviation		N2O	0	1	-47	247	0.003
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	CH4	1	1	41	159	0.001
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Diesel	N2O	8	28	22	297	0.073
1A3b	1. Energy	A. Fuel Combustion	3. Transport: Road Transportation	Gasoline	N2O	88	91	22	296	0.235
1A3c	1. Energy	A. Fuel Combustion	3. Transport: Railways		CO2	64	81	90	110	0.015
1A3c	1. Energy	A. Fuel Combustion	3. Transport: Railways		CO2	111	115	90	110	0.021
1A3e	1. Energy	A. Fuel Combustion	3. Transport: Other Transportation (military aviation)		CH4	0	0	41	159	0.000
1A3e	1. Energy	A. Fuel Combustion	3. Transport: Other Transportation (military aviation)		N2O	2	1	-47	247	0.003
1A4	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	CH4	2	4	71	129	0.002
1A4	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Liquid Fuels	CH4	3	1	71	129	0.001
1A4	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Biomass	CH4	8	18	71	129	0.010
1A4	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Gaseous Fuels	N2O	1	1	22	178	0.001
1A4	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Liquid Fuels	N2O	11	9	22	178	0.014
1A4	1. Energy	A. Fuel Combustion	4. Other Sectors: Commercial/Institutional	Biomass	N2O	2	3	22	178	0.005
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Solid Fuels	CO2	57	35	90	110	0.006
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Gaseous Fuels	CH4	3	5	71	129	0.003
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Liquid Fuels	CH4	6	3	71	129	0.001
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Solid Fuels	CH4	4	2	71	129	0.001
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Biomass	CH4	52	46	71	129	0.026
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Gaseous Fuels	N2O	1	1	22	178	0.002
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Liquid Fuels	N2O	26	23	22	178	0.034
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Solid Fuels	N2O	0	0	22	178	0.000
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors: Residential	Biomass	N2O	10	9	22	178	0.013
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Gaseous Fuels	CO2	40	15	98	102	0.001
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Gaseous Fuels	CH4	0	0	71	129	0.000
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	CH4	2	2	71	129	0.001
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Gaseous Fuels	N2O	0	0	22	178	0.000
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors: Agriculture/Forestry	Liquid Fuels	N2O	5	5	22	178	0.008
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	2	2	71	129	0.001
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	5	7	22	178	0.010
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CO2	139	110	90	110	0.020
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		N2O	0	0	22	178	0.000
2A	0.2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40	46	98	102	0.002
2A	0.2. Industrial Proc.	A. Mineral Products			CH4	1	1	71	129	0.000
2B	2. Industrial Proc.	B. Chemical Industry			CO2	14	15	90	110	0.003
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8	7	71	129	0.004
2C	0.2. Industrial Proc.	C. Metal Production without Aluminium Production			N2O	174	144	60	140	0.109
2C	0.2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	NA,NO	36	92	108	0.005
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6			PF6	0	0	-	-	0.000
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6			CO2	0	0	-	-	0.000
2F	0.2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PF6	0	53	85	115	0.015
2F	0.2. Industrial Proc.	F. Consumption of Halocarbons and SF6			SF6	80	42	78	122	0.017

(cont'd next page)

2F_o 2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F-1-HFC & 2F8-SF6	CO2	0	0	-	-	0.000
2F8 2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.	SF6	64	84	84	116	0.025
2G 2. Industrial Proc.	G. Other	CO2	1	3	90	110	0.001
3 3. Solvent and Other Product Use		N2O	110	53	22	178	0.078
4D2 4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure	N2O	200	157	25	160	0.200
4D4 4. Agriculture	D. Agricultural Soils; Sewage sludge and compost	N2O	0	21	22	178	0.031
4F 4. Agriculture	F. Field Burning of Agricultural Residues	CH4	10	10	41	159	0.011
4F 4. Agriculture	F. Field Burning of Agricultural Residues	N2O	4	4	-47	247	0.011
6A 6. Waste	A. Solid Waste Disposal on Land	CO2	9	0	90	110	0.000
6B 6. Waste	B. Wastewater Handling	CH4	29	33	71	129	0.018
6C 6. Waste	C. Waste Incineration	CO2	53	15	90	110	0.003
6C 6. Waste	C. Waste Incineration	CH4	4	4	71	129	0.002
6C 6. Waste	C. Waste Incineration	N2O	15	25	22	178	0.037
6D 6. Waste	D. Other	N2O	6	20	22	178	0.029
Total			52800	53209	96	104	4.02

\* Trend not calculated when base year emission = 0

Relative Percentile im Verhältnis zum Calculated Mean

(cont'd)

## Annex 8: Supplementary Information under Article 7, paragraph 1 of the Kyoto Protocol

Annex 8 responds to the requirements as set out in Decision 15/CMP.1 relating to the preparation of information required under Article 7 of the Kyoto Protocol. The structure of Annex 8 is based on the structure of Annex I to Decision 15/CMP.1.

