Switzerland's Greenhouse Gas Inventory 1990–2006

National Inventory Report 2008

Submission of 15 April 2008
under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Office for the Environment FOEN

Published and distributed by:

Federal Office for the Environment FOEN

Climate, Economics and Environmental Observation Division

3003 Bern, Switzerland

www.environment-switzerland.ch/climate

www.climatereporting.ch

Bern, 15 April 2008

Switzerland's Greenhouse Gas Inventory 1990–2006

National Inventory Report 2008

Submission of 15 April 2008
under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol

Authors

INFRAS	
Jürg Heldstab	Exec. Summ., Chapters 1 and 2, Energy (Transport, Off-Road Transport, Bunkers), NIR compilation
Stefan Kessler	Industrial Processes (Synthetic Gases)
Myriam Steinemann	Agriculture
Florian Kasser	Monte Carlo simulation
Bettina Rüegge	Consistency checking
Ernst Basler + Partner	
Markus Sommerhalder	Solid Waste
Roman Bolliger	Energy (Stationary), Industrial Processes (Non-synthetic Gases), Solvent Use, Key Category Analysis
Christian Lüthi	Wastewater Handling
Meteotest	
Beat Rihm	Land Use, Land-Use Change and Forestry
Agroscope ART	
Daniel Bretscher	Agriculture

Federal Office for the Environment (FOEN)

Paul Filliger	FOEN; Climate, Economics and Environmental Observation Division (project leader)
Fabio Leippert	FOEN; Air Pollution Control and Non-Ionising Radiation Division
Andreas Liechti	FOEN; Air Pollution Control and Non-Ionising Radiation Division
Beat Müller	FOEN; Air Pollution Control and Non-Ionising Radiation Division
Sophie Hoehn	FOEN; Air Pollution Control and Non-Ionising Radiation Division
Markus Nauser	FOEN; Climate, Economics and Environmental Observation Division
Andreas Schellenberger	FOEN; Climate, Economics and Environmental Observation Division
Esther Thürig	FOEN; Forest Division
Richard Volz	FOEN; Forest Division

NIR-CH-Submission-Apr-20088505.doc

15 April 2008

Table of Contents

Table of Contents **5**
Glossary **9**
Executive Summary **11**
Inventory Preparation in Switzerland 11
Trend Summary: National GHG Emissions and Removals 12
Overview of Source and Sink Category Estimates and Trends 14
Acknowledgements **16**
1. Introduction **17**
1.1. Background Information on Swiss Greenhouse Gas Inventories 17
1.2. Institutional Arrangements for Inventory Preparation 17
1.3. Process for Inventory Preparation 20
1.4. Methodologies 21
1.5. Key Categories 23
1.5.1. Methodology 23
1.5.2. KCA without LULUCF categories 24
1.5.3. Combined KCA without and with LULUCF categories 27
1.6. Quality Assurance and Quality Control (QA/QC) 30
1.6.1. The Quality Management System 30
1.6.2. Treatment of Confidential Data 32
1.7. Uncertainty Evaluation 32
1.7.1. Data Used 33
1.7.2. Uncertainty Estimates 33
1.7.3. Results of Tier 1 Uncertainty Evaluation 34
1.7.4. Results of Tier 2 Uncertainty Evaluation (Monte Carlo) 37
1.7.5. Comparison of Tier 1 and Tier 2 Results 41
1.8. Completeness Assessment 41
2. Trends in Greenhouse Gas Emissions and Removals **43**
2.1. Aggregated Greenhouse Gas Emissions 2006 43
2.2. Emission Trends by Gas 45
2.3. Emission Trends by Sources and Sinks 47
2.4. Emission Trends for Indirect Greenhouse Gases and SO_2 52
3. Energy **55**
3.1. Overview 55
3.1.1. Greenhouse Gas Emissions 55
3.1.2. CO_2 Emission Factors 58

3.1.3. Feedstocks 58
3.1.4. Correction of Fuel Consumption Related to Liechtenstein 59
3.1.5. Disaggregation of the energy consumption 59
3.1.6. Leakage from Natural Gas Distribution 60
3.2. Source Category 1A – Fuel Combustion Activities 60
3.2.1. Source Category Description 60
a) Energy Industries (1A1) 60
b) Manufacturing Industries and Construction (1A2) 61
c) Transport (1A3) 62
d) Other Sectors (1A4 – Commercial/Institutional, Residential, Agriculture/ Forestry) 63
e) Other / Mobile (Off-road): Construction, Garden/Hobby, Industry and Military (1A5b) 63
3.2.2. Methodological Issues 64
General Issues 64
a) Energy Industries (1A1) 65
b) Manufacturing Industries and Construction (1A2) 69
c) Transport (1A3) 81
d) Other Sectors (Commercial, Residential, Agriculture, Forestry; 1A4) 93
e) Other / Mobile (Off-road): Construction, Garden/Hobby, Industry and Military (1A5b) 98
3.2.3. Uncertainties and Time-Series Consistency 99
3.2.4. Source-Specific QA/QC and Verification 102
3.2.5. Source-Specific Recalculations 104
3.2.6. Source-Specific Planned Improvements 105
3.3. Source Category 1B – Fugitive Emissions from Fuels 105
3.4. Source Category International Bunker Fuels 108
3.5. CO_2 Emissions from Biomass 109
3.6. Comparison of Sectoral Approach with Reference Approach 110
4. Industrial Processes 113
4.1. Overview 113
4.2. Source Category 2A – Mineral Products 114
4.3. Source Category 2B – Chemical Industry 118
4.4. Source Category 2C – Metal Production 121
4.5. Source Category 2D – Other Production 125
4.6. Source Category 2E – Production of Halocarbons and SF_6 126
4.7. Source Category 2F – Consumption of Halocarbons and SF_6 127
4.8. Source Category 2G – Other 135
5. Solvent and Other Product Use 137

5.1. Overview 137
5.2. Source Category 3A – Paint Application 138
5.3. Source Category 3B – Degreasing and Dry Cleaning 140
5.4. Source Category 3C – Chemical Products, Manufacture and Processing 141
5.5. Source Category 3D – Other 143
6. Agriculture 145
6.1. Overview 145
6.2. Source Category 4A – Enteric Fermentation 147
6.3. Source Category 4B – Manure Management 154
6.4. Source Category 4C – Rice Cultivation 161
6.5. Source Category 4D – Agricultural Soils 161
6.6. Source Category 4E – Burning of savannas 169
6.7. Source Category 4F – Field Burning of Agricultural Residues 169
7. Land Use, Land-Use Change and Forestry 171
7.1. Overview 171
7.2. Methodical Approach and Activity Data 173
7.3. Source Category 5A – Forest Land 190
7.4. Source Category 5B – Crop Land 213
7.5. Source Category 5C – Grassland 215
7.6. Source Category 5D – Wetlands 221
7.7. Source Category 5E – Settlements 223
7.8. Source Category 5F – Other Land 225
8. Waste 227
8.1. Overview 227
8.2. Source Category 6A – Solid Waste Disposal on Land 232
8.3. Source Category 6B – Wastewater Handling 236
8.4. Source Category 6C – Waste Incineration 240
8.5. Source Category 6D – Other 243
9. Recalculations 246
9.1. Explanations and Justifications for Recalculation 246
9.2. Implications for Emission Levels 1990 and 2005 248
9.3. Implications for Emissions Trends, including Time Series Consistency 250
References 251
References to EMIS database comments 265
Annexes 267
Annex 1: Key Category Analysis and Uncertainty Evaluation 267
A1.1 Key Category Analysis 267
A1.2 Uncertainty Evaluation 276

Annex 2: Energy......**290**
A2.1 Swiss Energy Flux......290
A2.2 Carbon Dioxide (CO_2)......292
A2.3 Sulphur Dioxide (SO_2)......293
A2.4 Emissions from Fuel Consumption......295
A2.5 Civil Aviation......298
A2.6 Road Transportation......301
A2.7 Off-road Vehicles......308
Annex 3: Industrial Processes......**314**
A3.1 Documentation of Model for Mobile Air-Conditioning / Cars......314
Annex 4: Agriculture......**315**

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	biomass expansion factor
BFL	Bundesamt für Forstwesen und Landschaftsschutz (1989-2005: SAEFL, since 2005: FOEN)
Carbura	Swiss Central Office for the Import of Liquid Fuels
cemsuisse	Association of the Swiss Cement Industry
CC	Combination category
CH_4	Methane, IPCC GWP (1995): 21 (FCCC 2003, table 1)
CHP	Combined heat and power production
CO	Carbon monoxide
CO_2, CO_2 eq	Carbon dioxide, carbon dioxide equivalent
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
EAFV	Eidg. Anstalt für das forstliche Versuchswesen (since 1989: WSL)
EF	Emission factor
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)
Gg	Gigagram (10^9 g = 1’000 tons)
GHG	Greenhouse gas
GWP	Global Warming Potential
ha	hectare

HFC	Hydrofluorocarbons (e.g. HFC-32 difluoromethane)
HFO	Heavy fuel oil
IDP	Inventory Development Plan
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
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_2O	Nitrous oxide; IPCC GWP (1995): 310 (FCCC 2003, table 1)
NO_x	Nitrogen oxides
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_6	Sulphur hexafluoride, IPCC GWP (1995): 23900 (FCCC 2003, tbl. 1)
SFOE	Swiss Federal Office of Energy
SFSO	Swiss Federal Statistical Office
SGCI/SSCI	Schweiz. Gesellschaft für Chemische Industrie / Swiss Society of Chemical Industries
SO_2	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)
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
VSAI/AISA	Vereinigung Schweiz. 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 on, the inventories have been submitted in the Common Reporting Format (CRF). The present report is Switzerland's fifth National Inventory Report, NIR 2008, prepared under the UNFCCC and under the Kyoto Protocol. It includes, as a separate document, Switzerland's 1990–2006 Inventory in the CRF.

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

The Federal Office for the Environment (FOEN; formerly known as the Swiss Agency for the Environment, Forests and Landscape, SAEFL) 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 (former Swiss Federal Research Station for Agroecology and Agriculture FAL) and the Federal Office of Civil Aviation (FOCA) participate directly in the compilation of the inventory. Several other administrative and research institutions are involved in inventory preparation.

In preparing its fifth National Inventory Report, Switzerland took into account the findings of the 2004 in-country review, the 2005 centralized review as well as the in-country review of the 2006 inventory submission in March 2007.

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 (IPCC 2000) and for LULUCF in the IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003). 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 a specialized task force, the GHG Inventory Core Group, which is responsible for ensuring the conformity of the inventory with 2003 UNFCCC guidelines (FCCC 2003). 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 analysis and the uncertainty analyses, and were responsible for performing some tasks relating to the inventory development plan.

The inventory quality assurance and control 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. The QA/QC Officer advises the NIS Supervisory Board on matters relating to the conformity of the inventory with reporting requirements.

Moreover, Chapter 1 provides information on key categories and uncertainties: 36 key categories are identified for 2006, 21 of which are in the energy sector. For the emission data of 2006, an uncertainty analysis (Monte Carlo) estimates a level uncertainty of 4.0% and a trend uncertainty of 2.8% for total CO_2 equivalent emissions.

Chapter 2 provides an analysis of Switzerland's trends in greenhouse gas emissions. The most important results are also reported below in this Executive Summary.

Chapters 3 to 8 provide principal source and sink category estimates. Only few input data has 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 2007. The recalculations result in an marginal increase of the total base year (1990) emissions of 0.10% in CO_2 equivalents. For the year 2005, there is an increase of 0.29% without emissions/removals from LULUCF. If the LULUCF sector is included, due to substantial recalculations in this sector, there is a decrease of 0.84% in the national total.

Trend Summary: National GHG Emissions and Removals

In 2006, Switzerland emitted about 53'209 Gg (kilotonnes) CO_2 equivalent, or 7.04 tonnes CO_2 equivalent per capita (CO_2 only: 6.03 tonnes per capita), to the atmosphere, excluding emissions/removals from Land Use, Land-Use Change and Forestry (LULUCF)[1].

For 2006, 36 key categories were identified in the country's level and trend analysis, covering 97.3% of total CO_2 equivalent greenhouse gas (GHG) emissions. 37.3% of total GHG emissions derived from the two most important key sources: CO_2 from gasoline combustion – Transport (source category 1A3b, road transportation) and CO_2 from liquid fuel combustion – Other Sectors (source category 1A4b, residential).

Table 1 shows Switzerland's annual GHG emissions by individual GHG from 1990 (base year) to 2006. There is no significant trend in the period 1990–2006. Year-to-year variations are mainly caused by changing winter temperatures. In 2006, total gross GHG emissions (excluding LULUCF Removals/Emissions) show an increase of 0.77% compared to the level recorded for 1990 (see also Table 2).

[1] Inhabitants in Switzerland in 2006: 7.557 million

Table 1 Summary of Switzerland's GHG emissions in CO_2 equivalent (Gg), 1990–2006 (from CRF Tables 10s5 and 10s5.2).

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	41'963	46'578	45'998	39'269	38'486	39'552	41'139	40'092	42'932	39'148
CO_2 emissions excluding net CO_2 from LULUCF	44'558	46'194	46'216	43'625	42'852	43'338	44'027	43'360	44'586	44'817
CH_4 emissions including CH_4 from LULUCF	4'382	4'351	4'240	4'100	4'007	3'990	3'933	3'864	3'799	3'747
CH_4 emissions excluding CH_4 from LULUCF	4'374	4'350	4'239	4'100	4'005	3'987	3'931	3'853	3'797	3'747
N_2O emissions including N_2O from LULUCF	3'637	3'652	3'626	3'580	3'575	3'504	3'550	3'430	3'426	3'410
N_2O emissions excluding N_2O from LULUCF	3'625	3'644	3'618	3'572	3'567	3'495	3'542	3'418	3'419	3'404
HFCs	0	0	6	13	29	169	209	271	317	364
PFCs	100	85	69	30	18	15	17	24	28	40
SF_6	144	146	148	126	112	95	92	130	159	146
Total (including LULUCF)	**50'226**	**54'813**	**54'087**	**47'117**	**46'227**	**47'324**	**48'941**	**47'812**	**50'662**	**46'855**
Total (excluding LULUCF)	**52'800**	**54'420**	**54'298**	**51'465**	**50'583**	**51'098**	**51'819**	**51'056**	**52'306**	**52'518**

Greenhouse Gas Emissions	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	Change base year to 2006 (%)
	CO2 equivalent (Gg)							
CO_2 emissions including net CO_2 from LULUCF	44'749	43'531	42'539	46'390	43'998	45'208	43'324	*3.2%*
CO_2 emissions excluding net CO_2 from LULUCF	43'916	44'703	43'783	44'906	45'360	46'067	45'561	*2.3%*
CH_4 emissions including CH_4 from LULUCF	3'697	3'709	3'649	3'547	3'527	3'542	3'539	*-19.2%*
CH_4 emissions excluding CH_4 from LULUCF	3'697	3'708	3'646	3'542	3'527	3'541	3'538	*-19.1%*
N_2O emissions including N_2O from LULUCF	3'431	3'410	3'409	3'327	3'326	3'297	3'280	*-9.8%*
N_2O emissions excluding N_2O from LULUCF	3'425	3'404	3'402	3'319	3'320	3'291	3'274	*-9.7%*
HFCs	425	501	523	582	649	638	617	
PFCs	93	52	51	87	74	56	56	*-44.0%*
SF_6	203	235	210	195	176	196	162	*13.0%*
Total (including LULUCF)	**52'598**	**51'438**	**50'383**	**54'127**	**51'750**	**52'937**	**50'979**	***1.50%***
Total (excluding LULUCF)	**51'759**	**52'604**	**51'616**	**52'632**	**53'106**	**53'790**	**53'209**	***0.77%***

With regard to the distribution of emissions by individual greenhouse gases, CO_2 is the largest single contributor to emissions, accounting for 85.6% of total gross GHG emissions (excluding LULUCF) in 2006 (1990: 84.4%). The share of CH_4 decreased from 8.3% (1990) to 6.6% (2006). Over the same period, the share of N_2O decreased from 6.9% to 6.2%, while the share of synthetic gases increased from 0.5% to 1.6%.

Table 2 Switzerland's total gross GHG emissions (excluding LULUCF) in CO_2 equivalent (Gg), selected years.

Greenhouse Gas Emissions	**1990**		**1995**		**2000**		**2005**		**2006**	
(excluding LULUCF)	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
CO_2	44'558	84.4%	43'338	84.8%	43'916	84.8%	46'067	85.6%	45'561	85.6%
CH_4	4'374	8.3%	3'987	7.8%	3'697	7.1%	3'541	6.6%	3'538	6.6%
N_2O	3'625	6.9%	3'495	6.8%	3'425	6.6%	3'291	6.1%	3'274	6.2%
HFCs	0	0.0%	169	0.3%	425	0.8%	638	1.2%	617	1.2%
PFCs	100	0.2%	15	0.0%	93	0.2%	56	0.1%	56	0.1%
SF_6	144	0.3%	95	0.2%	203	0.4%	196	0.4%	162	0.3%
Total (excluding LULUCF)	**52'800**	**100%**	**51'098**	**100%**	**51'759**	**100%**	**53'790**	**100%**	**53'209**	**100%**

Figure 1 shows the shares of 2006 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 1990–2006.

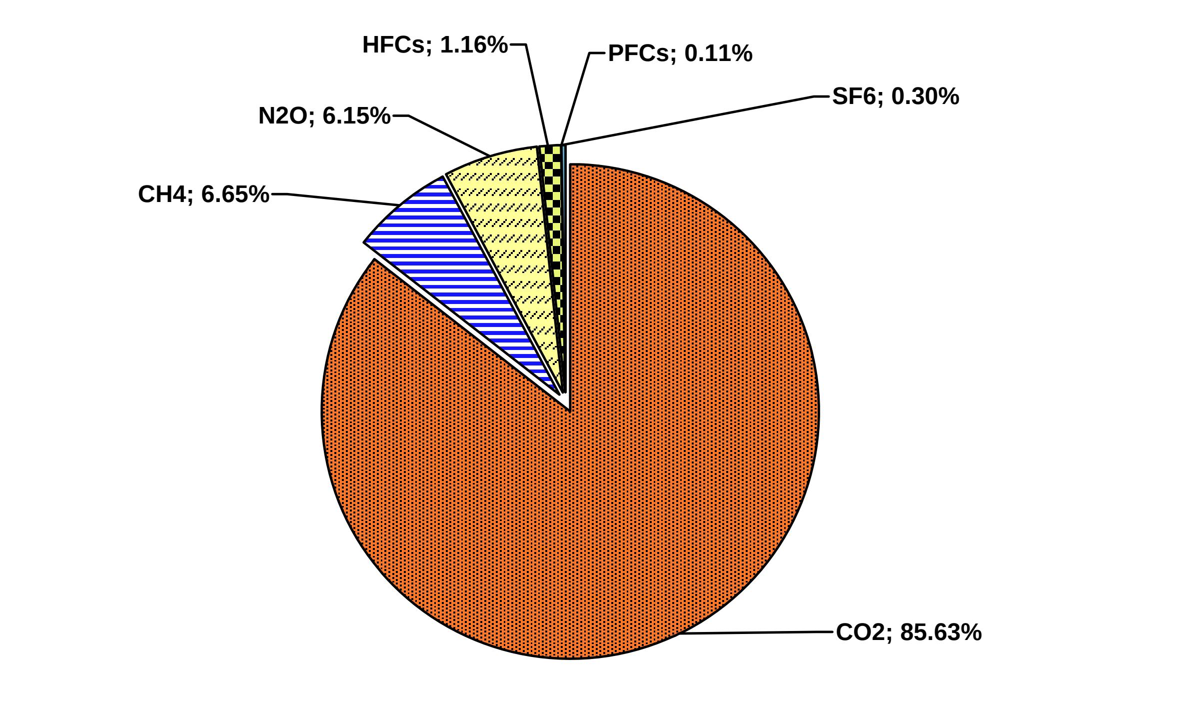


Figure 1 Contribution of individual gases to Switzerland's GHG emissions (excluding LULUCF) in 2006. 100% = 3'209 CO_2 eq (Gg).

Overview of Source and Sink Category Estimates and Trends

Table 3 and Figure 2 show the GHG emissions and removals by the main source and sink categories. There is no significant trend in the period 1990–2006. Year-to-year variations are mainly caused by changing winter temperatures. The energy sector is the largest source of national emissions.

Table 3 Switzerland's GHG emissions/removals by source and sink categories in CO_2 equivalent (Gg), 1990–2006 (from CRF Tables 10s5 and 10s5.2).)