### A8.1 Greenhouse gas inventory information

#### §5 Inclusion of Data for Activities under Article 3, Paragraphs 3 and 4 of the Kyoto Protocol

Switzerland submits for the first time the KP LULUCF Tables NIR-1, NIR-2, NIR-3 (cf. Table A - 51, Table A - 52 and Table A - 53) and Table 5(KP) (including subtables) for the years 2000 to 2007. Switzerland selected forest management as the only activity under Article 3, paragraph 4. An overview of GHG source and sink activities for the time series 2000 to 2007 is presented in Table A - 48.

Table A - 48 Overview on net CO<sub>2</sub> equivalent emissions (positive sign) and removals (negative sign) for activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol.

GREENHOUSE GAS SOURCE AND SINK A	Net CO <sub>2</sub> Equivalent emissions/removals (Gg CO <sub>2</sub> )							
	2000	2001	2002	2003	2004	2005	2006	2007
<b>A. Article 3.3 activities</b>	<b>18.78</b>	<b>29.63</b>	<b>46.96</b>	<b>8.99</b>	<b>-6.69</b>	<b>-17.10</b>	<b>26.80</b>	<b>8.66</b>
A.1. Afforestation and Reforestation	-50.22	-52.68	-55.15	-57.61	-60.07	-63.29	-65.69	-67.73
A.1.1. Units of land not harvested since the beginning of the commitment period	-50.22	-52.68	-55.15	-57.61	-60.07	-63.29	-65.69	-67.73
A.1.2. Units of land harvested since the beginning of the commitment period	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.2. Deforestation	69.00	82.31	102.11	66.60	53.38	46.19	92.49	76.39
<b>B. Article 3.4 activities</b>	<b>-372.83</b>	<b>-905.49</b>	<b>-738.39</b>	<b>-2695.34</b>	<b>-822.76</b>	<b>-338.06</b>	<b>-87.31</b>	<b>-1741.70</b>
B.1. Forest Management incl. Biom. Burning	-372.83	-905.49	-738.39	-2695.34	-822.76	-338.06	-87.31	-1741.70
- growth of LivBiom	-12950.12	-13946.89	-13492.10	-12610.33	-11748.55	-10901.07	-12234.35	-13409.85
- cut&Mortality	13830.08	14295.67	14144.82	11445.76	11065.46	11538.57	11999.80	12499.35
- dead wood pool	-1253.20	-1254.68	-1395.73	-1537.11	-139.90	-976.09	146.09	-833.84
- sum FM without Biom. Burning	-373.24	-905.91	-743.01	-2701.68	-822.99	-338.59	-88.45	-1744.34
B.2. Cropland Management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing Land Management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	NA	NA	NA	NA	NA	NA	NA	NA
<b>SUM Art. 3.3 and 3.4</b>	<b>-354.05</b>	<b>-875.86</b>	<b>-691.43</b>	<b>-2686.35</b>	<b>-829.45</b>	<b>-355.16</b>	<b>-60.51</b>	<b>-1733.04</b>

#### §6 General Information to be Reported for Activities under Article 3, Paragraph 3, and Any Elected Activities under Article 3, Paragraph 4

The supplementary information for Activities under Article 3, Paragraph 3 and Article 3, Paragraph 4 of the Kyoto Protocol is provided in accordance with Decision 15/CMP.1 and 17/CMP.1. Most of the information provided in §6-§9 is described in detail in Chapter 7.3 covering source category 5A (Forest Land) and in Switzerland's Initial Report under Article 7, Paragraph 4 of the Kyoto Protocol (FOEN 2006h).

#### Accounting Periodicity

Switzerland has chosen to account annually for emissions and removals from the LULUCF sector (FOEN 2006h, Sect. G).

#### Definition of Forest

The forest definition used under the Kyoto Protocol follows the definition applied for the national inventory report (Chapter 7.3.1) as it is defined in Switzerland's Initial Report (FOEN 2006h, Sect. E). The selected values are listed in KP LULUCF Table NIR1 (Table A - 51).

Some categories were excluded from the main category "Forest Land", although they can fulfill the requirements of the Swiss forest definition used under the Kyoto Protocol (see Chapter 7.2.4, Table 7-4). Those are mainly:

- Vineyards, Low-Stem Orchards, Tree nurseries, Copse and Orchards in the main category "Grassland";
- Cemeteries and public parks in the main category "Settlements".

### **Elected Activities under Article 3, Paragraph 4**

Switzerland has decided to account for Forest Management under the elective voluntary activities of Article 3, paragraph 4 of the Kyoto Protocol (FOEN 2006h, Sect. F). In accordance with the Annex to Decision 16/CMP.1, credits from Forest Management are capped in the first commitment period. For Switzerland the cap amounts to 1.83 Mt CO<sub>2</sub> (0.5 Mt C) per year, or 9.15 Mt CO<sub>2</sub> for the whole commitment period.

### **Swiss Definitions of Activities under Article 3, Paragraph 3 and Elected Activities under Article 3, Paragraph 4**

The Swiss definitions of afforestation, deforestation and forest management are published in Switzerland's Initial Report (see FOEN 2006h, Sect. E and F)

#### *Afforestation*

Afforestation is the conversion to forest of an area not fulfilling the definition of forest for a period of at least 50 years if the definition of forest in terms of minimum area (625 m<sup>2</sup>) is fulfilled, and the conversion is a direct human-induced activity.

#### *Deforestation*

Deforestation is the permanent conversion of areas fulfilling the definition of forest in terms of minimum forest area (625 m<sup>2</sup>) to areas not fulfilling the definition of forest as a consequence of direct human influence.

#### *Forest management*

Forest management includes all activities serving the purpose of fulfilling the Federal Law on Forests (Swiss Confederation 1991, Art. 1c), i.e. the obligation to conserve forests and to ensure forest functions - such as wood production, protection against natural hazards, preservation of biodiversity, purification of drinking water and maintenance of recreational value - in a sustainable manner.

### **Accounting Methodology**

#### *Reforestation*

Reforestation does not occur in Switzerland (FOEN 2006h, Sect. E).

#### *Afforestation*

In Switzerland, afforestations occur mostly on grasslands (see Table 7-7 in Chapter 7.2.5) where there is no litter, no dead wood and mostly a lower carbon stock level than in forests. Because an increase of carbon in these pools is expected (Chapter 7.3.2.h-i) we followed the Tier 1 approach in terms of IPCC good practice (IPCC 2003, Sect. 3.1.5) and report no changes in the litter, dead wood and soil carbon pool. Thus, for afforestations only changes in living biomass are reported.

#### *Deforestation*

Changes in all pools were considered after deforestation: living biomass, dead wood and litter are completely removed. Losses in soil carbon due to soil disturbance caused by deforestation are accounted for by reducing the soil carbon pool by 50%.

#### *Forest management*

Carbon stock change in living biomass: growth of living biomass is considered under Gains; cut and mortality reflect Losses. Further, net carbon stock change in dead wood is considered. In the litter and soil carbon pool, we applied the Tier 1 approach of the IPCC good practice guidance (IPCC 2003, Sect. 3.1.5) and report no changes.

### **§6a Information on How Inventory Methodologies Have Been Applied Taking into Account Any IPCC Good Practice Guidance**

Methodological issues and assumptions used for the reporting under the Kyoto Protocol Article 3, paragraphs 3 and 4 of the Kyoto Protocol, follow the IPCC good practice guidance and are described in Switzerland's National Inventory Report (Chapter 7.3.2).

The inventory datasets on which the calculations are based (Swiss Land Use Statistics AREA and National Forest Inventory NFI) are described in Chapters 7.2.2 and 7.3.2, respectively.

### **§6b Geographical Location of the Boundaries**

The change in area between the activities under Article 3, paragraph 3 and Article 3, paragraph 4 is listed in KP LULUCF Table NIR2 (Table A - 52).

#### *Units of Land Subject to Activities under Article 3, Paragraph 3*

All afforestations and deforestations are accounted for under Article 3, paragraph 3 and are not considered under "forest management" under Article 3, paragraph 4.

#### *Land Subject to Elected Activities under Article 3, Paragraph 4*

Since all forests in Switzerland are subject to forest management, the area of managed forest corresponds to the forest area derived from the Swiss Land Use Statistics (AREA) of the Swiss Federal Statistical Office (see FOEN 2006h, Sect. E).

Forest areas under forest management are subdivided into forests usable for wood production (productive forests) and forests not usable for wood production (unproductive forests).

Productive forests in Switzerland reveal a high heterogeneity in terms of elevation, growth conditions, tree species composition, and inter-annual growth variability (see Chapter 7.2.3, Figure 7-4). We therefore stratified Switzerland into the five NFI production regions (L1: Jura, L2: Central Plateau, L3: Pre-Alps, L4: Alps, L5: Southern Alps) and 3 altitudinal zones (Z1: <601 m, Z2: 601-1200 m, Z3: >1200 m). In the voluntary submission of the KP LULUCF tables 2009, this stratification of the activity data is indicated in the column "Subdivision".

### **§6c Spatial Assessment Unit Used for Determining the Area of Accounting for Afforestation, Reforestation and Deforestation**

The spatial assessment unit for the voluntary submission of the KP LULUCF tables 2009 covers the entire territory of Switzerland. The methodology used to develop the land transition matrix is described in detail in Chapter 7.2.5.