Greenhouse Gas Source and Sink Categories	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
1. Energy	42'142	44'138	44'292	41'928	41'006	41'671	42'558	42'067	43'293	43'501
2. Industrial Processes	3'258	2'912	2'745	2'438	2'617	2'560	2'411	2'321	2'429	2'523
3. Solvent and Other Product Use	467	445	425	401	386	368	346	324	302	292
4. Agriculture	5'903	5'907	5'833	5'755	5'706	5'638	5'655	5'499	5'468	5'410
6. Waste	1'030	1'018	1'004	943	867	861	848	845	814	791
Total (excluding LULUCF)	**52'800**	**54'420**	**54'298**	**51'465**	**50'583**	**51'098**	**51'819**	**51'056**	**52'306**	**52'518**
5. Land Use, Land-Use Change and Forestry	-2'574	393	-211	-4'348	-4'356	-3'774	-2'878	-3'244	-1'644	-5'663
Total (including LULUCF)	**50'226**	**54'813**	**54'087**	**47'117**	**46'227**	**47'324**	**48'941**	**47'812**	**50'662**	**46'855**

Greenhouse Gas Source and Sink Categories	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	***2006/1990***
	CO_2 equivalent (Gg)							%
1. Energy	42'448	43'213	42'314	43'450	43'799	44'398	43'924	*4.2%*
2. Industrial Processes	2'846	2'958	2'913	2'949	3'095	3'159	3'061	*-6.0%*
3. Solvent and Other Product Use	281	271	259	250	237	238	238	*-49.0%*
4. Agriculture	5'411	5'416	5'391	5'285	5'259	5'281	5'288	*-10.4%*
6. Waste	772	747	740	698	717	714	697	*-32.3%*
Total (excluding LULUCF)	**51'759**	**52'604**	**51'616**	**52'632**	**53'106**	**53'790**	**53'209**	*0.77%*
5. Land Use, Land-Use Change and Forestry	839	-1'166	-1'233	1'496	-1'356	-854	-2'230	*-13.3%*
Total (including LULUCF)	**52'598**	**51'438**	**50'383**	**54'127**	**51'750**	**52'937**	**50'979**	*1.50%*

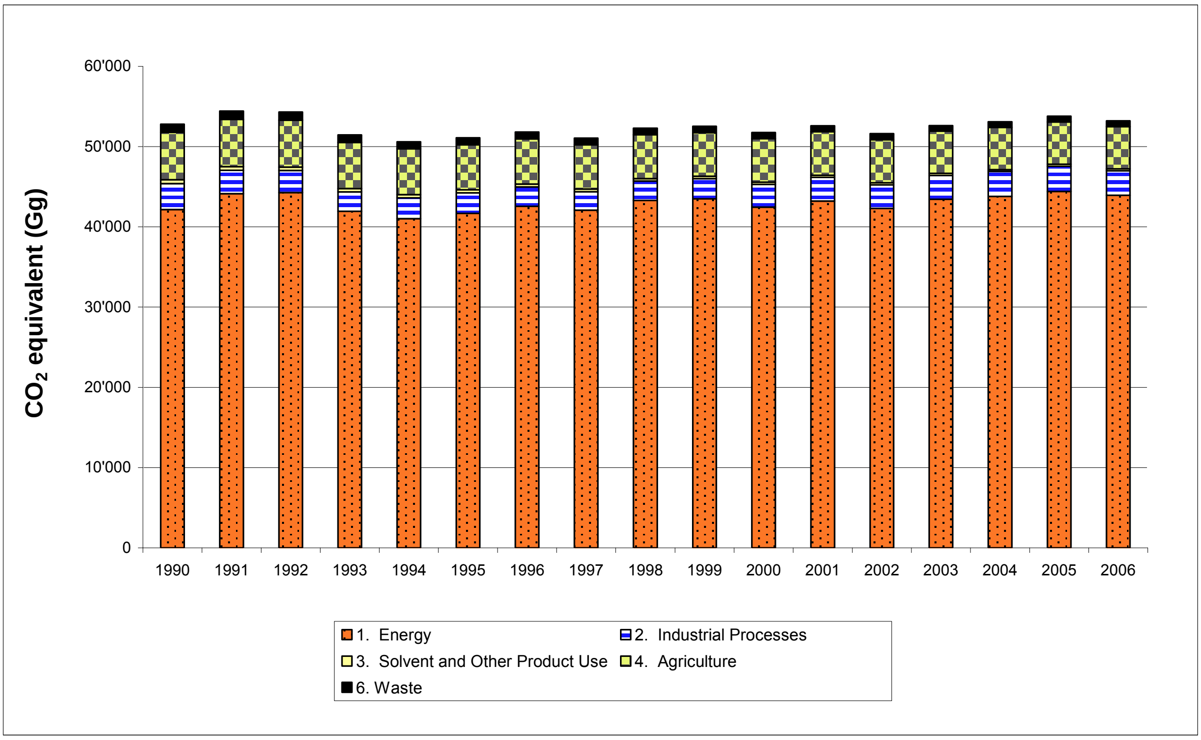


Figure 2 Switzerland's greenhouse gas emissions in CO_2 equivalent (Gg) by main source categories, 1990–2006 (Total excluding LULUCF).

Table 4 shows the contributions of individual sectors to total gross emissions for selected years in more detail. Between 1990 and 2006, the relative contribution of sector 1 Energy increased from 79.8% to 82.5%, whereas decreases were seen from 6.2% to 5.8% for sector 2 Industrial Processes, from 11.2% to 9.9% for sector 4 Agriculture, and from 1.9% to 1.3% for sector 6 Waste.

Table 4 Switzerland's total gross GHG emissions (excluding LULUCF) in CO_2 equivalent (Gg) and the contribution of individual source categories, selected years.

Source and Sink Categories	**1990**		**1995**		**2000**		**2005**		**2006**	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	42'142	79.8%	41'671	81.6%	42'448	82.0%	44'398	82.5%	43'924	82.5%
1A1 Energy Industries	*2'545*	*4.8%*	*2'619*	*5.1%*	*2'886*	*5.6%*	*3'527*	*6.6%*	*3'730*	*7.0%*
1A2 Manufacturing Industries and Construction	*6'057*	*11.5%*	*5'512*	*10.8%*	*5'811*	*11.2%*	*5'930*	*11.0%*	*6'023*	*11.3%*
1A3 Transport	*14'811*	*28.1%*	*14'387*	*28.2%*	*16'018*	*30.9%*	*15'927*	*29.6%*	*16'011*	*30.1%*
1A4 Other Sectors	*17'743*	*33.6%*	*18'214*	*35.6%*	*16'799*	*32.5%*	*18'120*	*33.7%*	*17'263*	*32.4%*
1A5 Other (Offroad)	*466*	*0.9%*	*547*	*1.1%*	*600*	*1.2%*	*611*	*1.1%*	*612*	*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%*
2. Industrial Processes	3'258	6.2%	2'560	5.0%	2'846	5.5%	3'159	5.9%	3'061	5.8%
3. Solvent and Other Product Use	467	0.9%	368	0.7%	281	0.5%	238	0.4%	238	0.4%
4. Agriculture	5'903	11.2%	5'638	11.0%	5'411	10.5%	5'281	9.8%	5'288	9.9%
6. Waste	1'030	1.9%	861	1.7%	772	1.5%	714	1.3%	697	1.3%
Total (excluding LULUCF)	**52'800**	**100.0%**	**51'098**	**100.0%**	**51'759**	**100.0%**	**53'790**	**100.0%**	**53'209**	**100.0%**

Acknowledgements

The GHG inventory preparation is a joint effort which is based on input from many 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, 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 on, the inventories have been submitted in the Common Reporting Format (CRF): In 2004, Switzerland started submitting a yearly National Inventory Report under the UNFCCC, on 10 November 2006 together with Switzerland's Initial Report under Article 7, paragraph 4 of the Kyoto Protocol (FOEN 2006, 2006h).

The present inventory submission includes the National Inventory Report on hand, the greenhouse gas inventory in the Common Reporting Format 1990–2006 (FOEN 2008) and, as a supplement, the update of the Description of the Quality Management System (FOEN 2008a).

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. On 6 December 2007, the NIS quality management system was certified to comply with ISO 9001:2000 requirements (SQS 2008).

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 3 gives a schematic overview of the institutional setting of the NIS.

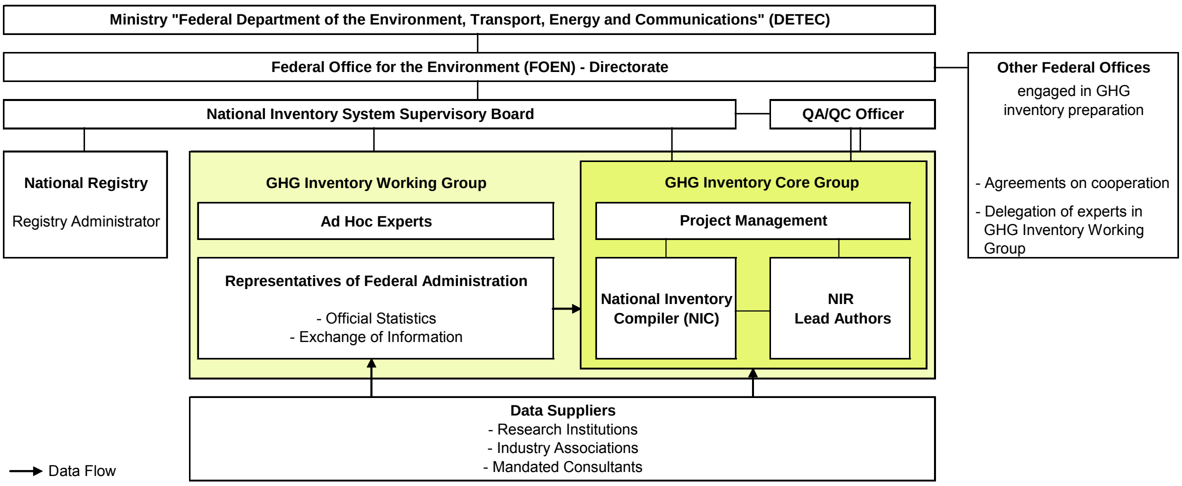


Figure 3 Institutional setting of the National Inventory System.

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 2008a), 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. 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).

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 5). 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 2008a, section 2.2.)

Table 5 Suppliers of raw and processed data: 1–15 provide annual updates, 16–20 provide sporadic updates. The IPCC nomenclature is used for the inventory categories (1A1 = Energy Industries, 1A2 = Manufacturing Industries and Construction etc.). RA = Reference Approach. For further abbreviations see the glossary.

	Institution	**Subject**	**Data supplied for inventory category…**												**References**
			1A1	1A2	1A3	1A4	1A5	1B	RA	2	3	4	5	6	
	Data suppliers (annual updates)														
1	FOEN, Air Pollution Control	EMIS Database	x	x		x	x	x		x	x	x		x	EMIS 2005/ (NFR-Code)
2	FOEN, Air Pollution Control	Off-road Database			x		x								INFRAS 2007
3	FOEN, Waste and Raw Materials	Waste Statistics	x	x										x	FOEN 2007e
4	FOEN, Forest Division	Forest Statistics											x		FOEN 2008b
5	SFOE	Swiss overall energy statistics	x	x	x	x		x	x					x	SFOE 2007
6	FOCA	Civil Aviation			x										FOCA 2006a, 2007
7	Swiss Air Force Administration	Military Aviation			x										VTG 2007
8	SFSO	Agriculture, LULUCF,										x	x		SFSO 1997, 2000, 2000a, 2002, 2003, 2005, 2006b, 2007a
9	ART	Agriculture, LULUCF										x	x		internal document
10	WSL	National Forest Inventory											x		Brassel and Brändli 1999; EAFV/BFL 1988
11	CEPE/Basics AG	Energy Consumption		x		x									CEPE 2007; Basics 2007
12	Carbotech	Synthetic Gases								x					Carbotech 2008
13	Industry Associations: SGCI, Swissmem, VSAI etc.	Synthetic Gases								x					Carbotech 2008
14	Swiss Petroleum Association	Oil Statistics							x						EV 2007
15	cemsuisse	Cement, Clinker Production		x						x					Cemsuisse 2007
	Data suppliers (sporadic updates)														
16	SVGW	Gas Distribution Losses						x							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 2007
20	Sigmaplan, Meteotest	LULUCF											x		internal document

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, 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 IPCC Good Practice Guidances (IPCC 2000, IPCC 2003), are necessarily to be taken into account. Diverse QA/QC activities (see Chapter 1.6) 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 4 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. The FOEN internal GHG inventory files, that had been used for the generation of CRF tables in previous submissions, have been replaced by a comprehensive data set produced by the redesigned national air pollution database EMIS. From EMIS, an interface transfers the data to the CRF Reporter (Version 3.2.1) that generates the CRF tables. Nevertheless, the internal GHG inventory files have been updated independently, serving as a rigorous controlling tool for the new EMIS database. For further details see Chapter 1.4.3.

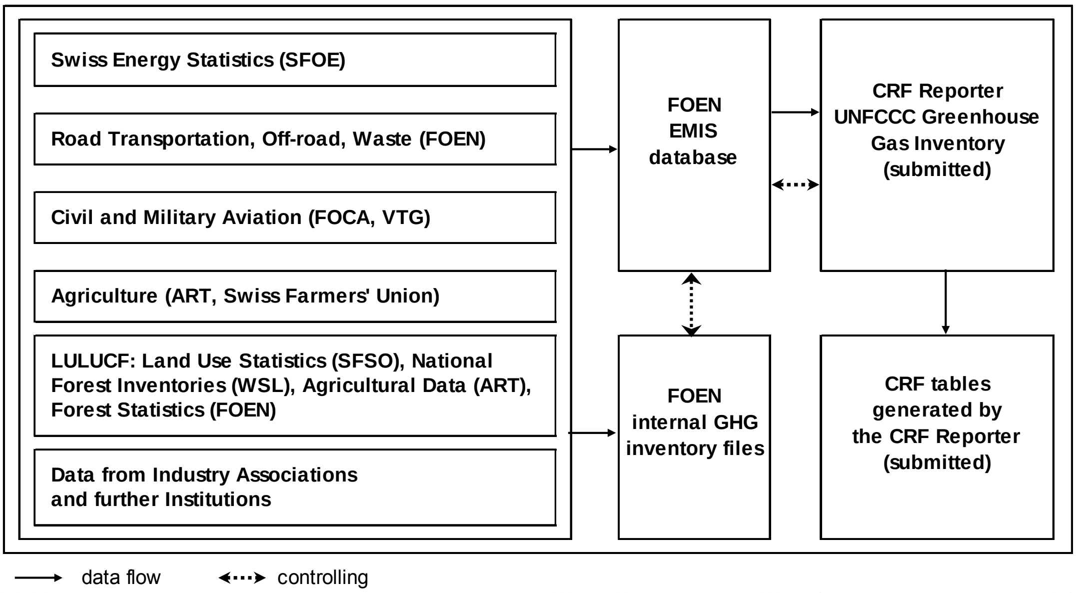


Figure 4 Data collection for EMIS database, CRF Reporter and FOEN internal GHG inventory files (for quality control purposes only).

1.4. Methodologies

1.4.1. General Description

Emissions are calculated on the basis of the standard methods and procedures of the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC 1997a, 1997b, 1997c) and IPCC Good Practice Guidance (IPCC 2000, IPCC 2003), as adopted by the UNFCCC.

To date, emissions have been calculated, in part, by multiplying emission factors and activity rates in the “FOEN EMIS database” and the “FOEN internal GHG inventory files”. For the other part, emissions have been calculated by the data suppliers listed in Table 5 (e.g. for agriculture). In the latter cases, the resulting emission data have been directly inserted into the two databases. For the present submission, the internal GHG inventory files have been updated only for controlling purposes. The GHG inventory files were replaced by the Swiss national air pollution database EMIS in 2006, which was redesigned and extended during 2005/2006 to serve climate policy purposes as well. By means of an interface the data have been exported from EMIS into the CRF Reporter. Therefore, the data in the actual CRF tables have been produced in EMIS. For further details, see Chapter 1.4.3 below.

The National Approach for source category 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, 2 and 3 methodologies according to IPCC Guidelines (IPCC 1997b) and Good Practice Guidance (IPCC 2000[2]) are used. The following list indicates the general approach adopted for each of the key categories.

[2] For the new LULUCF reporting in Annex 4, IPCC 2003 (see References LULUCF in Annex 4) is used.

1 Energy

- 1A1 Energy Industries, 1A2 Manufacturing Industries and Construction, 1A4 Other Sectors: Country specific, Tier 2 method (1A2 also Tier 3 method).
  Emission factors: Country specific; exception N_2O: IPCC default.
- 1A3a Civil aviation: IPCC Tier 3a method. Emission factors: CO_2 country specific, N_2O IPCC default, other gases country specific/CORINAIR.
- 1A3 Transport, 1A5 Off-road: CO_2: Tier 1 approach is based on oil imports, refinery production numbers, fuel statistics and carbon content of the fuels, Tier 2 for 1A3c/1A3d, 1A5b. Emission factor: Country specific.
  Other gases: Tier 2 approach, bottom-up model for activities. Emission factors are country specific, N_2O emission factors are taken from a Dutch measurement programme.
- 1B Fugitive Emissions from Fuels: Country specific methods and emission factors.

2 Industrial Processes

- 2A1 Cement Production: IPCC Tier 2 method.
  Emission factors: Country specific.
- 2C Metal Production: CORINAIR, Tier 2 or country specific methods for CO_2, and Tier 3b method for PFCs.
  Emission factors: Country specific (2C3 Aluminium production: plant-specific).
- 2F Consumption of Halocarbons and SF_6: CORINAIR, Tier 2 method with two different approaches (statistics, surveys), Tier 1 for 2F5 Solvents.
  Emission factors: Country specific (2F2) and IPCC-default (2F4, 2F5).
- Indirect CO_2 emissions from the decomposition of NMVOC in the atmosphere are accounted for by means of a Tier 2 approach (country specific).

3 Solvents

- Solvents: Approach is based on country specific industry data, surveys, statistics on number of employees and inhabitants, etc. Indirect CO2 emissions from the decomposition of NMVOC in the atmosphere are accounted for using a Dutch approach.

4 Agriculture

- 4A Enteric Fermentation (CH_4) and 4B Manure Management (CH_4): IPCC, Tier 2 method, Emission factors: Country specific.
- 4B Manure Management (CH_4, N_2O) and 4D Agricultural Soils (N_2O): The methods are country specific, derived from the IPCC Tier 2. Emission factors: CH_4 and N_2O IPCC default and country specific (CH_4).
- 4D Agricultural soils: Methods are Tier 1b, emission factors (N2O) are IPCC default.
- 4F Field Burning of Agricultural Residues: IPCC/CORINAIR default method and IPCC default emission factors.

5 LULUCF

- Methods: IPCC Tier 2 due to the Good Practice Guidance 2003 (IPCC 2003). Emission factors are mainly country specific, few are IPCC default factors.

6 Waste

- 6A Solid Waste Disposal on Land (CH_4): IPCC first order decay methane model,
  6A (CO_2), 6C Waste Incineration (CO_2): country specific Tier 2 method.
  Emission factors: Country specific and IPCC default.

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_2 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 2007). 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_2 emissions differing by only 1.73% in 2006 (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 SO_2, NO_x, N_2O, NH_3, NMVOC, CO, HCl, particulate matter, Pb, Zn, Cd, Hg, PCDD/PCDF, HF, HFC, PFC, SF6, CH_4, CO_2 (fossil/geological origin) and CO_2 (from biomass). 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. Emissions from EMIS that are relevant for the GHG inventory are exported to the CRF Reporter. As a quality control measure in the implementation of the new EMIS database, all the emission estimates are generated independently by (i) the new EMIS database and (ii) the Internal GHG Inventory Files, both using the same updated emission factors and activity data. The results are compared, and differences are used to identify and eliminate bugs. The output of the two approaches is fully congruent.

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 4).

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%. Tier 2 key category analyses have not been carried out yet.