#### *Afforestation*

Activity data for afforestations are derived from the Swiss Land Use Statistics (AREA) of the Swiss Federal Statistical Office (SFSO 2008) (see also Chapter 7.2.2). AREA provides a regular sample grid over the whole of Switzerland with a grid size of 100 m. Therefore, the spatial assessment unit for the voluntary submission of the KP LULUCF tables 2009 covers the entire territory of Switzerland. The reference area for each sample plot is 50 x 50 m. In case of inhomogeneous land cover, the reference area is reduced.

Natural forest regeneration due to abandonment of land, mainly occurring in the Alpine area, is not considered to be a direct human-induced activity. Only afforestations which can clearly be attributed as direct human-induced from aerial photographs are considered as afforestation.

#### *Deforestation*

Values for deforestations are derived from the Swiss Statistics of Deforestation (FOEN 2009b, and additional data from former editions 1985-2008), a deforestation database constructed and updated at the Federal Office for the Environment. Precise data on deforestations are available in units of m<sup>2</sup>. Only deforestations with an area larger than 625 m<sup>2</sup> are considered (see definition of deforestation above).

*Reforestation*

Reforestation does not occur in Switzerland (FOEN 2006h, Sect. E).

**§6d Information on Anthropogenic Greenhouse Gas Emissions**

Temporary data on greenhouse gas emissions from 2000 to 2007 are listed in the voluntary submission 2009 of the KP LULUCF table 5(KP). Activity data of afforestations, deforestations and managed forests are listed in Table A - 49. Total Swiss area remains constant and amounts 4128.42 kha.

**§6e Information on Which Pools Were not Accounted for**

KP LULUCF Table NIR1 (Table A - 51) summarizes the activity coverage.

*Change in Carbon Pool Reported*

When using the conservative Tier 1 approach (IPCC 2003, Sect. 3.1.5) assuming a specific carbon pool to be in carbon balance, the carbon pool is indicated as reported (R).

- The pool “above ground biomass” always reflects the total living biomass, which was calculated by applying the BCEF factor (see Chapter 7.3.2.c). Since we cannot separate the above and below ground biomass carbon pool, below ground biomass is included in the above ground biomass pool and therefore always marked with “include elsewhere” (IE).
- Changes in the dead organic matter pool only reflect changes in dead wood.
- Switzerland follows the Tier 1 approach in terms of IPCC good practice (IPCC 2003, Sect. 3.1.5) and report no changes in soil carbon pool. As argued in Chapter 7.3.2.i, forest soils in Switzerland are assumed to be a carbon sink. Changes in litter (L, F, H horizon) are included in the soil carbon pool. Currently, it is being clarified how temporal changes of soil carbon and litter can be quantified. It is planned to report better estimates for the inventory year 2008 in the 2010 submission of the GHG inventory.

*Greenhouse Gas Sources Reported*

- Fertilization of forests is prohibited by the Swiss forest law and adherent ordinances (Swiss Confederation 1991, 1992). Thus, emissions from fertilization are not occurring.
- Drainage of forests is not a permitted practice in Switzerland and is thus not occurring.
- Disturbance associated with land-use conversion to croplands: deforestation of forest for conversion into cropland is prohibited by Swiss forest law and adherent ordinances (Swiss Confederation 1991, 1992) and thus does not occur.
- Biomass burning: emissions of CH<sub>4</sub> and N<sub>2</sub>O are reported; CO<sub>2</sub> emissions are included implicitly in the NFI data. The calculation of these emissions is described in Chapter 7.3.2.n.

**§7 Information on Factoring Out Anthropogenic Greenhouse Gas Emissions from LULUCF Activities**

No anthropogenic greenhouse gas emissions and removals resulting from LULUCF activities under Article 3, paragraph 3 and 4 have been factored out.

**§8 Specific Information for Activities under Article 3, Paragraph 3**

For more than 100 years, the area of forest in Switzerland has been increasing, and a decrease in forest area as a result of deforestation is prohibited by the Federal Law on Forests (Swiss Confederation 1991). Therefore, reforestation of areas not forested for a period of at least 50 years does not occur in Switzerland (FOEN 2006h, Sect. E). Switzerland only has to consider afforestation and deforestation under Article 3, paragraph 3.

**§8a Information that Demonstrates that Activities under Article 3, Paragraph 3, Began on or After 1 January 1990 and Before 31 December of the Last Year of the Commitment Period, and Are Directly Human-Induced**

The Swiss definitions of afforestation and deforestation only consider directly human-induced activities (see FOEN 2006h, Sect. E).

#### *Afforestation*

The annual rate of afforestation since 1990 is assessed by AREA (Chapter 7.2.2). For reporting under the Kyoto Protocol, afforested areas always remain in the "afforestation" category. Therefore, the area of afforestations is increasing since 1990 (see Table A - 49).