Similar detailed disaggregation as in 2007 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 A1.1. The categories 2C Metal Production, 2F Consumption of Halocarbons and SF6 and 4D Agricultural Soils have been separated into the following sub-categories:

- 2C3 Metal Production; Aluminium Production CO_2 (No. 24 in Table 6)
- 2C3 Metal Production; Aluminium Production PFC (No. 25 in Table 6)
- 2C_o Metal Production; without Aluminium Production CO_2 (No. 23 in Table 6)
- 2F, sum of PFC (no key category, therefore not contained in Table 6)
- 2F_o, sum of HFC without HFC from 2F1 (No. 26 in Table 6)
- 2F1, HFC from 2F1 Refrigeration and Air Conditioning Equipment (No. 27 in Table 6)
- 2F_o, sum of SF_6 without SF_6 from 2F8 (no key category, therefore not contained in Table 6)
- 4D1, N_2O from Agricultural Soils, Direct Soil Emissions (No. 32 in Table 6)
- 4D3, N_2O from Agricultural Soils, Indirect Emissions (No. 33 in Table 6)
- 4D_o, N_2O from Agricultural Soils without 4D1-N_2O and without 4D3-N_2O (no key category in 2006, therefore not contained in Table 6),
- 4D_o, CH_4 from Agricultural Soils without 4D1-N_2O and without 4D3-N_2O (not occurring, no key category in 2006, therefore not contained in Table 6)

1.5.2. KCA without LULUCF categories

For 2006, among a total of 132 categories, 36 have been identified as key categories with an aggregated contribution of 97.3% to total national emissions. 25 categories are key due to the level assessment, 33 due to the trend assessment.

Of the 36 key categories, 21 are in sector 1 Energy, accounting for 81.3% of total CO_2 equivalent emissions in 2006. The other key categories are from sectors 2 Industrial Processes (4.9%), 3 Solvent and Other Product Use (0.3%), 4 Agriculture (9.6%), and 6 Waste (1.1%). There are two major key sources:

- 1A3b Energy, Fuel Combustion, Road Transportation, gasoline, CO_2, level contribution 20.1%,
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, liquid fuels, CO_2, level contribution 17.2%.

Compared to the key category analysis in the previous inventory report, CO_2 emissions from 2C_o Metal Production without Aluminium Production (KC Trend) is a new key category, while N_2O emissions from 3 Solvent and Other Product Use (previously KC Trend) is no longer a key category.

The following table shows the contributions of the individual key categories. The complete results of the key category analysis for 2006 are given in Annex A1.1.

Table 6 List of Switzerland's key categories 2006 without LULUCF categories, sorted by category code.

Key category analysis 2006 without LULUCF categories

	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate	Year 2006 Estimate	Level Assessm.	Trend Assessm.	%Contrib. in Trend	Result level assessm.	Result trend assessm.
							[Gg CO2eq]	[Gg CO2eq]					
1	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	321.38	0.60%	0.00158	0.6%	KC level	KC trend
2	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	912.20	1.71%	0.00402	1.6%	KC level	KC trend
3	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2'181.29	4.10%	0.01212	4.7%	KC level	KC trend
4	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	121.47	0.23%	0.00136	0.5%	-	KC trend
5	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.90	187.53	0.35%	0.00262	1.0%	KC level	KC trend
6	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'063.19	2'094.91	3.94%	0.01909	7.5%	KC level	KC trend
7	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'387.45	2'864.13	5.38%	0.01025	4.0%	KC level	KC trend
8	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	156.87	306.62	0.58%	0.00277	1.1%	KC level	KC trend
9	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'387.85	708.24	1.33%	0.01287	5.0%	KC level	KC trend
10	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	121.34	0.23%	0.00248	1.0%	-	KC trend
11	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'624.02	4'741.09	8.91%	0.03910	15.3%	KC level	KC trend
12	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'362.70	10'686.76	20.08%	0.01425	5.6%	KC level	KC trend
13	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.54	19.01	0.04%	0.00137	0.5%	-	KC trend
14	1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	122.40	0.23%	0.00148	0.6%	-	KC trend
15	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	942.41	1'429.27	2.69%	0.00894	3.5%	KC level	KC trend
16	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'392.19	3'741.09	7.03%	0.01278	5.0%	KC level	KC trend
17	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2'235.68	4.20%	0.01526	6.0%	KC level	KC trend
18	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	9'144.79	17.19%	0.02144	8.4%	KC level	KC trend
19	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	552.93	528.00	0.99%	0.00054	0.2%	KC level	-
20	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous Fuels	CO2	457.96	603.16	1.13%	0.00264	1.0%	KC level	KC trend
21	1B2	1. Energy	B. Fugitive Emissions fr	2. Oil and Natural Gas		CH4	380.46	174.45	0.33%	0.00390	1.5%	-	KC trend
22	2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'812.58	3.41%	0.01365	5.3%	KC level	KC trend
23	2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	177.39	0.33%	0.00119	0.5%	-	KC trend
24	2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	19.20	0.04%	0.00226	0.9%	-	KC trend
25	2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	2.82	0.01%	0.00183	0.7%	-	KC trend
26	2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	68.54	0.13%	0.00128	0.5%	-	KC trend
27	2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	548.89	1.03%	0.01024	4.0%	KC level	KC trend
28	3	3. Solvent and Other Product Use				CO2	357.17	185.64	0.35%	0.00325	1.3%	-	KC trend
29	4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	2'303.39	4.33%	0.00355	1.4%	KC level	KC trend
30	4B	4. Agriculture	B. Manure Management			CH4	557.43	501.59	0.94%	0.00112	0.4%	KC level	KC trend
31	4B	4. Agriculture	B. Manure Management			N2O	448.20	403.29	0.76%	0.00090	0.4%	KC level	-
32	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	1'205.54	2.27%	0.00364	1.4%	KC level	KC trend
33	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.84	1.28%	0.00266	1.0%	KC level	KC trend
34	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	290.66	0.55%	0.00760	3.0%	KC level	KC trend
35	6B	6. Waste	B. Wastewater Handling			N2O	190.66	212.01	0.40%	0.00037	0.1%	KC level	-
36	6D	6. Waste	D. Other			CH4	30.34	97.09	0.18%	0.00124	0.5%	-	KC trend

Table 7 List of Switzerland's key categories for the base year 1990 without LULUCF categories, sorted by category code.

No.	Key cetegoray analysis for the base year 1990 IPCC Source Categories and fuels if applicable (without LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2eq]	Level Assessm.
1	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	0.44%
2	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	1.31%
3	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2.88%
4	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'063.19	2.01%
5	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'387.45	6.42%
6	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'387.85	2.63%
7	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	0.48%
8	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'624.02	4.97%
9	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'362.70	21.52%
10	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	942.41	1.78%
11	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'392.19	8.32%
12	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2.66%
13	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	19.35%
14	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	552.93	1.05%
15	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous Fuels	CO2	457.96	0.87%
16	1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CH4	380.46	0.72%
17	2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	4.78%
18	3	3. Solvent and Other Product Use				CO2	357.17	0.68%
19	4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	4.69%
20	4B	4. Agriculture	B. Manure Management			CH4	557.43	1.06%
21	4B	4. Agriculture	B. Manure Management			N2O	448.20	0.85%
22	4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	0.38%
23	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	2.63%
24	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	1.55%
25	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	1.31%

There are 25 level key categories in the base year 1990 which are mostly key categories in 2006.

1.5.3. Combined KCA without and with LULUCF categories

The key category analysis including LULUCF categories is also carried out for 2006 and 1990. The complete results of the key category analysis for 2006 are shown in Annex A1.1. 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. The results are summarised in Table 8. and Table 9.

In the KCA for the year 2006 including LULUCF categories there are three additional categories out of the LULUCF sector:

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

5A1 Forest Land remaining Forest Land is a large category, contributing 5.7% to the level assessment. 5B1 and 5E2 contribute less to the level assessment with 1.0% and 0.5%, 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 6.

In the KCA for the year 1990, the same LULUCF categories are key categories.

The three LULUCF key categories 5A1, 5B1, 5E2 were also key in the analysis for 2005 as contained in the previous inventory report. However, 5C2 Land converted to Grassland was a key category in that analysis as well, which is now no longer the case.

Table 8 List of Switzerland's key categories, combined KCA without and with LULUCF categories 2006, sorted by category code.

Combined key category analysis 2006 without and with LULUCF categories													
	A					B	C	D	E-L	E-T	F-T	M	N
No.	IPCC Source Categories and fuels if applicable (combined key category analysis without and with LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2eq]	Year 2006 Estimate [Gg CO2eq]	Level Assessm.	Trend Assessm.	% Contrib. in Trend	Result level assessm.	Result trend assessm.
1	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	321.38	0.60%	0.001578	0.6%	KC level	KC trend
2	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	912.20	1.71%	0.004021	1.6%	KC level	KC trend
3	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2'181.29	4.10%	0.012118	4.7%	KC level	KC trend
4	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	121.47	0.23%	0.001355	0.5%	-	KC trend
5	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.90	187.53	0.35%	0.002616	1.0%	KC level	KC trend
6	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'063.19	2'094.91	3.94%	0.019087	7.5%	KC level	KC trend
7	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'387.45	2'864.13	5.38%	0.010249	4.0%	KC level	KC trend
8	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	156.87	306.62	0.58%	0.002770	1.1%	KC level	KC trend
9	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'387.85	708.24	1.33%	0.012875	5.0%	KC level	KC trend
10	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	121.34	0.23%	0.002484	1.0%	-	KC trend
11	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'624.02	4'741.09	8.91%	0.039103	15.3%	KC level	KC trend
12	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'362.70	10'686.76	20.08%	0.014247	5.6%	KC level	KC trend
13	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.54	19.01	0.04%	0.001366	0.5%	-	KC trend
14	1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	122.40	0.23%	0.001477	0.6%	-	KC trend
15	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	942.41	1'429.27	2.69%	0.008943	3.5%	KC level	KC trend
16	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'392.19	3'741.09	7.03%	0.012777	5.0%	KC level	KC trend
17	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2'235.68	4.20%	0.015259	6.0%	KC level	KC trend
18	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	9'144.79	17.19%	0.021445	8.4%	KC level	KC trend
19	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	552.93	528.00	0.99%	0.000545	0.2%	KC level	-
20	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous Fuels	CO2	457.96	603.16	1.13%	0.002642	1.0%	KC level	KC trend
21	1B2	1. Energy	B. Fugitive Emissions from	2. Oil and Natural Gas		CH4	380.46	174.45	0.33%	0.003897	1.5%	-	KC trend
22	2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'812.58	3.41%	0.013647	5.3%	KC level	KC trend
23	2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	177.39	0.33%	0.001195	0.5%	-	KC trend
24	2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	19.20	0.04%	0.002259	0.9%	-	KC trend
25	2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	2.82	0.01%	0.001830	0.7%	-	KC trend
26	2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	68.54	0.13%	0.001278	0.5%	-	KC trend
27	2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	548.89	1.03%	0.010236	4.0%	KC level	KC trend
28	3	3. Solvent and Other Product Use				CO2	357.17	185.64	0.35%	0.003251	1.3%	-	KC trend
29	4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	2'303.39	4.33%	0.003555	1.4%	KC level	KC trend
30	4B	4. Agriculture	B. Manure Management			CH4	557.43	501.59	0.94%	0.001122	0.4%	KC level	KC trend
31	4B	4. Agriculture	B. Manure Management			N2O	448.20	403.29	0.76%	0.000902	0.4%	KC level	-
32	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	1'205.54	2.27%	0.003640	1.4%	KC level	KC trend
33	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.84	1.28%	0.002656	1.0%	KC level	KC trend
34	*5A1*	*5. LULUCF*	*A. Forest Land*	*1. Forest Land remaining Forest Land*		*CO2*	*3'686.87*	*3'287.42*	*5.70%*	*0.006814*	*2.8%*	*KC level*	*KC trend*
35	*5B1*	*5. LULUCF*	*B. Cropland*	*1. Cropland remaining Cropland*		*CO2*	*584.63*	*572.40*	*0.99%*	*0.000193*	*0.1%*	*KC level*	-
36	*5E2*	*5. LULUCF*	*E. Settlements*	*2. Land converted to Settlements*		*CO2*	*405.66*	*315.35*	*0.55%*	*0.001555*	*0.6%*	*KC level*	*KC trend*
37	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	290.66	0.55%	0.007604	3.0%	KC level	KC trend
38	6B	6. Waste	B. Wastewater Handling			N2O	190.66	212.01	0.40%	0.000371	0.1%	KC level	-
39	6D	6. Waste	D. Other			CH4	30.34	97.09	0.18%	0.001240	0.5%	-	KC trend

Table 9 List of Switzerland's key categories for the base year 1990, combined KCA without and with LULUCF categories, sorted by category code.

Combined key category analysis 1990 without and with LULUCF categories									
	A					B	C	E-L	M
No.	IPCC Source Categories and fuels if applicable (combined key category analysis without and with LULUCF categories)					Direct GHG	Base Year 1990 Estimate [Gg CO2eq]	Level Assessm.	Result level assessm.
1	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	0.44%	KC level
2	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	1.31%	KC level
3	1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2.88%	KC level
4	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'063.19	2.01%	KC level
5	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'387.45	6.42%	KC level
6	1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'387.85	2.63%	KC level
7	1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	0.48%	KC level
8	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'624.02	4.97%	KC level
9	1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'362.70	21.52%	KC level
10	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	942.41	1.78%	KC level
11	1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'392.19	8.32%	KC level
12	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2.66%	KC level
13	1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	19.35%	KC level
14	1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	552.93	1.05%	KC level
15	1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous Fuels	CO2	457.96	0.87%	KC level
16	1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CH4	380.46	0.72%	KC level
17	2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	4.78%	KC level
18	3	3. Solvent and Other Product Use				CO2	357.17	0.68%	KC level
19	4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	4.69%	KC level
20	4B	4. Agriculture	B. Manure Management			CH4	557.43	1.06%	KC level
21	4B	4. Agriculture	B. Manure Management			N2O	448.20	0.85%	KC level
22	4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	0.38%	KC level
23	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	2.63%	KC level
24	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	1.55%	KC level
25	*5A1*	*5. LULUCF*	*A. Forest Land*	*1. Forest Land remaining Forest Land*		*CO2*	*3'686.87*	*6.38%*	*KC level*
26	*5B1*	*5. LULUCF*	*B. Cropland*	*1. Cropland remaining Cropland*		*CO2*	*584.63*	*1.01%*	*KC level*
27	*5E2*	*5. LULUCF*	*E. Settlements*	*2. Land converted to Settlements*		*CO2*	*405.66*	*0.70%*	*KC level*
28	6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	1.31%	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 2008a), 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

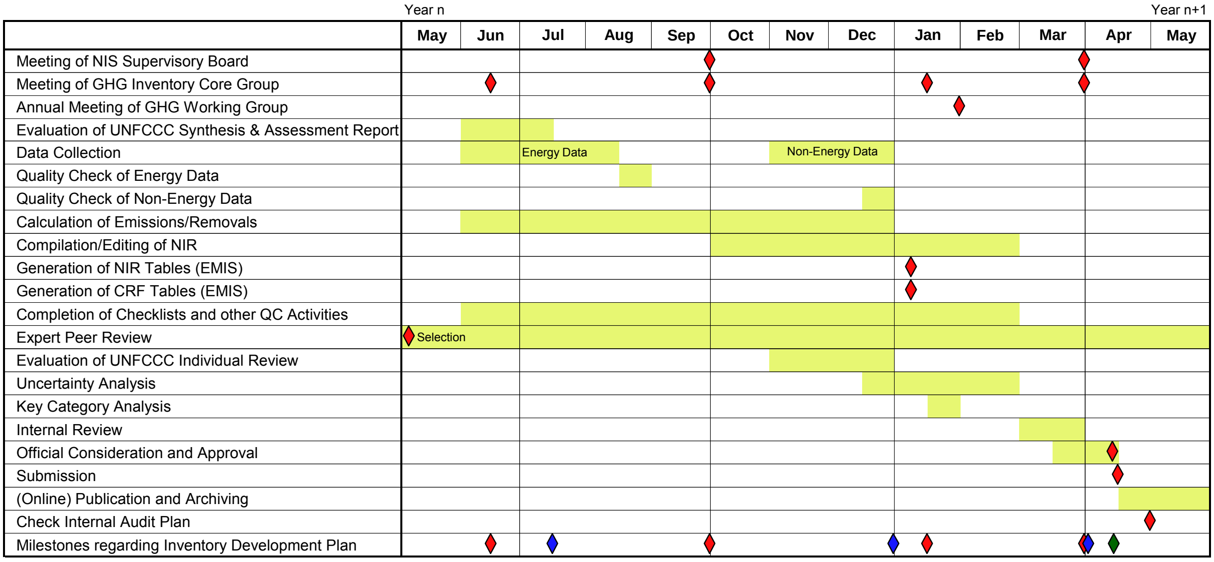
The quality manual constitutes the heart of the quality management system. It is designed as an interlinked compilation of all documents relevant to quality issues and runs on the FOEN Internal Document Management System (IDM).

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 2008a). Specific monitoring protocols for core und 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 links 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 2008a). Overall inventory work thus benefits from the quality manual and its services.

Table 10 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 10 Annual cycle of inventory planning, preparation, and management.



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 2008a: Chapter 3).

d) QA review procedures

QA procedures include an internal review of NIR, 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 results of the UNFCCC inventory review reports are evaluated by the Project Management together with the QA/QC Officer and subsequently used to update the IDP.

FOEN operates a homepage (www.climatereporting.ch) where the Swiss GHG inventories (NIR, CRF tables, QA/QC supplement), 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 inventory on hand 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 2005/(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 backups 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. The two exceptions relate to the reporting of emissions from synthetic gases and, to a small extent, from civil aviation.

The FOEN collects the data needed for calculating emissions of HFCs, PFCs and SF_6 from private companies or industry associations. In the National Inventory Report, the activity data underlying emissions estimates of HFCs, PFCs and SF_6 are only partly presented at the most disaggregated level for reasons of confidentiality. However, complete emissions are reported in aggregated tables. In the case of civil aviation a few activity data have been marked confidential by the Federal Office of Civil Aviation (FOCA).

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.

1.7. Uncertainty Evaluation

The uncertainty analyses of the April 2006 submission (FOEN 2006a) have been updated for the present submission. The main focus of the update was on the uncertainty of the agricultural sector, since half of the total uncertainty stems from this sector. This assessment was an essential element of the planned improvements in the agricultural sector.

The IPCC Good Practice Guidance lists two methodologies (Tier 1 and Tier 2) for calculating uncertainties. For relatively small and uncorrelated uncertainties where normal distributions are appropriate, use of error propagation equations (Tier 1) is suggested. If these assumptions are not fulfilled sufficiently, a Tier 2 Monte Carlo simulation is suggested. This simulation enables the attribution of correlations and probability distributions of any physically possible shape and width.

The current NIR presents both of these quantitative uncertainty evaluations. 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. In former uncertainty analyses, only key categories were accounted individually, the other sources were aggregated to a virtual category “rest of sources”. For the uncertainty analyses in the present submission, all non-key categories have been attributed with an adequate uncertainty (see Table 173 in the annex). 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 2nd International Workshop on Uncertainty in Greenhouse Gas Inventories (Vienna 27-28 Sep 2007) a list of overall uncertainties has been defined (see below).

In the sectoral chapters (energy, industrial processes, etc.), specific information is provided on the uncertainty estimation for activity data, emission factors or emissions from key category sources..

Since the May 2006 submission (FOEN 2006b), as suggested by the IPCC Guidelines (IPCC 1997a), uncertainties are expressed as half of the 95% confidence interval divided by the mean and expressed as a percentage (approximately 2 σ). In earlier submissions, uncertainties of emissions factors and activity data that were not based on IPCC default values have been defined as *one* standard deviation divided by the mean, i.e. about half the value of non-default uncertainties with the present definition.

1.7.1. Data Used

For many key data sources, no explicit information on uncertainties is available – e.g., the Swiss overall energy statistics (SFOE 2007) do not provide estimates of uncertainties. For these cases, the authors of the NIR chapters, the FOEN experts involved and several data suppliers derived first estimates of uncertainties based on the IPCC Good Practice Guidance 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 of 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.

1.7.2. 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 presented in Table 11 are used. They are motivated by the comparison of uncertainty analyses of several countries carried out by Keizer et al. (2007), as presented at the 2nd Internat. Workshop on Uncertainty in Greenhouse Gas Inventories (Vienna 27-28 Sep 2007), and by Table A1-1 of IPCC Guidelines, Vol. 1, Annex 1, Managing uncertainties (IPCC 1996).

Table 11 Semi-quantitative uncertainties (2 σ) for non-key categories.

Gas	Uncertainty category	Relative uncertainty
CO_2	low	2%
	medium	10%
	high	40%
CH_4	low	15%
	medium	30%
	high	60%
N_2O	low	40%
	medium	80%
	high	150%
HFC	medium	20%
PFC	medium	20%
SF_6	medium	20%

1.7.3. Results of Tier 1 Uncertainty Evaluation

With this submission, results of a new uncertainty evaluation are presented. In the previous (2007) submission, no update had been made for the uncertainty evaluation. The results of the Tier 1 uncertainty analysis for GHG emissions without LULUCF are summarised in Table 12 and Table 13. 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_2 equivalent emissions is estimated to be 3.50% (level uncertainty). Trend uncertainty is 1.73%.

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 12 Tier 1 uncertainty results for sources in Switzerland 2006 (IPCC 2000, Table 6.1).

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 2006 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combinded uncertainty as % of total national emission in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
			Gg CO2 eq	Gg CO2 eq	%	%	%	%	%	%	%	%	%
1. CO2 emissions from Fuel Combustion													
1A	1. Energy A. Fuel Combustion Gaseous fuels	CO2	3'696.03	6'113.68	5.0	4.6	6.8	0.781	0.0452	0.1158	0.21	0.82	0.84
1A	1. Energy A. Fuel Combustion Liquid fuels	CO2	34'303.41	33'642.65	1.0	0.5	1.1	0.720	-0.0174	0.6372	-0.01	0.90	0.90
1A	1. Energy A. Fuel Combustion Solid fuels	CO2	1'491.85	930.91	5.7	5.0	7.6	0.133	-0.0108	0.0176	-0.05	0.14	0.15
1A	1. Energy A. Fuel Combustion Other fuels	CO2	1'676.60	2'487.90	10.0	30.0	31.6	1.479	0.0151	0.0471	0.45	0.67	0.81
Total CO2 Emissions Fuel Combustion		CO2	41'167.90	43'175.15									
A		B	C	D	E	F	G	H	I	J	K	L	M
			Gg CO2 eq	Gg CO2 eq	%	%	%	%	%	%	%	%	%
2. Emissions which are not CO2 emissions from Fuel Combustion													
Key Sources													
1A1	1. Energy A. Fuel Combustion 1. Energy Industries Other Fuels	N2O	48.42	121.47	10.0	80.0	80.6	0.184	0.0014	0.0023	0.11	0.03	0.11
1A3b	1. Energy A. Fuel Combustion 3. Transport; Road Tı Gasoline	CH4	91.54	19.01	10.0	*59.2*	60.0	0.021	-0.0014	0.0004	-0.08	0.01	0.08
1B2	1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	CH4	380.46	174.45		*50.0*	50.0	0.164	-0.0040	0.0033	-0.20	0.00	0.20
2A1	2. Industrial Proc. A. Mineral Products; Cement Production-CO2	CO2	2'524.77	1'812.58	2.0	6.0	6.3	0.215	-0.0139	0.0343	-0.08	0.10	0.13
2C3	2. Industrial Proc. C. Metal Production; Aluminium Production-CO2	CO2	139.26	19.20	5.0	30.0	30.4	0.011	-0.0023	0.0004	-0.07	0.00	0.07
2C3	2. Industrial Proc. C. Metal Production; Aluminium Production-PFC	PFC	100.17	2.82	2.0	48.9	49.0	0.003	-0.0019	0.0001	-0.09	0.00	0.09
2C_o	2. Industrial Proc. C. Metal Production without Aluminium Production	CO2	112.45	177.39	2.0	40.0	40.0	0.134	0.0012	0.0034	0.05	0.01	0.05
2F1	2. Industrial Proc. F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	548.89		13.8	13.8	0.143	0.0104	0.0104	0.14	0.00	0.14
2F_o	2. Industrial Proc. F. Consumption of Halocarbons and SF6 without 2F1-HFC	HFC	0.00	68.54		21.9	21.9	0.028	0.0013	0.0013	0.03	0.00	0.03
3	3. Solvent and Other Product Use	CO2	357.17	185.64		50.0	50.0	0.174	-0.0033	0.0035	-0.17	0.00	0.17
4A	4. Agriculture A. Enteric Fermentation	CH4	2'474.84	2'303.39	6.4	17.2	18.3	0.794	-0.0036	0.0436	-0.06	0.40	0.40
4B	4. Agriculture B. Manure Management	CH4	557.43	501.59	6.4	54.1	54.5	0.514	-0.0011	0.0095	-0.06	0.09	0.11
4B	4. Agriculture B. Manure Management	N2O	448.20	403.29		63.1	63.1	0.478	-0.0009	0.0076	-0.06	0.00	0.06
4D1	4. Agriculture D. Agricultural Soils; Direct Soil Emissions	N2O	1'389.94	1'205.54		76.5	76.5	1.733	-0.0037	0.0228	-0.28	0.00	0.28
4D3	4. Agriculture D. Agricultural Soils; Indirect Emissions	N2O	818.89	682.84		159.1	159.1	2.042	-0.0027	0.0129	-0.43	0.00	0.43
6A	6. Waste A. Solid Waste Disposal on Land	CH4	693.04	290.66	20.0	56.6	60.0	0.328	-0.0077	0.0055	-0.44	0.16	0.46
6B	6. Waste B. Wastewater Handling	N2O	190.66	212.01	0.003	100.0	100.0	0.398	0.0004	0.0040	0.04	0.00	0.04
6D	6. Waste D. Other	CH4	30.34	97.09	10.0	*49.0*	50.0	0.091	0.0013	0.0018	0.06	0.03	0.07
Non Key Sources													
	Rest of sources		1274.63	1'207.53		*17.8*	17.8	0.404	-0.0015	0.0229	-0.03	0.00	0.03
Total emissions which are not CO2 emissions from Fuel Combustion			11'632.24	10'033.92									
A		B	C	D				H					M
3. Total (combined uncertainty of 1. and 2.)													
Total Emissions		all gases	52'800.14	53'209.07									
Total Uncertainties							**Overall uncertainty in the year (%)**	**3.50**				**Trend uncertainty (%)**	**1.73**

Tier 1 Uncertainty calculation and reporting for sources in Switzerland 2006 (continued).

Table 6.1 (CONTINUED)
Tier 1 Uncertainty Calculation and Reporting

A (continued)					B	N	O	P	Q
IPCC Source category					Gas	Emission factor quality indicator IPCC **D**efault, **M**easurement based, national **R**eferenced data	Activity data quality indicator IPCC **D**efault, **M**easurement based, national **R**eferenced data	Expert judgement reference numbers	Reference to section in NIR
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
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	R	R		Section 4.4.3
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	M	M		Section 4.4.3
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
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			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
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
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	R	R		Section 8.2.3
6D	6. Waste	D. Other			CH4	R	R		Section 8.5.3
	Rest of sources				CO2	R	R		Exp. est.

Table 13 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 2006 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combinded uncertainty as % of total national emission in year 2006
						Gg CO2 eq	Gg CO2 eq	%	%	%	%
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.84		159.1	159.1	2.042
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	1'205.54		76.5	76.5	1.733
1A	1. Energy	A. Fuel Combustion		Other fuels	CO2	1'676.60	2'487.90	10.0	30.0	31.6	1.479
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	2'303.39	6.4	17.2	18.3	0.794
1A	1. Energy	A. Fuel Combustion		Gaseous fuels	CO2	3'696.03	6'113.68	5.0	4.6	6.8	0.781
1A	1. Energy	A. Fuel Combustion		Liquid fuels	CO2	34'303.41	33'642.65	1.0	0.5	1.1	0.720
4B	4. Agriculture	B. Manure Management			CH4	557.43	501.59	6.4	54.1	54.5	0.514
4B	4. Agriculture	B. Manure Management			N2O	448.20	403.29		63.1	63.1	0.478
	Rest of sources					1'274.63	1'207.53		17.8	17.8	0.404
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	290.66	20.0	56.6	60.0	0.328
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'812.58	2.0	6.0	6.3	0.215
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	121.47	10.0	80.0	80.6	0.184
3	3. Solvent and Other Product Use				CO2	357.17	185.64		50.0	50.0	0.174
1B2	1. Energy	B. Fugitive Emissions	2. Oil and Natural Gas		CH4	380.46	174.45		50.0	50.0	0.164
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	548.89		13.8	13.8	0.143
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	177.39	2.0	40.0	40.0	0.134
1A	1. Energy	A. Fuel Combustion		Solid fuels	CO2	1'491.85	930.91	5.7	5.0	7.6	0.133
6D	6. Waste	D. Other			CH4	30.34	97.09	10.0	49.0	50.0	0.091
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	68.54		21.9	21.9	0.028
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Tı	Gasoline	CH4	91.54	19.01	10.0	59.2	60.0	0.021
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	19.20	5.0	30.0	30.4	0.011
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	2.82	5.0	48.7	49.0	0.003

Ranked by their contribution to uncertainty in the total national emissions level (cf. Column H, Table 13), indirect and direct emissions of N_2O from Agricultural Soils, CO_2 from 1A Fuel Combustion Activities (Other fuels) and CH_4 from Enteric Fermentation are the top four contributors. Their combined uncertainty amounts to 6.0% of total national emissions in 2004. The table permits the identification of future areas of improvement in the context of the Inventory Development Plan (IDP).

1.7.4. 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 present analysis, 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 A1.2.2). 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.

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 A1.2.2. For consistency reasons, Crystal Ball software adjusted a few of the correlation coefficients by an average of 0.10.

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 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 5). The uncertainty estimates as derived from the Monte Carlo simulations are shown in Table 14.

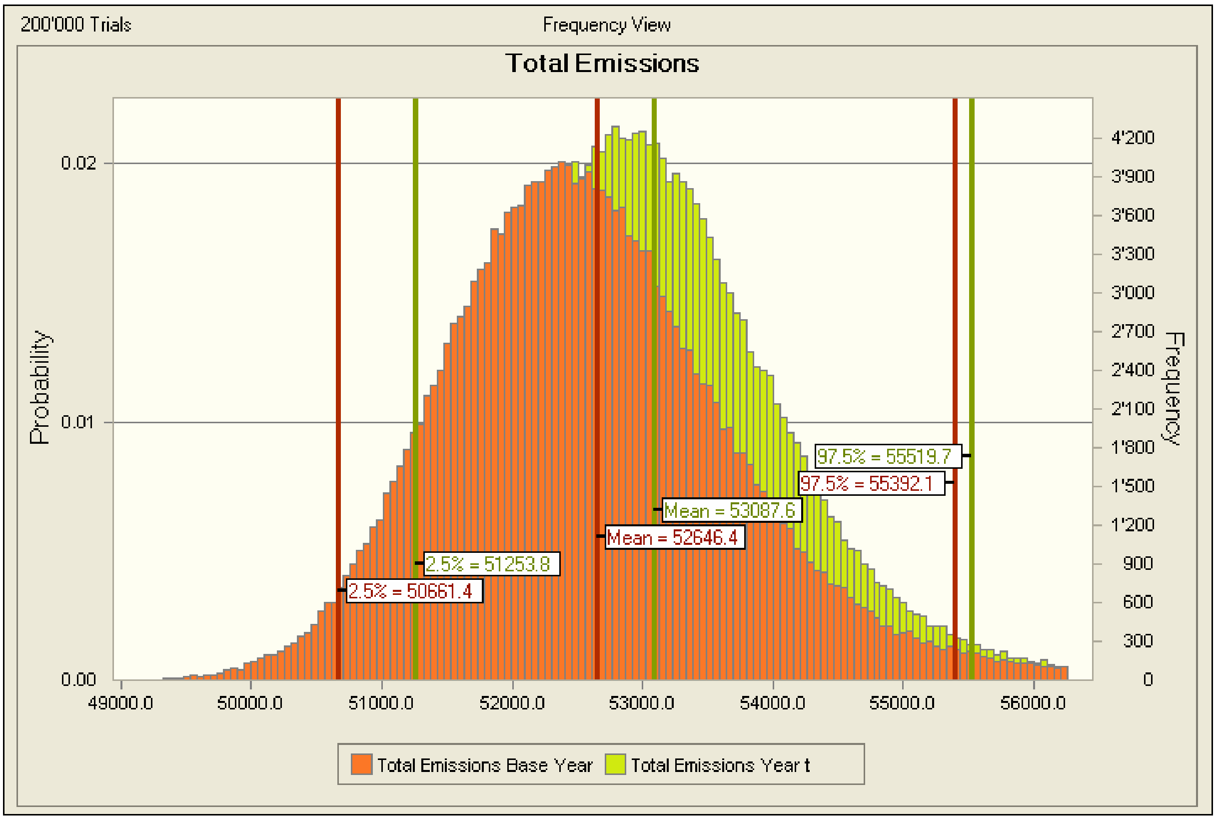


Figure 5 Probability distributions of total emissions for the base year (1990) and year t (2006) based on the submission of April 2008. On the x-axis, the total emissions reported in the Swiss inventory (without CO_2 from LULUCF) are given in Gg CO_2 equivalent. Number of Monte Carlo runs: 200'000. The 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 179 in Annex A1.2.2.

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_2 equivalent) of the total GHG emissions (53'209 Gg CO_2 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 present uncertainty analysis with 2006 data.

The trend uncertainty, 2.8% is significantly lower than reported in the previous submissions (5.8%) based on the simulation in FOEN (2006a). The modification results from an error correction and a new assumption.

- Error correction: It is assumed that the emission factors do not change between 1990 and year t and therefore are fully correlated (r = 1). In the calculations for the previous submission, the correlations were defined but not accounted for in the simulation process due to memory overflow. If the simulation is carried out correctly, one notes that the correlation have a striking effect on the trend uncertainty: Without correlation it is 6.3%, with full correlations (r = 1) it drops down to 3.5%.
- In former simulations, the activity data between 1990 and year t were treated as independent variables (as recommended by IPCC 2000). A close look at the methods to obtain the Swiss activity data shows that their determination in year t is not really independent from 1990 but is actually correlated positively. Therefore, correlations were introduced for each category between 1990 and 2006 (r = 0.8). This assumption is relevant: If the correlations are switched on, the trend uncertainty is lowered from 3.5% to 2.8%.

Table 14 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 181 in Annex A1.2.

A	B	C	D	E	F	G	H	I	J
IPPC Source Category	Gas	Base year (1990) emissions	Year t (2006) emissions	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t	% change in emissions between year t and base year	Range of likely % change between year t and base year	
		(Gg CO2 equivalent)	(Gg CO2 equivalent)	% below (2.5 percentile)	% above (97.5 percentile)	(%)	(%)	% below (2.5 percentile)	% above (97.5 percentile)
1A A. Fuel Combustion									
1A1 1. Energy Industries Gaseous Fuels	CO2	235	321	93	107	0.04	36.8	33	41
1A1 1. Energy Industries Liquid Fuels	CO2	691	912	99	101	0.02	32.0	31	33
1A1 1. Energy Industries Other Fuels	CO2	1520	2181	72	134	1.27	43.5	30	61
1A1 1. Energy Industries Solid Fuels	CO2	47	188	93	108	0.03	299.8	277	324
1A1 1. Energy Industries Other Fuels	N2O	48	121	21	180	0.18	150.9	32	273
1A2 2. Manufacturing Industries and Construction Gaseous Fuels	CO2	1063	2095	90	110	0.39	97.0	85	109
1A2 2. Manufacturing Industries and Construction Liquid Fuels	CO2	3387	2864	98	102	0.09	-15.4	-16	-14
1A2 2. Manufacturing Industries and Construction Other Fuels	CO2	157	307	53	158	0.31	95.5	42	160
1A2 2. Manufacturing Industries and Construction Solid Fuels	CO2	1388	708	92	109	0.11	-49.0	-53	-45
1A3a 3. Transport; Civil Aviation	CO2	253	121	99	101	0.00	-52.0	-53	-51
1A3b 3. Transport; Road Transportation Diesel	CO2	2624	4741	99	101	0.13	80.7	79	83
1A3b 3. Transport; Road Transportation Gasoline	CO2	11363	10687	98	102	0.31	-5.9	-7	-5
1A3b 3. Transport; Road Transportation Gasoline	CH4	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	CO2	942	1429	90	110	0.27	51.7	43	60
1A4a 4. Other Sectors; Commercial/Institutional Liquid Fuels	CO2	4392	3741	98	102	0.12	-14.8	-16	-14
1A4b 4. Other Sectors; Residential Gaseous Fuels	CO2	1407	2236	95	105	0.20	58.9	56	62
1A4b 4. Other Sectors; Residential Liquid Fuels	CO2	10216	9145	98	102	0.30	-10.5	-12	-9
1A4c 4. Other Sectors; Agriculture/Forestry Liquid Fuels	CO2	553	528	98	102	0.02	-4.5	-6	-3
1A5 5. Other Liquid Fuels	CO2	449	586	99	101	0.02	30.3	29	32
1A5 5. Other Gaseous Fuels	CO2	9	18	90	110	0.00	103.2	91	116
1B B. Fugitive Emissions from Fuels									
1B2 2. Oil and Natural Gas	CH4	380	174	51	149	0.16	-54.1	-84	-24
2 Industrial Processes									
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	*	*	*
3 Solvent and Other Product Use	CO2	357	186	51	149	0.17	-48.0	-76	-20
4 Agriculture									
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	N2O	42	37	15	112	0.03	-13.8	-28	6
4B B. Manure Management solid	N2O	406	367	38	150	0.39	-9.6	-33	12
4D1 D. Agricultural Soils; Direct Soil Emissions fertilizer	N2O	1324	1139	21	181	1.71	-13.9	-55	27
4D1 D. Agricultural Soils; Direct Soil Emissions organic soil	N2O	66	66	24	193	0.11	0.0	-66	67
4D3 D. Agricultural Soils; Indirect Emissions deposition	N2O	272	235	18	209	0.42	-13.7	-103	56
4D3 D. Agricultural Soils; Indirect Emissions leaching and runof	N2O	546	448	8	482	2.00	-18.1	-182	85
6 Waste									
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 15. The relative uncertainty of CO_2 is very low in accordance with the high precision of fuel statistics and carbon contents of fuels. CH_4 and synthetic gases have medium uncertainties. N_2O has the highest uncertainty in relative and absolute terms.

Table 15 Uncertainties by gas using Monte Carlo simulation for the emissions in 2006.

Gas	**Emission 2006 (excl. LULUCF)** Gg CO_2 eq	**Lower bound 2.5 percentile** Gg CO_2 eq	**Upper bound 97.5 percentile** Gg CO_2 eq	**Mean absolute uncertainty** Gg CO_2 eq	**Mean relative uncertainty** %
CO_2	45561	44768	46453	842	1.8%
CH_4	3538	2893	4184	645	18.2%
N_2O	3274	1762	5338	1788	56.7%
HFC	617	529	705	88	14.3%
PFC	56	48	64	8	14.3%
SF_6	162	146	179	17	10.2%
Total	53209	1869	2357	2113	4.02%

1.7.5. 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. This value is somewhat larger then the result of Tier 1 uncertainty analysis (3.50%). The trend uncertainty of Tier 2, 2.8%, is larger than that of Tier 1 analysis,1.7%. 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_2) 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 A1.2.2.) 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. From today's 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 1990–2006.

2.1. *Aggregated Greenhouse Gas Emissions 2006*

In 2006, Switzerland emitted 53’209 Gg CO_2 equivalent (excluding LULUCF) to the atmosphere, or 7.04 tonnes CO_2 equivalent per capita (inhabitants 2006: 7.557 million, SFOE 2007). The largest contributor gas was CO_2, 45’561 Gg (6.03 tonnes per capita), and the most important source was sector 1 Energy, 43’924 Gg CO_2 equivalent. Table 16 shows emissions by gas and sector in Switzerland for the year 2006. A breakdown of Switzerland’s total emissions by gas (excluding LULUCF) is given in Figure 6. Figure 7 charts the relative contributions of the individual sectors (excluding LULUCF) to the emission of each GHG.

Table 16 Switzerland’s GHG emissions in CO_2 equivalent (Gg) by gas and sector, 2006.