#### *Deforestation*

In Switzerland, human-induced deforestation is subject to authorization (Swiss Confederation 1991, Art. 5). Approved deforestations are retrieved from the Swiss Statistics of Deforestation (FOEN 2009b, and additional data from former editions 1985-2008), a database managed at the Federal Office for the Environment. This database contains detailed information on all units of lands deforested in Switzerland in one specific year: coordinates and area of the forest, reason for deforestation, compensation measures and some additional remarks. From this database information can be found on when the deforestation was approved and carried out. Only deforestations carried out after 1 January 1990 are considered.

### **§8b Information on How Harvesting or Forest Disturbance that is Followed by the Re-establishment of a Forest is Distinguished from Deforestation**

The Swiss definition for deforestation only covers permanent conversions from forest land into non-forest land and thus implicitly distinguishes between permanent conversions and transient situations like harvesting or forest disturbance. Construction of pipelines and power supply lines in a forest area requires an authorization for deforestation. Authorizations include the obligation to regenerate the forest area within a few years. Therefore, these areas do not fulfill the definition of deforestation and the loss of growing stock is accounted for under Article 3, paragraph 4 of the Kyoto Protocol.

### **§8c Information on Emissions and Removals of Greenhouse Gases from Lands Harvested During the First Commitment Period Following Afforestation and Reforestation on These Units of Land Since 1990**

Afforestations since 1990 were not subject to harvesting or clear cutting, since there are no forests with such short rotation lengths.

### **§9a Demonstration that Activities under Article 3, Paragraph 4, Have Occurred Since 1 January 1990 and are Human-Induced**

According to the Swiss Federal Law on Forests, the extent and the spatial distribution of the total forest area in Switzerland has to be preserved (Swiss Confederation 1991, Art. 1) and thus, any change of the forested area has to be authorized. All Swiss forests are under continuous observation of the Swiss Forest Service. Therefore, all forests in Switzerland are subject to forest management (FOEN 2006h, Sect. F).

**§9b** not applicable

### **§9c Information that Demonstrates that Emissions by Sources and Removals by Sinks Resulting from Elected Article 3, Paragraph 4, Activities are not Accounted for under Activities under Article 3, Paragraph 3**

Yearly values of the managed forest area and of afforestations are derived from the Swiss Land Use Statistics (AREA) of the Swiss Federal Statistical Office (SFSO 2006a). Values for deforestations are derived from the Swiss Statistics of Deforestation (FOEN 2009b, and additional data from former editions 1985-2008). The available datasets for Switzerland allow to clearly separate between the land areas subject to a specific activity. Absolute and cumulated activity data are shown in Table A - 49.

Table A - 49 Activity data under Article 3, paragraphs 3 and 4. Deforestation data are found in the Swiss Statistics of Deforestation (FOEN 2009b, and additional data from former editions 1985-2008); afforestation data are derived from the Swiss Land Use Statistics (AREA) of the Swiss Federal Statistical Office (SFSO 2006a).

Year	Deforested area [kha]	Cumulated deforested area since 1990 [kha]	Afforested area [kha]	Cumulated afforested area since 1990 [kha]	Swiss managed forest [kha]
1990	0.080	0.080	0.336	0.336	1234.748
1991	0.101	0.181	0.321	0.658	1236.927
1992	0.108	0.289	0.320	0.978	1239.107
1993	0.123	0.412	0.216	1.195	1240.690
1994	0.138	0.549	0.130	1.325	1242.059
1995	0.148	0.697	0.086	1.410	1243.289
1996	0.122	0.819	0.086	1.500	1244.520
1997	0.126	0.945	0.086	1.582	1245.751
1998	0.167	1.112	0.086	1.668	1246.982
1999	0.140	1.252	0.086	1.753	1248.213
2000	0.100	1.352	0.086	1.839	1249.444
2001	0.121	1.473	0.086	1.924	1250.675
2002	0.148	1.621	0.086	2.010	1251.906
2003	0.098	1.719	0.086	2.096	1253.137
2004	0.079	1.797	0.086	2.181	1254.368
2005	0.067	1.864	0.097	2.278	1255.327
2006	0.143	2.007	0.076	2.354	1256.235
2007	0.115	2.122	0.066	2.420	1257.139

### §9d Information that Indicates to What Extent the Anthropogenic Greenhouse Gas Removal by Sinks Offsets the Debit Incurred under Article 3, Paragraph 3

In accordance with the Annex to Decision 16/CMP.1, credits from Forest Management are capped in the first commitment period. For Switzerland the cap amounts 1.83 Mt CO<sub>2</sub> (0.5 Mt C) per year, or 9.15 Mt CO<sub>2</sub> for the whole commitment period.