Emissions 2006	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**Total**	**Share**
	CO_2 equivalent (Gg)							
1 All Energy	43'286	291	347				43'924	**82.5%**
2 Industrial Processes	2'074	7	144	617	56	162	3'061	**5.8%**
3 Solvent Use	186		53				238	**0.4%**
4 Agriculture (1 year average)		2'815	2'473				5'288	**9.9%**
6 Waste	15	425	257				697	**1.3%**
Total (excluding LULUCF)	45'561	3'538	3'274	617	56	162	53'209	**100.0%**
5 LULUCF	-2'237	1	6				-2'230	**-4.2%**
Total (including LULUCF)	43'324	3'539	3'280	617	56	162	50'979	**95.8%**
International Bunkers	*3'668*	*1*	*36*				*3'705*	

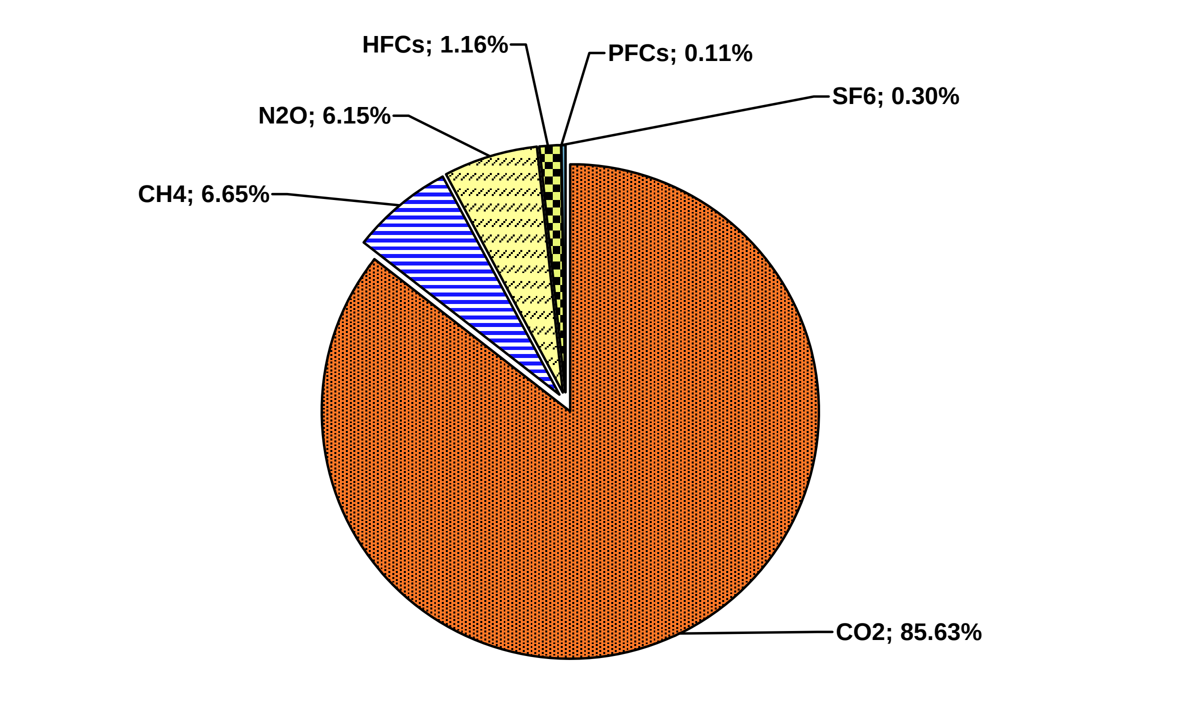


Figure 6 Contribution of individual gases to Switzerland's GHG emissions (excluding LULUCF) in 2006. 100% = 3'209 CO_2 eq (Gg).

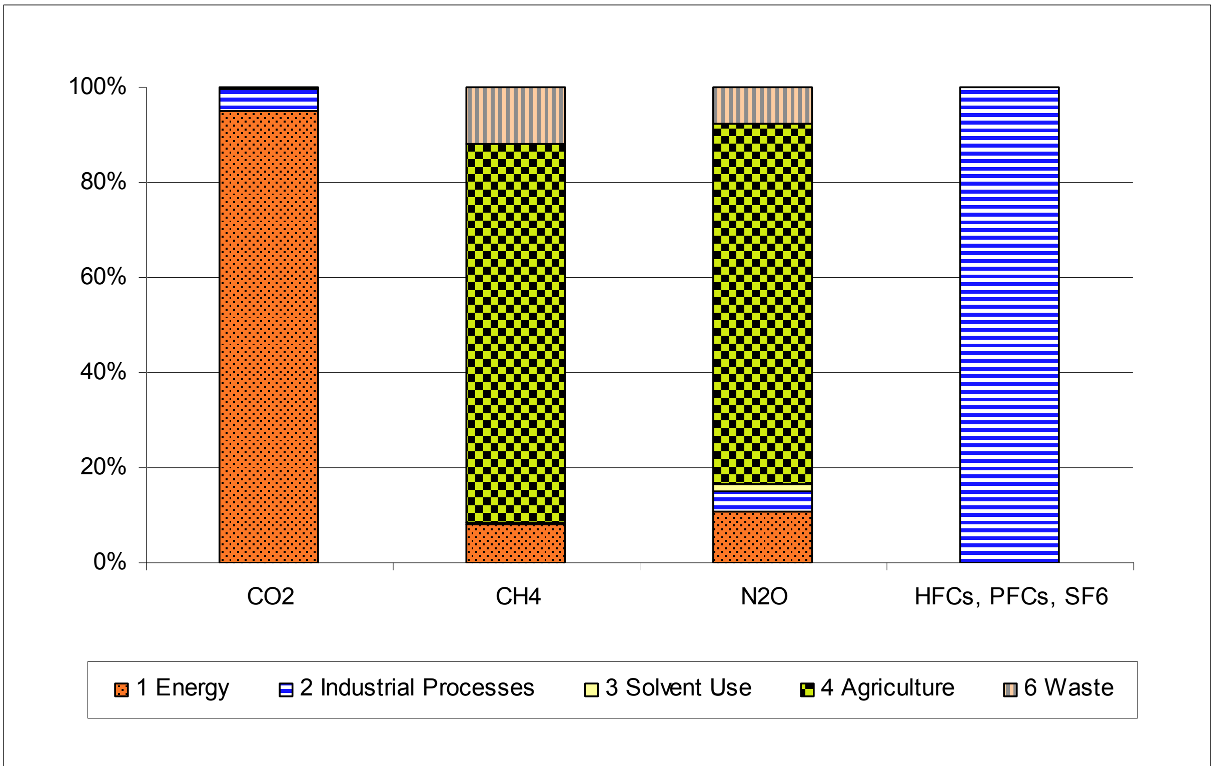


Figure 7 Relative contributions of the individual sectors (excluding LULUCF) to GHG emissions in 2006.

Fuel combustion within the energy sector was by far the largest source of emissions of CO_2 in 2006. Emissions of CH_4 and N_2O 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 1990–2006 are summarized in Table 17.

Table 17 Switzerland's GHG emissions in CO_2 equivalent (Gg) by gas, 1990–2006 (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 2006 as compared to the base year 1990.

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	CO_2 equivalent (Gg)									
CO_2 emissions including net CO_2 from LULUCF	41'963	46'578	45'998	39'269	38'486	39'552	41'139	40'092	42'932	39'148
CO_2 emissions excluding net CO_2 from LULUCF	44'558	46'194	46'216	43'625	42'852	43'338	44'027	43'360	44'586	44'817
CH_4 emissions including CH_4 from LULUCF	4'382	4'351	4'240	4'100	4'007	3'990	3'933	3'864	3'799	3'747
CH_4 emissions excluding CH_4 from LULUCF	4'374	4'350	4'239	4'100	4'005	3'987	3'931	3'853	3'797	3'747
N_2O emissions including N_2O from LULUCF	3'637	3'652	3'626	3'580	3'575	3'504	3'550	3'430	3'426	3'410
N_2O emissions excluding N_2O from LULUCF	3'625	3'644	3'618	3'572	3'567	3'495	3'542	3'418	3'419	3'404
HFCs	0	0	6	13	29	169	209	271	317	364
PFCs	100	85	69	30	18	15	17	24	28	40
SF_6	144	146	148	126	112	95	92	130	159	146
Total (including LULUCF)	**50'226**	**54'813**	**54'087**	**47'117**	**46'227**	**47'324**	**48'941**	**47'812**	**50'662**	**46'855**
Total (excluding LULUCF)	**52'800**	**54'420**	**54'298**	**51'465**	**50'583**	**51'098**	**51'819**	**51'056**	**52'306**	**52'518**

Greenhouse Gas Emissions	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	Change base year to 2006 (%)
	CO2 equivalent (Gg)							
CO_2 emissions including net CO_2 from LULUCF	44'749	43'531	42'539	46'390	43'998	45'208	43'324	*3.2%*
CO_2 emissions excluding net CO_2 from LULUCF	43'916	44'703	43'783	44'906	45'360	46'067	45'561	*2.3%*
CH_4 emissions including CH_4 from LULUCF	3'697	3'709	3'649	3'547	3'527	3'542	3'539	*-19.2%*
CH_4 emissions excluding CH_4 from LULUCF	3'697	3'708	3'646	3'542	3'527	3'541	3'538	*-19.1%*
N_2O emissions including N_2O from LULUCF	3'431	3'410	3'409	3'327	3'326	3'297	3'280	*-9.8%*
N_2O emissions excluding N_2O from LULUCF	3'425	3'404	3'402	3'319	3'320	3'291	3'274	*-9.7%*
HFCs	425	501	523	582	649	638	617	
PFCs	93	52	51	87	74	56	56	*-44.0%*
SF_6	203	235	210	195	176	196	162	*13.0%*
Total (including LULUCF)	**52'598**	**51'438**	**50'383**	**54'127**	**51'750**	**52'937**	**50'979**	***1.50%***
Total (excluding LULUCF)	**51'759**	**52'604**	**51'616**	**52'632**	**53'106**	**53'790**	**53'209**	***0.77%***

The emission trends for individual gases are as follows (see Table 17 above, Table 18 and Figure 8 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). In the period 1994–2006, a slightly increasing trend of +0.4% per annum may be identified. The 2006 total emissions increased by 0.77% as compared to the emissions recorded in the base year 1990. CO_2 contributed the largest share of emissions, accounting for 85.6% of the total in 2006.
- Total emissions (including LULUCF) in 2006 show an increase of 1.50% 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 annual climatic parameters, the net CO_2 emissions from LULUCF show considerable variability from year to year.
- A comparison of CO_2 emissions with the number of heating degree days (definition is shown in footnote 3) in the period 1990–2006 (see Figure 13 below) indicates a strong correlation between CO_2 emissions and winter climatic conditions.
- Between 1990 and 2006, CH_4 decreased by 19.2%, 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_4 share of total GHG emissions decreased from 8.3% in 1990 to 6.7% in 2006.

- In parallel to the reduction of CH_4 due to decreases in livestock populations, N_2O emissions from manure management and agricultural soils declined by 9.8% between 1990 and 2006.
- HFC emissions increased significantly due to their application as substitutes for CFCs, while PFC emissions declined by 44.0%. SF_6 emissions have shown relatively large fluctuations between 92 and 235 Gg CO_2 equivalent since 1990. In 2006, SF_6 emissions increased by 13.0% compared to 1990. The share of all synthetic gases combined rose from 0.5% in 1990 to 1.6% in 2006.

Table 18 Switzerland's total GHG emissions (excluding LULUCF) in CO_2 equivalent (Gg), selected years.

Greenhouse Gas Emissions	**1990**		**1995**		**2000**		**2005**		**2006**	
(excluding LULUCF)	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
CO_2	44'558	84.4%	43'338	84.8%	43'916	84.8%	46'067	85.6%	45'561	85.6%
CH_4	4'374	8.3%	3'987	7.8%	3'697	7.1%	3'541	6.6%	3'538	6.6%
N_2O	3'625	6.9%	3'495	6.8%	3'425	6.6%	3'291	6.1%	3'274	6.2%
HFCs	0	0.0%	169	0.3%	425	0.8%	638	1.2%	617	1.2%
PFCs	100	0.2%	15	0.0%	93	0.2%	56	0.1%	56	0.1%
SF_6	144	0.3%	95	0.2%	203	0.4%	196	0.4%	162	0.3%
Total (excluding LULUCF)	**52'800**	**100%**	**51'098**	**100%**	**51'759**	**100%**	**53'790**	**100%**	**53'209**	**100%**

Figure 8 below shows Switzerland's relative GHG emission trends by gas. The base year 1990 is set to 100%.

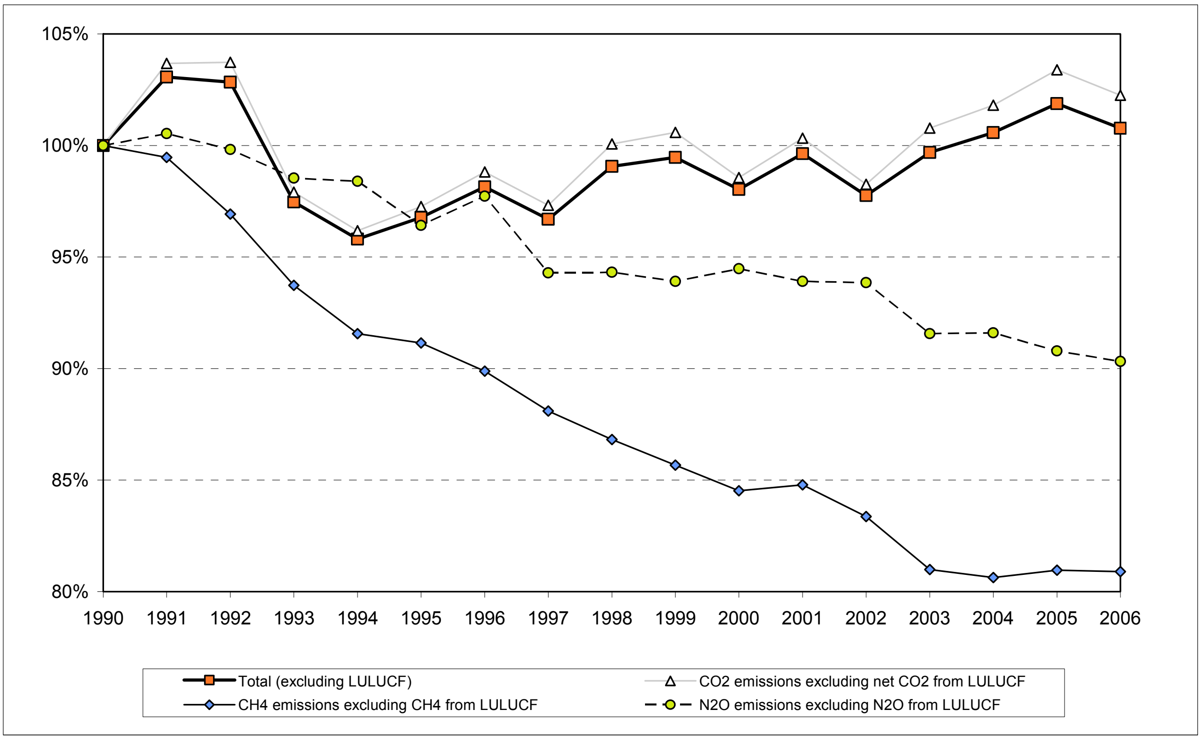


Figure 8 Relative trend of Switzerland's GHG emissions excluding LULUCF by gas, 1990–2006 (base year 1990 = 100%). The increase of the synthetic gases is not shown (342% in 2006, compared to 1990).

2.3. Emission Trends by Sources and Sinks

Table 19 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 19 Switzerland's GHG emissions in CO_2 equivalent (Gg) by sources and sinks, 1990–2006. The column below on the far right (digits in italics) indicates the percentage change in emissions in 2006 as compared to the base year 1990.

Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
1. Energy	**42'142**	**44'138**	**44'292**	**41'928**	**41'006**	**41'671**	**42'558**	**42'067**	**43'293**	**43'501**
1A1 Energy Industries	2'545	2'827	2'911	2'564	2'589	2'619	2'829	2'793	3'116	2'966
1A2 Manufacturing Industries and Construction	6'057	5'943	5'789	5'591	5'630	5'512	5'398	5'465	5'636	5'719
1A3 Transport	14'811	15'295	15'615	14'538	14'717	14'387	14'431	14'997	15'198	15'785
1A4 Other Sectors	17'743	19'093	19'017	18'290	17'124	18'214	18'964	17'884	18'410	18'087
1A5 Other (Offroad)	466	482	498	514	531	547	558	568	579	590
1B Fugitive emissions from oil and natural gas	520	497	462	432	416	392	379	361	353	355
2. Industrial Processes	**3'258**	**2'912**	**2'745**	**2'438**	**2'617**	**2'560**	**2'411**	**2'321**	**2'429**	**2'523**
3. Solvent and Other Product Use	**467**	**445**	**425**	**401**	**386**	**368**	**346**	**324**	**302**	**292**
4. Agriculture	**5'903**	**5'907**	**5'833**	**5'755**	**5'706**	**5'638**	**5'655**	**5'499**	**5'468**	**5'410**
6. Waste	**1'030**	**1'018**	**1'004**	**943**	**867**	**861**	**848**	**845**	**814**	**791**
Total (excluding LULUCF)	**52'800**	**54'420**	**54'298**	**51'465**	**50'583**	**51'098**	**51'819**	**51'056**	**52'306**	**52'518**
5. Land Use, Land-Use Change and Forestry	-2'574	393	-211	-4'348	-4'356	-3'774	-2'878	-3'244	-1'644	-5'663
Total (including LULUCF)	**50'226**	**54'813**	**54'087**	**47'117**	**46'227**	**47'324**	**48'941**	**47'812**	**50'662**	**46'855**

Source and Sink Categories	2000	2001	2002	2003	2004	2005	2006	*2006/1990*
	CO_2 equivalent (Gg)							%
1. Energy	**42'448**	**43'213**	**42'314**	**43'450**	**43'799**	**44'398**	**43'924**	***4.2%***
1A1 Energy Industries	2'886	3'019	3'083	3'066	3'381	3'527	3'730	***46.5%***
1A2 Manufacturing Industries and Construction	5'811	5'921	5'736	5'795	5'815	5'930	6'023	***-0.6%***
1A3 Transport	16'018	15'710	15'585	15'751	15'853	15'927	16'011	***8.1%***
1A4 Other Sectors	16'799	17'618	16'992	17'949	17'855	18'120	17'263	***-2.7%***
1A5 Other (Offroad)	600	603	605	607	609	611	612	***31.5%***
1B Fugitive emissions from oil and natural gas	334	342	313	282	285	282	285	***-45.2%***
2. Industrial Processes	**2'846**	**2'958**	**2'913**	**2'949**	**3'095**	**3'159**	**3'061**	***-6.0%***
3. Solvent and Other Product Use	**281**	**271**	**259**	**250**	**237**	**238**	**238**	***-49.0%***
4. Agriculture	**5'411**	**5'416**	**5'391**	**5'285**	**5'259**	**5'281**	**5'288**	***-10.4%***
6. Waste	**772**	**747**	**740**	**698**	**717**	**714**	**697**	***-32.3%***
Total (excluding LULUCF)	**51'759**	**52'604**	**51'616**	**52'632**	**53'106**	**53'790**	**53'209**	***0.77%***
5. Land Use, Land-Use Change and Forestry	839	-1'166	-1'233	1'496	-1'356	-854	-2'230	*-13.3%*
Total (including LULUCF)	**52'598**	**51'438**	**50'383**	**54'127**	**51'750**	**52'937**	**50'979**	***1.50%***

The percentage shares of source categories are shown for selected years in Table 20. Figure 9 through Figure 12 are graphical representations of Table 19 data. For the time series of the sub-sectors of 1 Energy see Chapter 3.

Table 20 Switzerland’s total gross GHG emissions (excluding LULUCF) in CO_2 equivalent (Gg) and the contribution of individual source categories, selected years.