In accordance with the requirements under paragraph 10 of the annex to Decision 16/CMP.1, Switzerland can account for anthropogenic greenhouse gas emissions by sources and removals by sinks in areas under forest management under Article 3, paragraph 4, up to a level that is equal to the net source of emissions under the provisions of Article 3, paragraph 3 if the total anthropogenic greenhouse gas emissions by sources and removals by sinks in the managed forest since 1990 is equal to, or larger than, the net source of emissions incurred under Article 3, paragraph 3.

Table A - 50 summarizes the accounting quantities for activities under Article 3, paragraphs 3 and 4.

Table A - 50 Calculation of accounting quantities (Gg CO<sub>2</sub>) for activities under Article 3, paragraphs 3 and 4.

Greenhouse gas source and sink activities	Net emissions/removals (Gg CO <sub>2</sub> )					
	2007	2008	2009	2010	2011	2012
<b>Article 3.3 activities</b>						
Afforestation & Reforestation	-67.73	NA	NA	NA	NA	NA
Deforestation	76.39	NA	NA	NA	NA	NA
<b>Article 3.4 activities</b>						
Forest Management	-1741.70	NA	NA	NA	NA	NA
FM cap	-1830.00	NA	NA	NA	NA	NA
<b>Article 3.3 and 3.4 activities</b>						
Debit incurred under Article 3.3 (3.3 offset; max 9.15 Mt CO <sub>2</sub> yr <sup>-1</sup> )	8.66	NA	NA	NA	NA	NA
Unexhausted reserve from FM cap	-88.30	NA	NA	NA	NA	NA
Unexhausted reserve from FM cap and 3.3 offset	-96.96	NA	NA	NA	NA	NA

## Additional Information: KP LULUCF Tables NIR1, NIR2, and NIR3

Table A - 51 Table NIR1 – Summary Table.

Switzerland  
2007  
2009TABLE NIR 1. SUMMARY TABLE  
Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4

Activity	Change in carbon pool reported <sup>(1)</sup>					Greenhouse gas sources reported <sup>(2)</sup>							
	Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization <sup>(3)</sup>	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning <sup>(4)</sup>			
						N <sub>2</sub> O	N <sub>2</sub> O	N <sub>2</sub> O	CO <sub>2</sub>	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	
Article 3.3 activities													
Afforestation and Reforestation	R	IE	R	NO	R	NO			NO	NO	NO	NO	NO
Deforestation	R	IE	R	R	R			NO	NO	NO	NO	NO	NO
Forest Management	R	IE	R	R	R	NO	NO		NO	IE	R	R	R
Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA	NA
Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA	NA
Revegetation	NA	NA	NA	NA	NA				NA	NA	NA	NA	NA

<sup>(1)</sup> Indicate R (reported), NR (not reported), IE (included elsewhere) or NO (not occurring), for each relevant activity under Article 3.3 or elected activity under Article 3.4. If changes in a carbon pool are not reported, it must be demonstrated in the NIR that this pool is not a net source of greenhouse gases. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

<sup>(2)</sup> Indicate R (reported), NE (not estimated), IE (included elsewhere) or NO (not occurring) for greenhouse gas sources reported, for each relevant activity under Article 3.3 or elected activity under Article 3.4. Indicate NA (not applicable) for each activity that is not elected under Article 3.4. Explanation about the use of notation keys should be provided in the text.

<sup>(3)</sup> N<sub>2</sub>O emissions from fertilization for Cropland Management, Grazing Land Management and Revegetation should be reported in the Agriculture sector. If a Party is not able to separate fertilizer applied to Forest Land from Agriculture, it may report all N<sub>2</sub>O emissions from fertilization in the Agriculture sector.

<sup>(4)</sup> If CO<sub>2</sub> emissions from biomass burning are not already included under changes in carbon stocks, they should be reported under biomass burning; this also includes the carbon component of CH<sub>4</sub>. Parties that include CO<sub>2</sub> emissions from biomass burning in their carbon stock change estimates should report IE (included elsewhere).

Table NIR 1.1 Additional information  
Selection of parameters for defining "Forest" under the Kyoto Protocol

Parameter	Range	Selected value
Minimum land area	0.05 - 1 ha	0.0625 ha
Minimum crown cover	10 - 30 %	20 %
Minimum height	2 - 5 m	3 m

Table A - 52 Table NIR2 – Land Transition Matrix.