Source and Sink Categories	**1990**		**1995**		**2000**		**2005**		**2006**	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1. Energy	42'142	79.8%	41'671	81.6%	42'448	82.0%	44'398	82.5%	43'924	82.5%
1A1 Energy Industries	*2'545*	*4.8%*	*2'619*	*5.1%*	*2'886*	*5.6%*	*3'527*	*6.6%*	*3'730*	*7.0%*
1A2 Manufacturing Industries and Construction	*6'057*	*11.5%*	*5'512*	*10.8%*	*5'811*	*11.2%*	*5'930*	*11.0%*	*6'023*	*11.3%*
1A3 Transport	*14'811*	*28.1%*	*14'387*	*28.2%*	*16'018*	*30.9%*	*15'927*	*29.6%*	*16'011*	*30.1%*
1A4 Other Sectors	*17'743*	*33.6%*	*18'214*	*35.6%*	*16'799*	*32.5%*	*18'120*	*33.7%*	*17'263*	*32.4%*
1A5 Other (Offroad)	*466*	*0.9%*	*547*	*1.1%*	*600*	*1.2%*	*611*	*1.1%*	*612*	*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%*
2. Industrial Processes	3'258	6.2%	2'560	5.0%	2'846	5.5%	3'159	5.9%	3'061	5.8%
3. Solvent and Other Product Use	467	0.9%	368	0.7%	281	0.5%	238	0.4%	238	0.4%
4. Agriculture	5'903	11.2%	5'638	11.0%	5'411	10.5%	5'281	9.8%	5'288	9.9%
6. Waste	1'030	1.9%	861	1.7%	772	1.5%	714	1.3%	697	1.3%
Total (excluding LULUCF)	**52'800**	**100.0%**	**51'098**	**100.0%**	**51'759**	**100.0%**	**53'790**	**100.0%**	**53'209**	**100.0%**

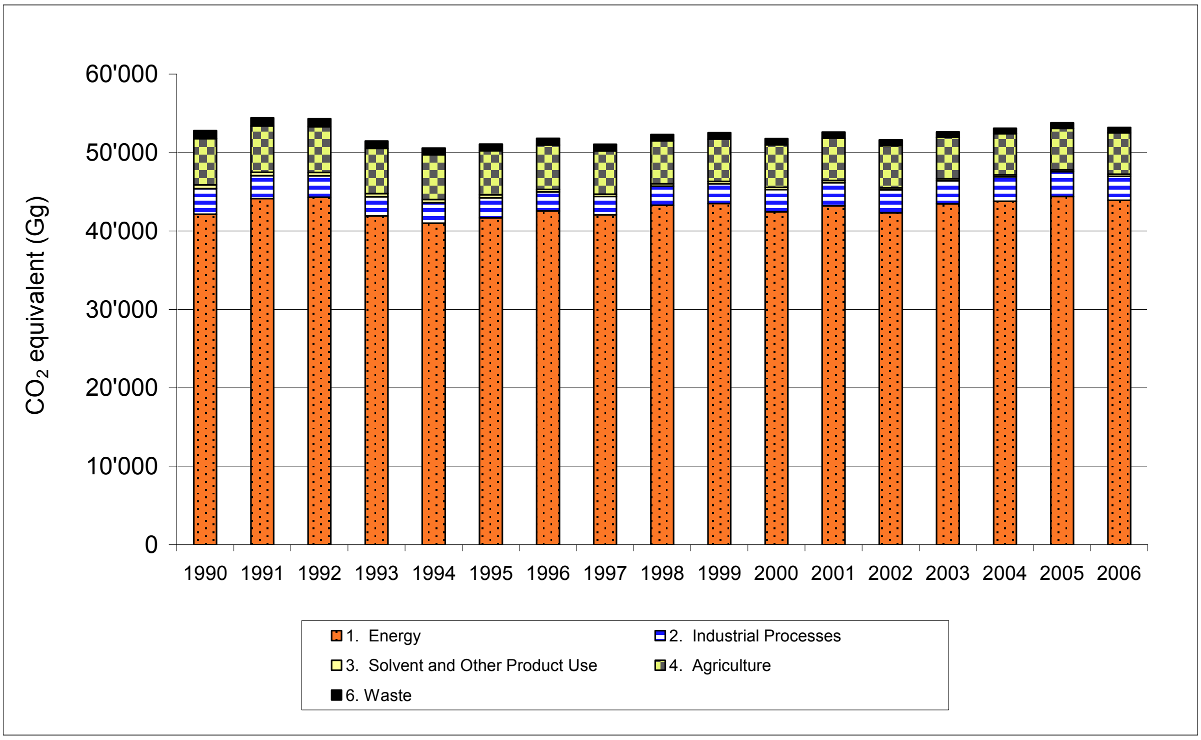


Figure 9 Switzerland’s GHG emissions in CO_2 equivalent (Gg) by sectors, 1990–2006 (excluding LULUCF).

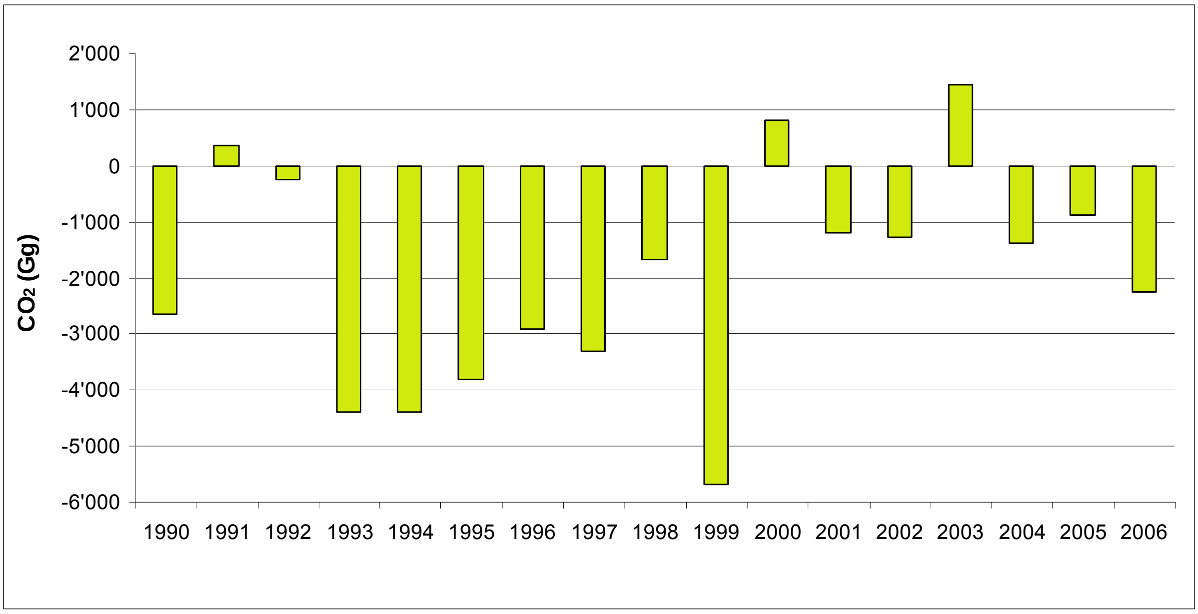


Figure 10 Switzerland's net CO_2 balance of source category 5 "Land Use, Land-Use Change and Forestry" (LULUCF) 1990–2006 in Gg CO_2. Positive values refer to emissions, negative values refer to removals. Note that the annual contribution of CH_4 and N_2O emissions from LULUCF in this period is very small compared to the net CO_2 emissions (it adds up to at most 24 Gg CO_2 equivalent in 1997; the minimum value is 6 Gg CO_2 equivalent in 2004) and would not be visible in the diagram.

Figure 10 shows the net emissions/removals from the LULUCF sector in Switzerland. In February 1990 and by the end of December 1999, two storms led to significant loss of biomass (in 1999, the amount of biomass destroyed was nearly three times higher than average annual net growth of Swiss forests). Further variation is caused by climatic fluctuations, e.g. by the extraordinary warm and dry summer in 2003.

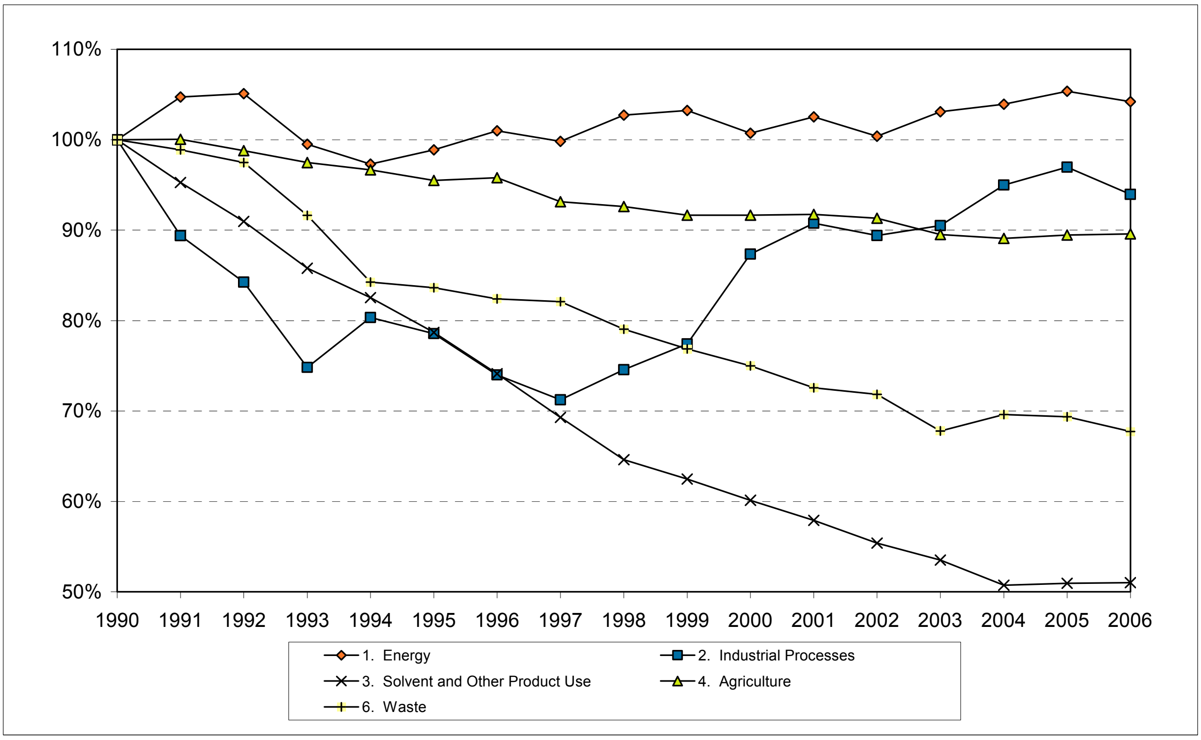


Figure 11 Relative emission trends by main source categories (base year 1990 = 100%).

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 12 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 towards the end of the period under consideration.
- 3 Solvent and Other Product Use: NMVOC emissions, the main source of indirect CO_2 of the sector, have diminished since 1990 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_2-equivalent emissions. Only in the last two years CH_4 emissions increased again due to slightly higher livestock numbers (mainly cattle)
- 6 Waste: Total emissions from the source category Waste decreased steadily throughout the period 1990-2006. Since 2000, emissions have been further reduced by a change in legislation: disposal of 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 (in sources 1A, 4D and 6) have *increased* since 1990 (see Figure 42 in Chapter 8).

The main sub-categories within the Energy sector – representing the major sources of Switzerland’s GHG emissions – are shown in Figure 12.

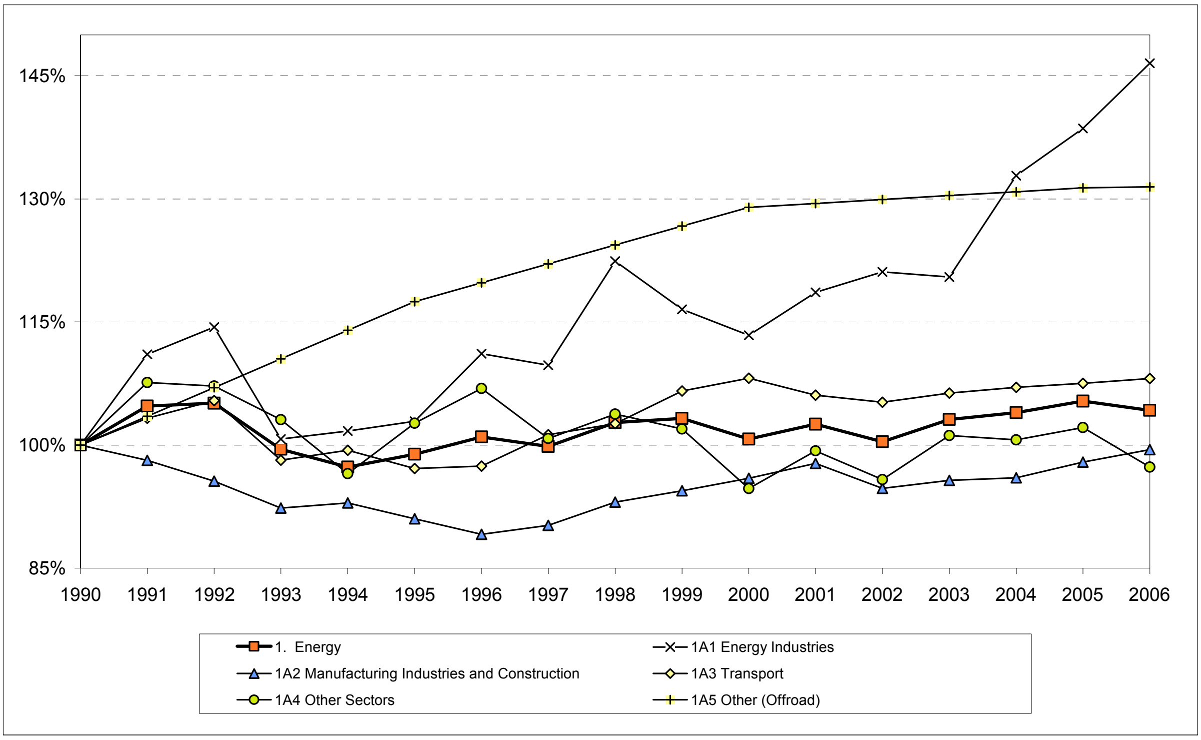


Figure 12 Emission trends for the sub-categories in the sector 1 Energy/1A Fuel Combustion. The trend for the sector as a whole (“1 Energy”) is shown in bold. Not included in the figure is the trend for 1B Fugitive Emissions which drops down steadily from 100% (1990) to 55% (2006).

It is noteworthy that, because of Switzerland's electricity production structure (about 94.6% generated by hydroelectric and nuclear power plants in 2006; SFOE 2007: 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:

- The differing trends for the various sub-sectors resulted in a relatively constant overall emission level for the 1 Energy sector (bold line in Figure 12).
- The trend for 1A1 Energy Industry is mainly caused by an increase in the amount of waste incinerated and an increase of the refinery capacity in 2004.
- The trend for the 1A3 Transport sector shows a slight increase over the period 1990–2006, but with significant 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 2004–2006 (SFSO 2007).
- The trend for 1A4 Other Sectors reflects the impact of climatic variations on demand for heating. The strong correlation with the number of "heating degree days"[3] – used as an index of cold weather conditions – is apparent from Figure 13, which shows CO_2 emissions from fuel combustion (i.e. from 1A without on-/off-road sources 1A3/1A5 or mobile sources in 1A4c).
  In the period 1990–2006, 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.

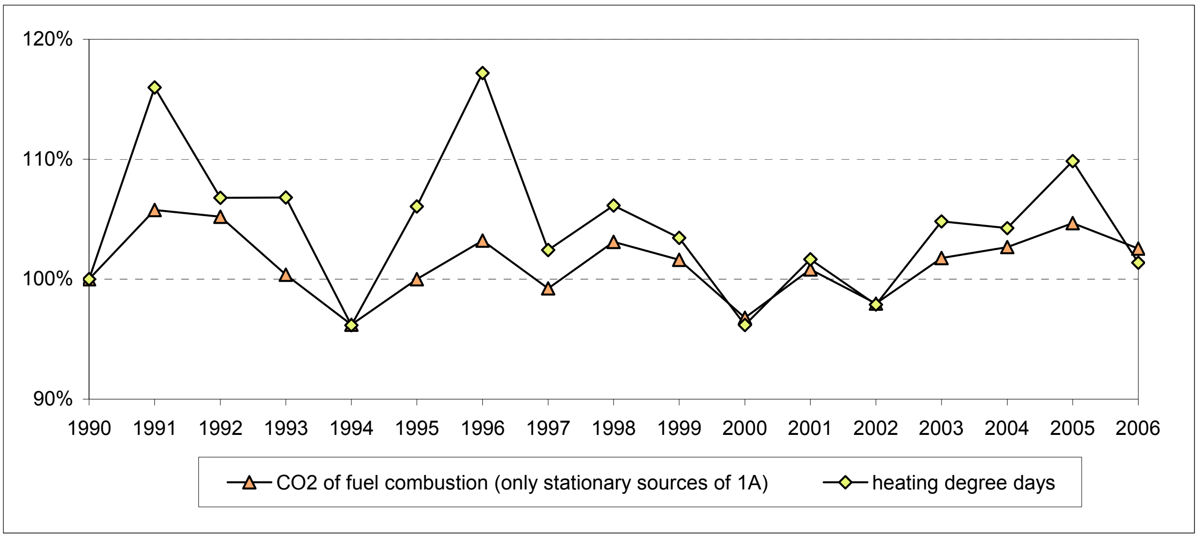


Figure 13 Relative trend for CO_2 emissions from 1A Fuel Combustion (excluding transport and off-road activities) compared with the number of heating degree days.

[3] 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.

2.4. Emission Trends for Indirect Greenhouse Gases and SO_2

Emission trends for indirect greenhouse gases show a very pronounced decline (see Table 21 and Figure 14). From 1990 to 2006, a strict air pollution control policy and the implementation of a large number of emission reduction measures led to a decrease of about 50% 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 and 1997).

Table 21 Switzerland's indirect GHG and SO_2 emissions (Gg), 1990–2006 (without NMVOC from LULUCF).

Indirect Greenhouse Gases and SO_2	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
	Gg									
NO_x	161	155	145	130	126	119	113	107	105	103
CO	717	692	652	579	540	506	496	480	467	465
NMVOC	296	279	260	233	212	195	183	172	158	151
SO_2	42	38	35	28	29	27	27	26	24	19

Indirect Greenhouse Gases and SO_2	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
	Gg						
NO_x	99	95	90	87	86	84	83
CO	448	427	401	389	370	352	335
NMVOC	144	136	126	118	109	105	102
SO_2	17.5	19.2	17.8	16.9	16.7	18.1	17.6

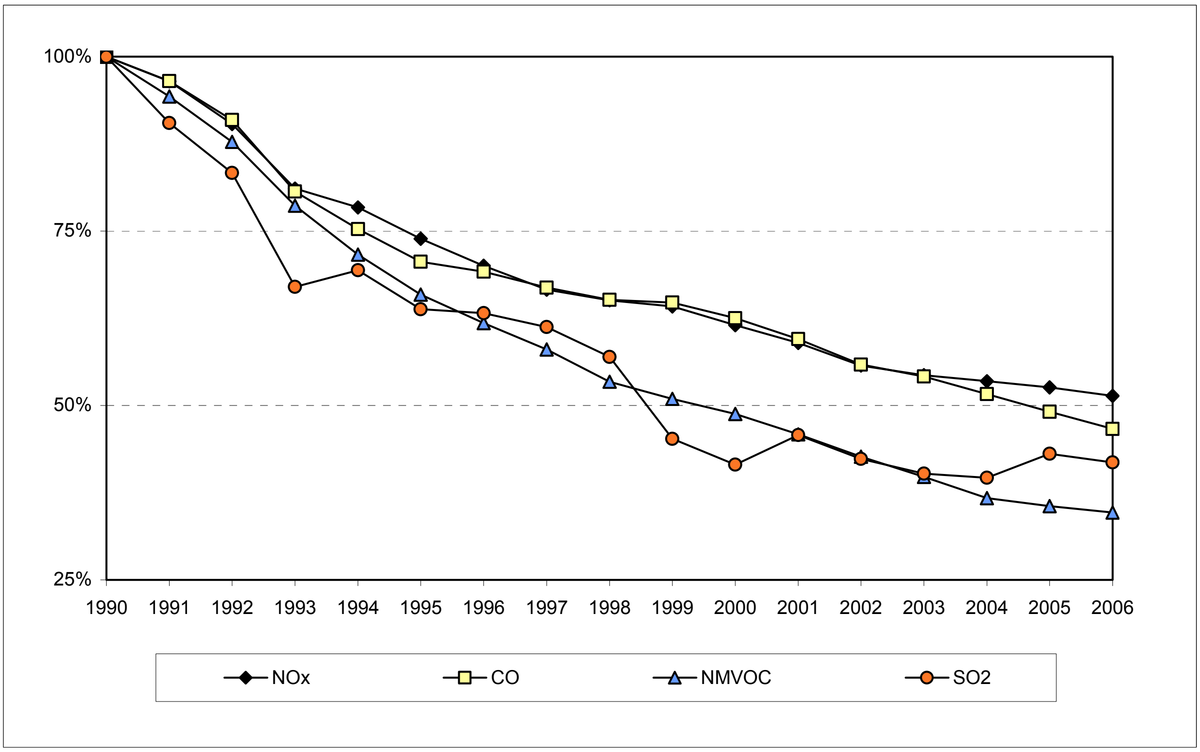


Figure 14 Relative trends for indirect GHG and SO_2 emissions (without NMVOC from LULUCF), 1990–2006 (base year 1990 = 100%).

Sector 1 Energy was by far the largest source of indirect greenhouse gas emissions (see Table 22), with the only exception being NMVOCs, where category 3 Solvent and Other Product Use accounted for 25.6% of the total. The total shown in Table 22 includes NMVOC emissions from LULUCF, which amounted to 95.5 Gg in 2006.

Table 22 Indirect GHG and SO_2 emissions (Gg) by source, 2006. The total NMVOC emissions include NMVOC from LULUCF.

Sources	**NO_x**	**CO**	**NMVOC**	**SO_2**
	Emissions 2006 (Gg)			
1 Energy	78.2	314.4	36.3	14.1
2 Industrial Processes	0.7	11.0	8.7	2.1
3 Solvent and Other Product Use	0.0	0.0	50.7	0.0
4 Agriculture	4.5	7.3	4.6	0.0
5 LULUCF	NO	NO	95.5	NO
6 Waste	0.4	2.0	2.1	1.4
Total	**83.8**	**334.7**	**197.9**	**17.6**

Figure 15 shows the relative contributions of the various sectors for each individual gas (data from Table 22). Sector 1 Energy can clearly be identified as the main source of NO_x, CO and SO_2.

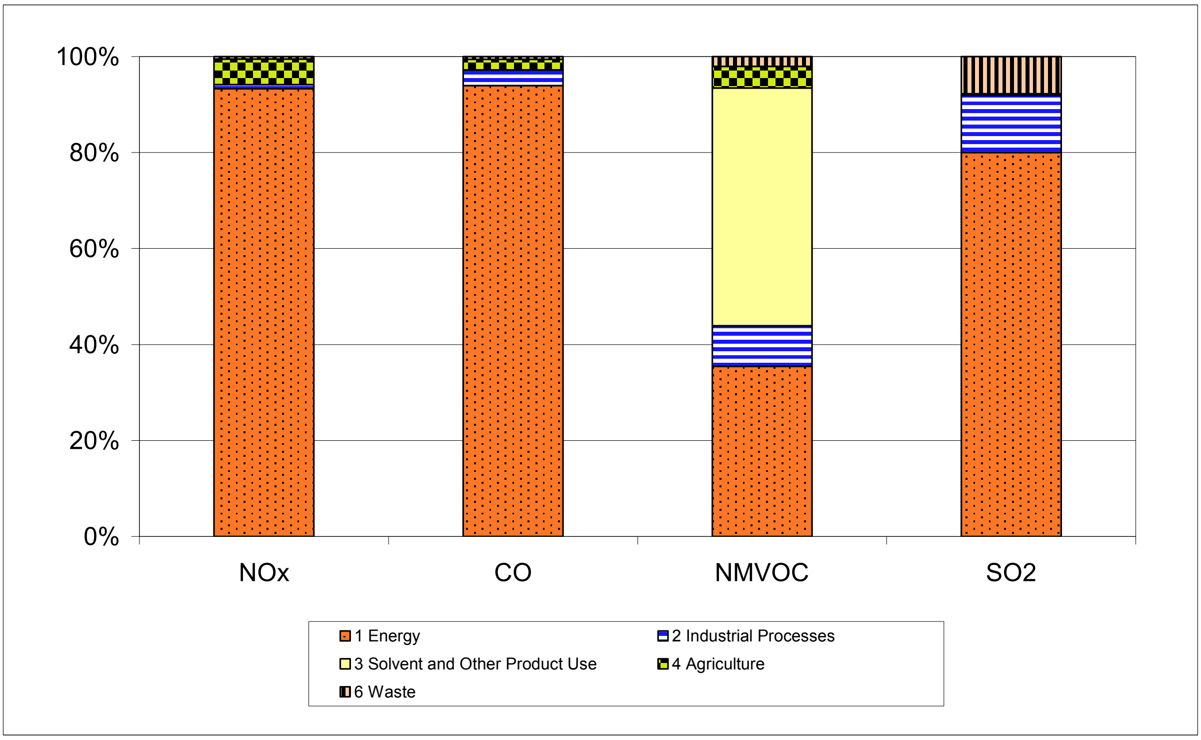


Figure 15 Relative contributions of individual sectors to indirect GHG and SO_2 emissions in 2006 (without NMVOC from LULUCF).

3. Energy

3.1. Overview

3.1.1. Greenhouse Gas Emissions

This chapter contains information about the greenhouse gas emissions of source category 1 Energy. In Switzerland, the energy sector is the most relevant greenhouse gas source. In 2006, it emitted 43’924 Gg CO_2 equivalent which correspond to 82.5% of total emissions (53’209 Gg CO_2 equivalent, national total without LULUCF). The emissions of the period 1990–2006 are depicted in Figure 16.

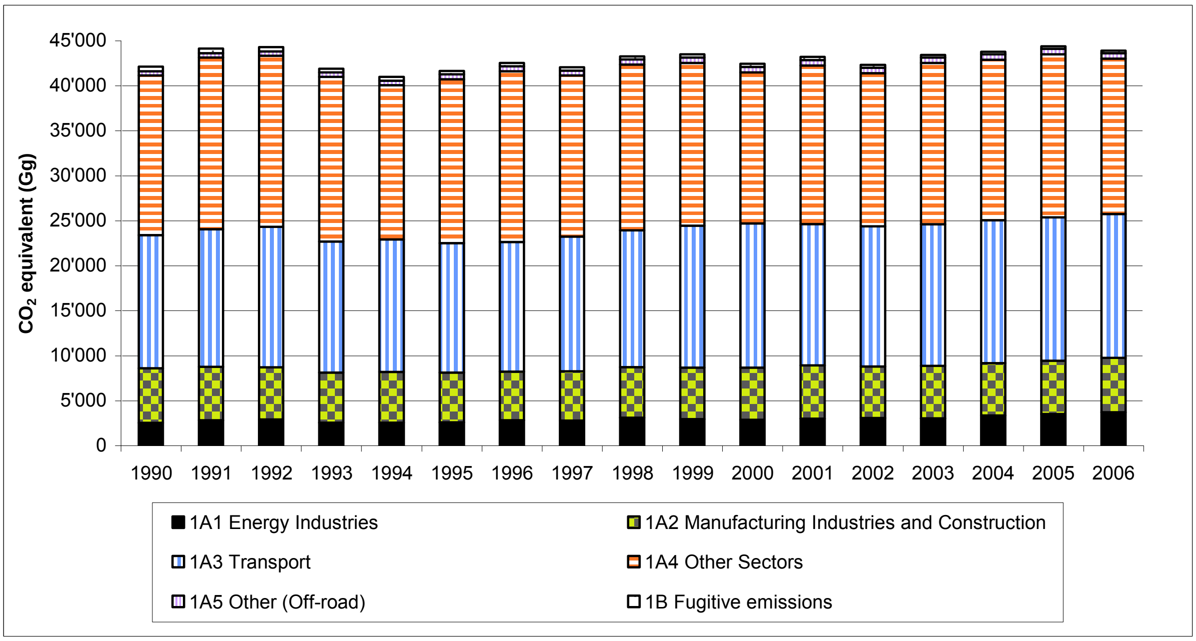


Figure 16 Switzerland’s GHG emissions of source category 1 Energy 1990–2006 in CO_2 equivalent (Gg).

For the total emissions of the energy sector, a slight increasing trend of 200 Gg CO_2 eq per year may be observed in the period 1994–2006. For the full time period, the percentage change in emissions of the energy sector in 2006 as compared to the base year 1990 is 4.2%. Three sub-categories dominate the emissions:

- 1A3 Transport and 1A4 Other Sectors are the main sources that cover 36.5% and 39.3%, respectively, of total emissions of the sector energy.
- 1A2 Manufacturing Industries and Construction are of minor importance. They contribute 13.7% 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 2006, they cover 8.5%, 1.4% and 0.6%, 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_2. It accounts for 98.5% of the category. Its fluctuations reflect climatic variability in Switzerland (see Figure 13 and related comments).

- In 2006, CH_4 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_2O contributed 0.79% to the total emissions of the sector energy. The changes in N_2O emissions may be explained by changes in the emission of passenger cars. The first generation of catalytic converters generated N_2O as undesirable by-product in the exhaust gases, leading to an increase of N_2O emissions until 2000. With new converter materials being used, the emission factors are decreasing since 2001.

Table 23 GHG emissions of source category 1 Energy by gas in CO_2 equivalent (Gg), 1990–2006.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	41'307	43'296	43'470	41'149	40'234	40'911	41'803	41'333	42'557	42'751
CH_4	567	549	504	462	439	415	396	368	360	365
N_2O	268	293	318	317	333	345	359	367	376	385
Sum	42'142	44'138	44'292	41'928	41'006	41'671	42'558	42'067	43'293	43'501

Gas	2000	2001	2002	2003	2004	2005	2006
	CO_2 equivalent (Gg)						
CO_2	41'722	42'481	41'621	42'778	43'140	43'749	43'286
CH_4	338	344	312	296	293	293	291
N_2O	388	388	380	375	365	355	347
Sum	42'448	43'213	42'314	43'450	43'799	44'398	43'924

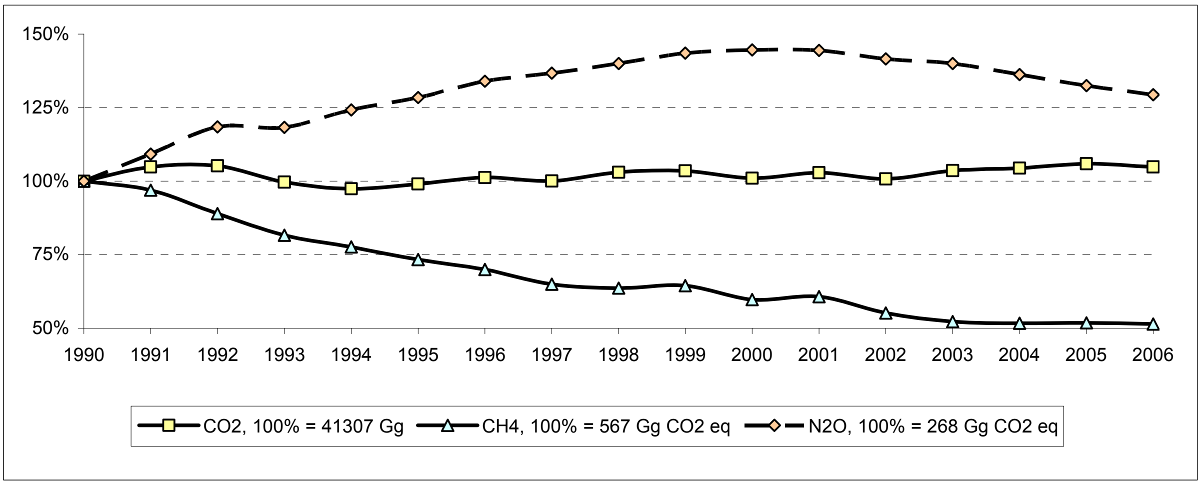


Figure 17 Relative trends of the greenhouse gases of source category 1 “Energy” in the period 1990–2006. The base year 1990 represents 100%.

The following table summarises the emissions of the sector energy in 2006. 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 24 Summary of source category 1 Energy, emissions[4] in 2006 in Gg CO_2 equivalent (Total: rounded values).

Emissions 2006	**CO_2**	**CH_4**	**N_2O**	***Total***
	CO_2 equivalent (Gg)			
1 Energy	**43'285.6**	**291.2**	**347.0**	***43'924***
1A Fuel Combustion	**43'175.1**	**116.7**	**347.0**	***43'639***
1A1 Energy Industries	3'602.4	1.9	125.6	***3'730***
1A2 Manufacturing Industries and Construction	5'973.9	10.8	38.2	***6'023***
1A3 Transport	15'866.8	20.9	123.8	***16'011***
1A4 Other Sectors	17'128.9	81.0	52.8	***17'263***
1A5 Other	603.2	2.2	6.6	***612***
1B Fugitive Emissions from Fuels	**110.5**	**174.4**	**0.0**	***285***
International Bunkers	3'668.0	1.3	35.7	***3'705***
CO_2 Emissions from Biomass	6'226.9	0.0	0.0	***6'227***

The Swiss greenhouse gas inventory identifies 36 key sources (see Chapter 1.5), 21 of which belong to the energy sector. These are depicted in the next figure. Most dominant are the CO_2 emissions from 1A3b Transport (gasoline, CO_2) and 1A4b Other Sectors (liquid fuels, CO_2).

[4] Biomass CO_2 emissions from 1 Energy in the Table and in the CRF inventory are for technical reasons incomplete. For full biomass CO_2 emissions see Section 3.5.

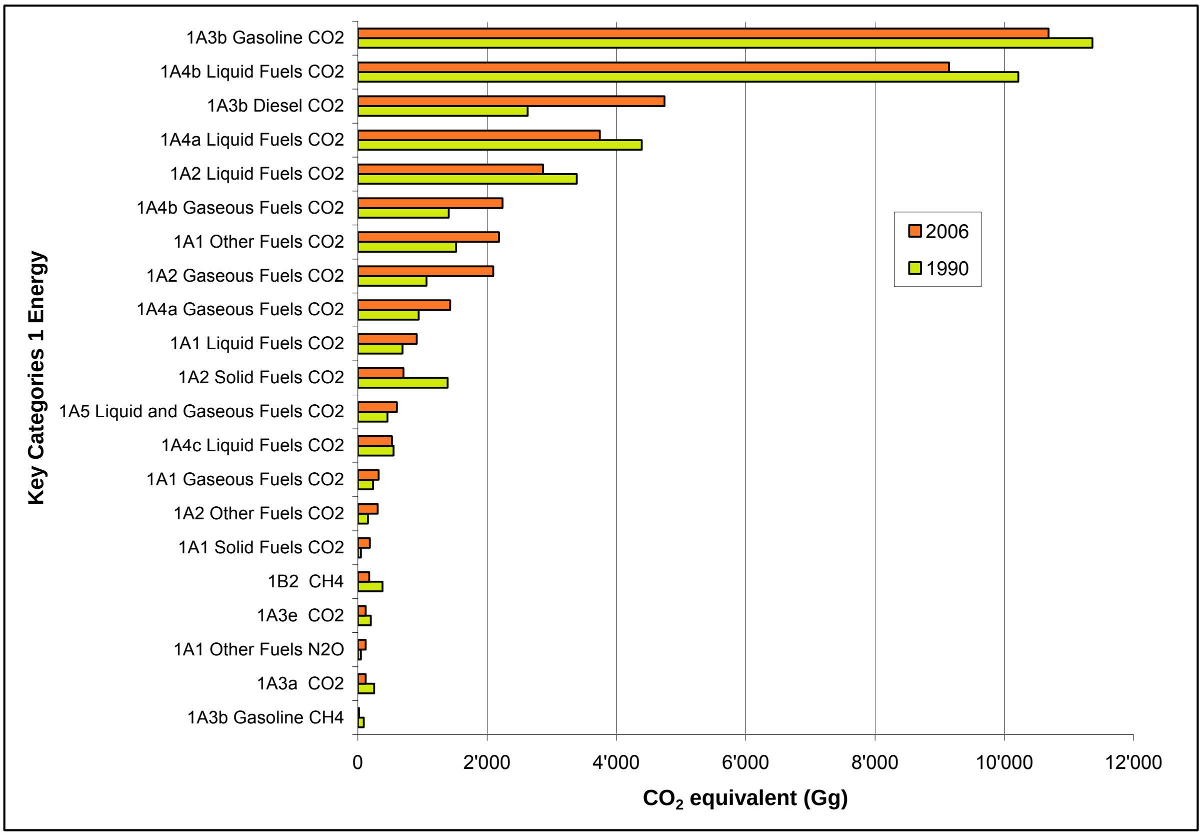


Figure 18 Key sources in the Swiss GHG inventory pertaining to the energy sector.

3.1.2. CO_2 Emission Factors

The CO_2 emission factors used for the calculation of the emissions of 1 Energy are shown in Table 25. Further details are given in Annex A2.2, Methodology for Estimating CO_2 Emissions.

Table 25 CO_2 emission factors for fuels. The values are assumed to be constant over the period 1990-2006 (SFOE 2001). The value for natural gas also holds for CNG (compressed natural gas).

CO_2 Emission Factors 1990-2006	
Fuel	t CO_2 / TJ
Hard Coal	94.0
Gas Oil	73.7
Residual Fuel Oil	77.0
Natural Gas and CNG	55.0
Gasoline	73.9
Diesel Oil	73.6
Propane/Butane (LPG)	65.5
Jet Kerosene	73.2
Lignite	104.0

3.1.3. Feedstocks

Energy data are taken from the Swiss overall energy statistics (SFOE 2007). 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_2 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 2007) contains the fossil fuel consumption of the Principality of Liechtenstein (about 35'200 inhabitants, 29’500 employees in industrial and service sector), since the two countries form a customs and monetary union governed by a customs treaty. For the submission of 31 May 2006, Switzerland corrected the energy consumption by subtracting Liechtenstein’s fuel consumption from the consumption provided in the Swiss overall energy statistics. (For the earlier submissions, Switzerland had included Liechtenstein’s energy related emission in the Swiss GHG inventory). 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 15 in Liechtenstein’s NIR (OEP 2008) on page 47]. 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 1990–2006. The Swiss emissions are then modelled using the reduced activity data.

3.1.5. Disaggregation of the energy consumption

Figure 19 shows the disaggregation procedure of the fuel consumption. The total due to the sales principle is given in the Swiss overall energy statistics (SFOE 2007). The statistics also contains the split into energy consumption and energy transformation. urther 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 A2.4.

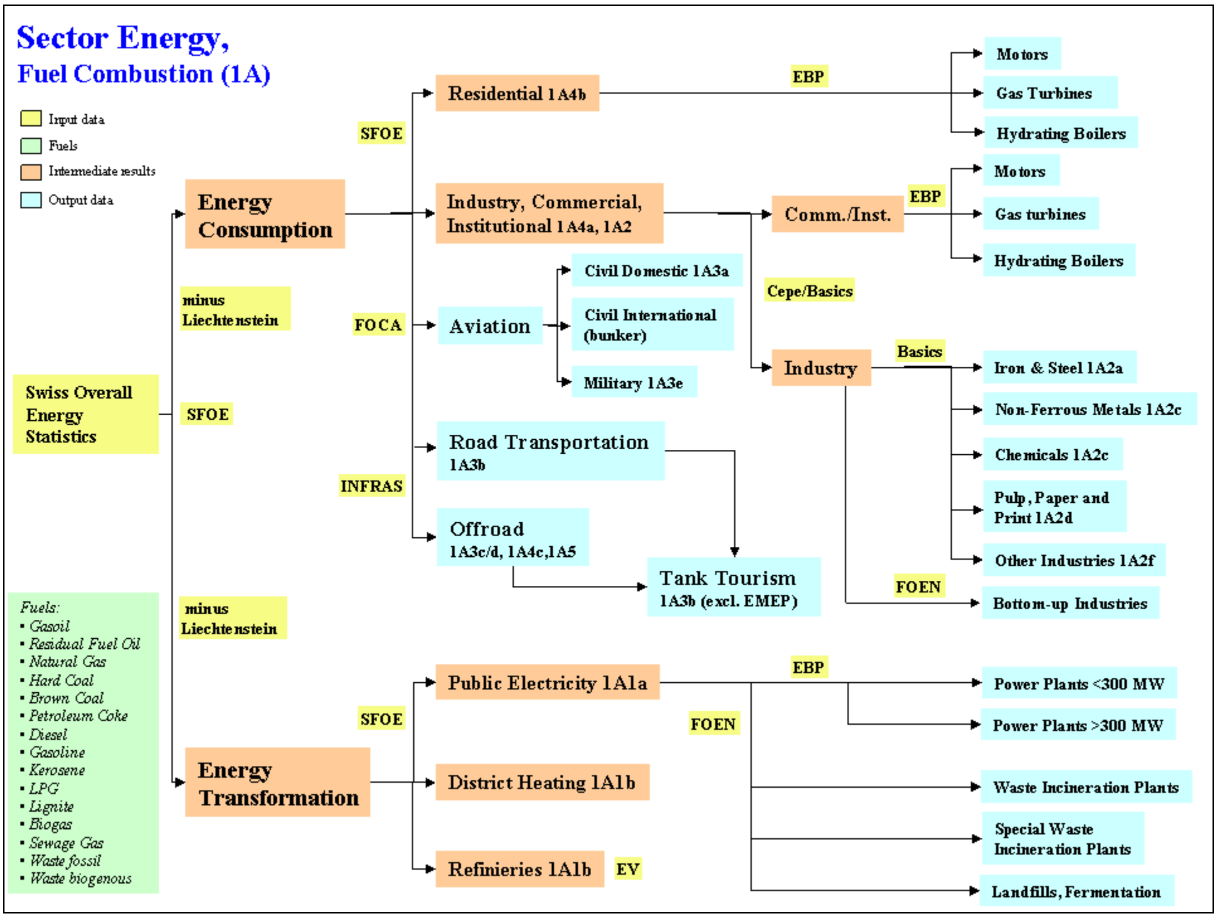


Figure 19 Schematic disaggregation of 1A Fuel Consumption.