Switzerland  
2007  
2009Table NIR 2. LAND TRANSITION MATRIX  
Area change between the previous and the current inventory year<sup>(1),(2),(3)</sup>

FROM...	TO...		Article 3.3 activities		Article 3.4 activities (kha)				Other	Total
	Afforestation and reforestation	Deforestation	Forest Management (if elected)	Deforestation	Forest Management (if elected)	Cropland Management (if elected)	Grazing Land Management (if elected)	Revegetation (if elected)		
Article 3.3 activities	2.35	NO		NO						2.35
Deforestation		2.01		2.01						2.01
Forest Management (if elected)		0.11	1256.12	0.11						1256.24
Article 3.4 activities	NA	NA		NA	NA	NA	NA	NA		0.00
Cropland Management <sup>(4)</sup> (if elected)	NA	NA		NA	NA	NA	NA	NA		0.00
Grazing Land Management <sup>(4)</sup> (if elected)	NA	NA		NA	NA	NA	NA	NA		0.00
Revegetation <sup>(4)</sup> (if elected)	0.07	NO	1.02	NO					2866.74	2867.82
Other									2866.74	2866.74
Total area	2.42	2.12	1257.14	2.12	0.00	0.00	0.00	0.00	2866.74	4128.42

(1) This table should be used to report land area and changes in land area subject to the various activities in the inventory year. For each activity it should be used to report area change between the previous year and the current inventory year. For example, the total area of land subject to Forest Management in the year preceding the inventory year, and which was deforested in the inventory year, should be reported in the cell in column B and in the row of Forest Management.

(2) Some of the transitions in the matrix are not possible and the cells concerned have been shaded.

(3) In accordance with section 4.2.3.2 of the IPCC good practice guidance for LULUCF, the value of the reported area subject to the various activities under Article 3.3 and 3.4 for the inventory year should be that on 31 December of that year.

(4) Lands subject to Cropland Management, Grazing Land Management or Revegetation which, after 2008, are subject to activities other than those under Article 3.3 and 3.4, should still be tracked and reported under Cropland Management, Grazing Land Management or Revegetation, respectively.

Table A - 53 Table NIR3 – Summary Overview for Key Categories for LULUCF Activities under the KP.

TABLE NIR 3. SUMMARY OVERVIEW FOR KEY CATEGORIES FOR LAND USE, LAND USE CHANGE AND FORESTRY ACTIVITIES UNDER THE KYOTO PROTOCOL

Switzerland  
2007  
2009

KEY CATEGORIES OF EMISSIONS AND REMOVALS	GAS	CRITERIA USED FOR KEY CATEGORY IDENTIFICATION			COMMENTS <sup>(3)</sup>
		Associated category in UNFCCC inventory <sup>(1)</sup> is key (indicate which category)	Category contribution is greater than the smallest category considered key in the UNFCCC inventory <sup>(1)</sup> (including LULUCF)	Other <sup>(2)</sup>	
Specify key categories according to the national level of disaggregation used <sup>(1)</sup>					
<i>For example: Cropland Management</i>	CO <sub>2</sub>	<i>X(Cropland remaining Cropland)</i>			
B.1 Forest Management	CO <sub>2</sub>	5A1 Forest Land remaining Forest Land	Yes	FM is KP key because FM is associated with the UNFCCC category 5A1. Since the total Swiss forest area is considered as managed, there is a good agreement between the KP category and the UNFCCC inventory category	Associated category in UNFCCC inventory is KC level and KC trend; GM and CM are not elected
A.1.1 Afforestation and Reforestation	CO <sub>2</sub>	5A2 Land converted to Forest Land	No	AR is KP key because AR is associated with the UNFCCC category 5A2. Natural forest regeneration due to abandonment of land is not considered as afforestation under KP. However, most of the afforestations are the result of natural generation (see Table 7-7 in Chapt. 7.2.5). Therefore AR is not considered key under KP.	Associated category in UNFCCC inventory is KC trend
A.2 Deforestation	CO <sub>2</sub>	5E2 Land converted to Settlements	No	D is KP key because D is associated with the UNFCCC category 5E2. Only a minor part (5%) of the land area converted to settlements comes from forest land (see Table 7-7 in Chapt. 7.2.5). Therefore D is not considered key under KP.	Associated category in UNFCCC inventory is KC level and KC trend; RV is not elected

<sup>(1)</sup> See section 5.4 of the IPCC good practice guidance for LULUCF.<sup>(2)</sup> This should include qualitative consideration as per section 5.4.3 of the IPCC good practice guidance for LULUCF or any other criteria.<sup>(3)</sup> Describe the criteria identifying the category as key.**Documentation box:**

Parties should provide in the NIR the full information on methodologies used for identifying key categories (according to section 5.4 of the IPCC good practice guidance for LULUCF).

2 Quantitative criteria for Key Category Analysis are sufficient in Switzerland

3 Level and trend assessment following IPCC (1997a) and IPCC (2003); Assessment of trend and level assessment see Chapter 1.5

## ***A8.2 Information on emission reduction units, certified emission reductions, temporary certified emission reductions, long-term certified emission reductions, assigned amount units and removal units***

### **§11 Standard Electronic Format (SEF)**

All SEF tables requested by the UNFCCC have been uploaded on the UNFCCC Submission Portal. The decision of Switzerland to issue only 5 million of its assigned amount during the go-live process on December 4, 2007 triggered a notification type 7 "Commitment Period Reserve" from the ITL. In response to this notification, the Swiss Registry issued the remaining 237'838'402 assigned amount units on February 14, 2008.

### **§12 List of Discrepant Transactions**

Switzerland's report R-2 of discrepant transactions has been uploaded on the UNFCCC Submission Portal.

The transaction number CH578 has been terminated with DES response codes 4003 and 4010. It is assumed that this transaction included unit blocks from a previous incoming transaction not yet finalized by the International Transaction Log (ITL). Hence these unit blocks were still in use and not available for the transaction number CH578.

### **§13 & §14 List of CDM Notifications**

Switzerland's report R-3 of the list of CDM notifications has been uploaded on the UNFCCC Submission Portal.

### **§15 List of Non-Replacements**

Switzerland's report R-4 of the list of non-replacements has been uploaded on the UNFCCC Submission Portal.

### **§16 List of Invalid Units**

Switzerland's report R-5 of the list of invalid units has been uploaded on the UNFCCC Submission Portal.

### **§17 Actions and Changes to Address Discrepancies**

No actions or changes.

### **§18 Commitment Period Reserve**

The commitment period reserve remains unchanged and is the same as defined in the update of the Initial Report (submitted on 20 December 2007; FOEN 2006h). The calculation of the commitment period reserve is based on the assigned amount (Method 1 in Table A - 54).

Table A - 54 Calculation of the commitment period reserve.

Method 1	Method 2
90 % of the assigned amount	Total of 2007 emissions without LULUCF times 5
[t CO <sub>2</sub> equivalent]	[t CO <sub>2</sub> equivalent]
242 838 402 x 0.9 = <b>218 554 562</b>	51 264 642 x 5 = <b>256 323 210</b>

Method 1 results in the lower value.

The commitment period reserve of Switzerland is calculated as 218 554 562 tonnes CO<sub>2</sub> equivalent.

**§19** not applicable

**§20** not applicable

### **A8.3 Changes in national systems in accordance with Article 5, paragraph 1**

#### **§21 Changes in the National System**

<b>Annual Submission Item</b>	<b>Reporting</b>
15/CMP.1 annex II.E §30a: Change of name or contact information	No change in this submission
15/CMP.1 annex II.E §30b: Change of roles and responsibilities as well as change of the institutional, legal and procedural arrangements	No change in this submission
15/CMP.1 annex II.E §30c: Changes in the process of inventory compilation	Since autumn 2007, the GHG Inv web platform is operative. The most important contributors to the GHG inventory are authorised to work online on IDM-based inventory files by means of a SSL connection.
15/CMP.1 annex II.E §30d: Change of key source identification and archiving	No change in this submission
15/CMP.1 annex II.E §30e: Change of process for recalculations	No change in this submission
15/CMP.1 annex II.E §30f: Changes with regard to QA/QC plan, QA/QC activities and procedures	Overall inventory cooperation and QA/QC performance benefits from the above-mentioned GHG Inv web platform and its services (e.g. the quality manual).  On 6 December 2007, the National Inventory System quality management system was certified by the Swiss Association for Quality and Management Systems to comply with ISO 9001:2000 requirements (SQS 2008).
15/CMP.1 annex II.E §30g: Change of procedures for the official consideration and approval	No change in this submission.

Changes in the Swiss national system as introduced in FOEN (2006h) are described in detail in FOEN (2009a).

## ***A8.4 Changes in national registries***

### **§22 Changes in the National Registry**

<b>Annual Submission Item</b>	<b>Reporting</b>
15/CMP.1 annex II.E §32a: Change of name or contact information	No change in this submission
15/CMP.1 annex II.E §32b: Change of cooperation arrangement	No change in this submission
15/CMP.1 annex II.E §32c: Change of the database or the capacity of National Registry	No change in this submission
15/CMP.1 annex II.E §32d: Change of conformance to technical standards	Switzerland's National Registry software has been updated from version 4.0.6 to version 4.2 (including all relevant patches of version 4.0.6). Apart from these regular updates and security patches, no major changes have occurred.
15/CMP.1 annex II.E §32e: Change of procedures	No change in this submission
15/CMP.1 annex II.E §32f: Change of security	No change in this submission.
15/CMP.1 annex II.E §32g: Change of list of publicly available information	No change in this submission.
15/CMP.1 annex II.E §32h: Change of Internet address	No change in this submission.
15/CMP.1 annex II.E §32i: Change of data integrity measures	No change in this submission.
15/CMP.1 annex II.E §32j: Change of test results	No change in this submission.