3.1.6. Leakage from Natural Gas Distribution

During the in-country review in 2007, an error was identified that arose from an assumption that fugitive losses during the transmission and distribution of natural gas should be subtracted from the amount of gas that is combusted, generating CO_2 emissions. The error has been corrected. The affected category is 1A4b. For reasons of simplicity, the entire amount of leaking natural gas had been subtracted from 1A4b, as it is the category with the largest leakages.

3.2. Source Category 1A – Fuel Combustion Activities

3.2.1. Source Category Description

a) Energy Industries (1A1)

Key categories 1A1
CO_2 from the combustion of Gaseous Fuels (level and trend)
CO_2 from the combustion of Liquid Fuels (level and trend)
CO_2 from the combustion of Solid Fuels (level and trend)
CO_2 from the combustion of Other Fuels (level and trend)
N_2O from the combustion of Other Fuels (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. Auto-producers in industry are included in category 1A2 “Manufacturing Industries and Construction”. Auto-production of heat and power in waste incineration plants however is included in 1A1.

In Switzerland, electricity production is dominated by hydroelectric power plants (52.4%) and nuclear power stations (42.2%). Other sources such as (fossil fueled) combined heat and power generation, and power generation from solar, wind and biogas account only for about 5.4% of the electricity generated in Switzerland (SFOE 2007; table 24; data for the year 2006).

Table 26 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_e; no public heat production) ceased operation in 1999.	Waste incineration: AD: FOEN 2007d; EMIS 2005/1A1a EF: CO_2 SAEFL 2005g; EMIS 2005/1A1a Other sources: AD: SFOE 2007: EMIS 2005/1A1a EF: SAEFL 2000; SFOE 2001; EMIS 2005/1A1a
1A1b	Petroleum Refining	Combustion activities supporting the refining of petroleum products, excluding evaporative emissions.	AD: Annual report EV 2007, SFOE 2007; EMIS 2005/1A1b EF: Industry data; EMIS 2005/1A1b
1A1c	Manufacture of Solid Fuels and Other Energy Industries	Not occurring in Switzerland	-

b) Manufacturing Industries and Construction (1A2)

Key categories 1A2
CO_2 from the combustion of Gaseous Fuels (level and trend)
CO_2 from the combustion of Liquid Fuels (level and trend)
CO_2 from the combustion of Solid Fuels (level and trend)
CO_2 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_2 from calcination are reported in category 2.

Table 27 Specification of source category 1A2 “Manufacturing Industries and Construction”

1A2	Source	Specification	Data Source
1A2a	Iron and Steel	Iron and Steel industry	AD: SFOE 2007, Basics 2007 and industry data; EMIS 2005/1A2 EF: EMIS 2005/1A2, 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 EnAW (2007)

c) Transport (1A3)

Key category 1A3a
CO_2 from the combustion of Jet Kerosene of civil aviation (trend)

Key categories 1A3b
CO_2 from the combustion of Diesel Oil (level and trend)
CO_2 from the combustion of Gasoline (level and trend)
CH_4 from the combustion of Gasoline (trend)

Key category 1A3e
CO_2 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 28 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 2007, FOCA 2006a, 2007 Emissions FOCA 2007
1A3b	Road Transportation	Light and heavy motor vehicles, coaches, two-wheelers	AD: SFOE 2007, EF: SAEFL 2004, 2004a, RWTÜV 2003, Hausberger et al. 2002, Gense 2002, 2002a
1A3c	Railways	Diesel locomotives	Method, AD, EF: INFRAS 2007, Emissions INFRAS 2007a

1A3d	Navigation (National)	Passenger ships, motor and sailing boats on the Swiss lakes	Method, AD, EF: INFRAS 2007, Emissions INFRAS 2007a
1A3e	Military Aviation		VTG 2006, 2006a, 2007

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

Key categories 1A4a
CO_2 from the combustion of Gaseous Fuels in the Commercial/Institutional Sector (level and trend)
CO_2 from the combustion of Liquid Fuels in the Commercial/Institutional Sector (level and trend)

Key categories 1A4b
CO_2 from the combustion of Gaseous Fuels in the Residential Sector (level and trend)
CO_2 from the combustion of Liquid Fuels in the Residential Sector (level and trend)

Key category 1A4c
CO_2 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 29 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 2007, CEPE 2007 EF: EMIS 2005/1A4a, SAEFL 2000; SFOE 2001, IPCC 1997c
1A4b	Residential	Emissions from fuel combustion in households	AD: SFOE 2007 EF: EMIS 2005/1A4b, SAEFL 2000; SFOE 2001, IPCC 1997c
1A4c	Agriculture/ Forestry/ Fishing	Comprises fuel combustion for grass drying and off-road machinery in agriculture	AD: EMIS 2005/1A4c and INFRAS 2007 EF: EMIS 2005/1A4c, SFOE 2001; INFRAS 2007 Off-road emissions INFRAS 2007a

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

Key category 1A5
CO_2 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 30 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	
	- Garden/Hobby	Household and gardening machinery and motorised equipment	Method, AD, EF: INFRAS 2007
	- Industry	Industrial off-road vehicles and machinery	Emissions INFRAS 2007a
	- 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 source category 1 Energy, 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!).

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 following, the National Approach is documented in detail for each source category within 1A.

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 2007) and the yearly reports of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2007). 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_2 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.

As the consumption of gaseous fuels strongly increased (1990 to 2006: +65.4% to 111'158 TJ), overestimating of oxidation factors for gaseous fuels tends to overestimate emission increase and is therefore conservative. As the consumption of liquid fuels slightly decreased (1990 to 2006: -1.4% to 459'086 TJ) overestimating of oxidation factors for liquid fuels tends to overestimate emission reduction and is therefore not conservative. It will be examined in the future if a recalculation is necessary including oxidation factors smaller than 100%.

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)[5].

The consumption of coal plays a minor role in Switzerland. It decreased over the considered period (1990 to 2006: -38.7% to 9'719 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 44% of total Swiss coal consumption in 2006. With a largeshare 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_2 from the combustion of Gaseous Fuels (level and trend)
CO_2 from the combustion of Liquid Fuels (level and trend)
CO_2 from the combustion of Solid Fuels (level and trend)
CO_2 from the combustion of Other Fuels (level and trend)
N_2O from the combustion of Other Fuels (trend)

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

- “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 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 the present submission, fermentation engines (previously in 6D – Other) and co-generation on landfills (previously in 6A1 – Managed Waste Disposal on Land) have been transferred into category 1A1a. GHG emissions are calculated by multiplying quantities of combusted CH_4 by emission factors.

[5] 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)."

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

(a) Waste incineration with heat and/or power generation (reported under "Other fuels")
Emission factors for CO_2, N_2O, NO_x, CO, NMVOC and SO_2 emissions per ton of waste incinerated are country specific based on measurements and expert estimates, documented in the EMIS database (EMIS 2005/1A1a). Emission factors are taking into account flue gas cleaning standards in incineration plants. CH_4 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_2 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 2007). Therefore the LFO emission factor for CO_2 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_4, NO_x, CO and NMVOC are country specific based on comprehensive life cycle analysis of industrial boilers, documented in SAEFL 2000 (pp. 14-27). For NO_x emission factors, expert judgement has been used to estimate the fraction of low-NO_x burners. For the related N_2O 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 2005/1A4a).

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_4 emissions from stationary sources in 1A1 of less than 2 tons of CH_4 per year (expert estimate FOEN).

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

Table 31 Emission Factors for 1A1a Public Electricity and Heat Production in Energy Industries in 2006. 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_2 t/TJ	CO_2 bio. t/TJ	CH_4 kg/TJ	N_2O kg/TJ	NO_x kg/TJ	CO kg/TJ	NMVOC kg/TJ	SO_2 kg/TJ
1A1a Public Electricity/Heat								
Light fuel oil	73.50		1	0.6	32	11	2	35
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	24	0.1				

Source/fuel	CO_2 t/TJ	CO_2 bio. t/TJ	CH_4 kg/TJ	N_2O kg/TJ	NO_x kg/TJ	CO kg/TJ	NMVOC kg/TJ	SO_2 kg/TJ
1A1a Public Electricity/Heat								
Biomass (fermentation engine)		55	24	0.1				
	CO_2 t/t	*CO_2 bio. t/t*	*CH_4 kg/t*	*N_2O g/t*	*NO_x kg/t*	*CO kg/t*	*NMVOC kg/t*	*SO_2 kg/t*
Other fuels (MSW)	*0.508*	*0.763*		*101.29*	*0.400*	*0.108*	*0.017*	*0.056*
Other fuels (special waste)	*1.450*			*101.29*	*0.400*	*0.108*	*0.017*	*0.056*

In the table above, the CO_2 emission factor of light fuel oil (73.50 t/TJ) is a weighted average[6] emission factor including both LFO (73.7 t/TJ) and LPG (65.5 t/TJ) emissions.

The emission factor for N_2O from municipal solid waste incineration has increased significantly from 60 g N_2O per ton of waste in 1990 to 101.29 g/t in 2006. This is due to the increased use of DeNOx-equipment with the municipal solid waste incineration plants (EMIS). It is expected that the N_2O emission factor is back to 14 g/t in 2020 (EMIS). This contributes to the fact that N_2O 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[7]. 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.

Table 32 Activity data for 1A1a "Other fuels": municipal solid waste and special waste incinerated with heat and/or power generation 1990 to 2006.

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
1A1a Other fuels								
Total Other fuels in 1A1a	Gg	3'040	3'163	3'258	3'226	3'366	3'527	3'856
Municipal solid waste	Gg	2'801	2'936	3'027	2'995	3'135	3'297	3'640
Special waste	Gg	239	227	232	231	231	230	216

The table above documents the increase of municipal solid waste incinerated by 47% from 1990 to 2006. This is due to the fact that since 1st 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_2 emissions from "Other fuels" (i.e. MSW

[6] Calculation: 73.50 t/TJ = (204'775 TJ * 73.7 t/TJ + 5'055 TJ * 65.5 t/TJ) / (209'829 TJ) for the year 2006, where 204'775 TJ refers to LFO and 5'055 TJ to LPG.

[7] In earlier submissions, some of the emissions from municipal solid waste incineration have been reported also under category 6C.

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 2006 correspond to the consumption of LFO, natural gas and biomass (wood) in public district heating systems (SFOE 2007; 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 32). Activity data for co-generation from landfills and fermentation engines is taken from the Swiss renewable energies statistics (SFOE 2007a).

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 33 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
1A1a Public Electricity /Heat Fuel Consumption								
Total	TJ	46417	48440	48713	49496	50813	53192	56398
Light fuel oil	TJ	512	554	512	682	554	852	938
Heavy fuel oil	TJ	0	0	0	0	0	0	9
Natural gas	TJ	5777	6273	6031	6780	6802	6947	5843
Coal	TJ	0	0	0	0	0	0	0
Other (waste-to-energy)	TJ	39371	40915	41472	41298	42786	44745	48900
Biomass (wood for district heating)	TJ	70	70	130	160	180	190	250
Biomass (co-generation from landfills)	TJ	525	460	377	358	246	186	160
Biomass (fermentation engine)	TJ	163	167	191	218	244	271	298

The table above documents the increase of Gaseous Fuel consumption by 37% from 1990 to 2006. This increase is one of the reasons for category 1A1 Gaseous Fuels – CO_2 being a key category regarding trend. From 2005 to 2006 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_2, CH_4, N_2O, CO, NMVOC and SO_2 are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2005/1A1b, see Section 1.4.3) and in SAEFL 2000.

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

Table 34 Emission Factors for 1A1b Petroleum Refining in 2006.

Source/fuel	CO_2 t/TJ	CH_4 kg/TJ	N_2O kg/TJ	NO_x kg/TJ	CO kg/TJ	NMVOC kg/TJ	SO_2 kg/TJ
1A1 b Petroleum Refining							
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 2007).

Table 35 Activity data in 1A1b Petroleum Refining (NO: not occurring).

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
1A1b Petroleum Refining Fuel Consumption								
Total	TJ	10'091	10'909	11'447	10'525	14'360	14'579	15'998
Heavy fuel oil	TJ	1'952	1'936	1'518	1'769	1'339	906	692
Gas (refinery LPG)	TJ	8'139	8'973	9'929	8'756	11'901	11'678	13'311
Petroleum coke	TJ	0	0	0	0	1'120	1'995	1'995

The table above documents the increase of gas (refinery LPG) consumption for Petroleum refining by 189% from 1990 to 2006. 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_2 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_2 from the combustion of Gaseous Fuels (level and trend)
CO_2 from the combustion of Liquid Fuels (level and trend)
CO_2 from the combustion of Solid Fuels (level and trend)
CO_2 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 36). For this submission, more activities have been calculated bottom-up than in previous submissions. This bottom-up approach does not change overall emissions of the gases CO_2, CH_4 and N_2O 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). 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_2 emissions from waste derived fuels used in cement industry ("Other fuels").

Table 36 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 2005/1A2a
1A2b Non-Ferrous Metals Aluminium second smelter and non-ferrous metal foundries Other sources in 1A2b	Bottom-up Top-down	EMIS 2005/1A2b
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 2005/1A2d
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 2005/1A2f

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

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_2 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 A2.2.1).

The activity data on LFO use from the Swiss overall energy statistics (SFOE 2007) includes also LPG consumption. Therefore the LFO emission factor for CO_2 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_2 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 A2.2.1.

Emission factors for CH_4, NO_x, CO and NMVOC are country specific based on comprehensive life cycle analysis of industrial boilers, documented in SAEFL 2000 (pp. 14-27). For NO_x emission factors, expert judgement has been used to estimate the fraction of low-NO_x burners. For top-down N_2O emissions the default emission factors from IPCC 1997c have been used. NO_x, CO, NMVOC and SO_2 implied emission factors for each of the categories (see Table 37) 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 CH_4 emissions from stationary sources in 1A2 of less than 4 tons of 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 37 Emission factors for sources in 1A2a-f for 2006. For sources that include activities calculated bottom-up (see Table 36 further above), the table shows implied emission factors.

Source/fuel	CO_2 t/TJ	CO_2 bio. t/TJ	CH_4 kg/TJ	N_2O kg/TJ	NO_x kg/TJ	CO kg/TJ	NMVOC kg/TJ	SO_2 kg/TJ
1A2 "top-down" sources								
1A2a Iron and Steel (Total)								
LFO	73.50		1.0	0.6	32	11	2	35
HFO	77.00		4.0	0.8	125	15	4	361
Coal	94.00		10.0	1.6	102	1'252	9	401
Gas	55.00		6.0	0.1	45	5	2	1
Biomass								
Other Fuels								
1A2b Non-Ferrous Metals								
LFO	73.50		1.0	0.6	32	230	46	34
HFO	77.00		4.0	0.8	125	15	4	361
Coal								
Gas	55.00		6.0	0.1	14	14	2	1
Biomass								
Other Fuels								
1A2c Chemicals								
LFO	73.50		1.0	0.6	32	11	2	35
HFO	77.00		4.0	0.8	125	15	4	361
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								
1A2d Pulp, Paper and Print								
LFO	73.50		1.0	0.6	32	11	2	35
HFO	77.00		4.0	0.8	125	15	4	361
Coal								
Gas	55.00		6.0	0.1	14	14	2	1
Biomass (Black liquor)		80.49	IE	IE	49	134	IE	51
Other Fuels								
1A2e Food Processing, Beverages and Tobacco								
LFO	73.50		1.0	0.6	32	11	2	35
HFO	77.00		4.0	0.8	125	15	4	361
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								
1A2f Other								
LFO	73.50		1.0	0.6	33	23	6	37
HFO	77.00		3.6	0.8	191	351	2	193
Coal	96.50		3.8	1.6	107	586	5	192
Gas	55.00		6.0	0.1	59	72	9	10
Biomass		84.29	16.8	1.0	106	317	5	12
Other Fuels	83.72		NO	13.6	IE	IE	IE	IE

Remark: In the table above, the CO_2 emission factor of light fuel oil of 73.50 t/TJ (2006) 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_2 emission factor for coal in 1A2f Other (96.50 t/TJ in 2006) is a weighted average emission factor including hard coal (94 t/TJ), petroleum coke (94 t/TJ) and lignite (104 t/TJ) emissions[8]. In the other categories, the CO_2 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_4, N_2O 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_2, CH_4 and N_2O 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_2, CH_4 or N_2O are based on production data (e.g. tons of cement or steel produced) or on fuel consumption. NO_x, CO, NMVOC and SO_2 implied emission factors for each of the categories (see Table 37) were revised to have a more coherent allocation of emissions to fuel use in different processes.

The emission factors for CO_2 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 A2.2.1.

The coal emission factor for CO_2 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_4, N_2O, CO and NMVOC are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2005/1A2, 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.

---

[8] Calculation:
96.50 t/TJ = (1'729 TJ * 104 t/TJ + 5'199 TJ * 94 t/TJ / (1'729 TJ + 5'199 TJ) for 2006, where 1'729 TJ refers to lignite and 5'199 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). Therefore, the emission factor for coal is slightly higher in 2006 than in previous years.

Table 38 Emission factors for sources in Iron and Steel 1A2a in 2006.

1A2a Iron and Steel (Coke and gas)	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	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 39 Emission factors for cement industry in 2006 (NO: not occurring). Source: EMIS data base (EMIS 2005/1A2f). Emission factors for CO_2 are fuel specific; they are the same as in the top-down approach (see Table 37).

Cement industry (part of 1A2f)	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	t/TJ	kg/t cement					
Cement	fuel specific	NO	0.0185	0.891	0.7	0.0045	0.03 7

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[9].

[9] As cited in the EMIS data base. These emission factors are preliminary and may be revised for future submissions.

Table 40 Emission factors and other characteristics of waste derived fuels ("Other fuels") used in the cement industry. Sources: FOEN internal data sources, Hackl and Mauschitz 2003.

	NCV	EF CO_2 Tot.	EF CO_2 Tot	Fraction biomass-C	EF CO_2-fossil	EF CO_2-biogenic
Waste derived fuel	MJ/kg	kg CO_2 / GJ	kg CO_2/t of fuel	%	kg CO_2/t of fuel	kg CO_2/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 36 above) are based on aggregated fuel consumption data from the Swiss overall energy statistics (SFOE 2007) 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 A2.4.1.

The resulting disaggregated fuel consumption data for 1990 to 2006 is provided in the table below.

Table 41 Activity data fuel consumption in 1A2 Manufacturing Industries and Construction 1990 to 2006; "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
1A2 Manufacturing Industries and Constr. (Total)	TJ	87'847	87'855	87'174	85'588	86'745	85'977	86'406	87'706	90'064	91'569
Light fuel oil	TJ	26'306	29'115	29'287	28'556	27'740	27'941	29'768	31'667	33'993	34'606
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	7'918	5'292	4'791	4'295	4'234
Natural gas	TJ	19'331	21'383	23'547	25'795	27'106	28'601	29'401	30'452	31'222	32'653
Biomass	TJ	6'557	6'526	6'624	6'643	6'795	6'865	7'554	7'393	7'385	7'287
Other Fuels	TJ	2'047	2'082	2'118	2'598	2'324	2'974	3'509	3'439	3'586	3'420
1A2a Iron and Steel	TJ	3'036	3'158	3'382	3'357	3'445	2'899	3'050	3'266	3'361	3'352
Light fuel oil	TJ	782	806	812	804	806	655	665	724	759	771
Heavy fuel oil	TJ	340	340	341	339	339	97	97	105	108	105
Coal	TJ	469	512	544	435	478	352	307	315	329	313
Natural gas	TJ	1'445	1'501	1'684	1'779	1'823	1'795	1'981	2'122	2'165	2'162
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
1A2b Non-Ferrous Metals	TJ	517	606	460	469	459	647	689	887	976	1'116
Light fuel oil	TJ	240	241	225	201	207	216	215	252	268	270
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	275	363	233	267	250	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
1A2c Chemicals	TJ	15'426	14'697	14'560	13'956	14'402	15'505	15'866	15'434	15'304	14'454
Light fuel oil	TJ	3'117	3'197	2'753	2'874	2'731	3'750	3'746	3'418	2'994	2'729
Heavy fuel oil	TJ	1'740	1'171	897	1'147	893	467	489	462	364	267
Coal	TJ	226	214	198	184	188	179	156	136	124	118
Natural gas	TJ	10'343	10'116	10'712	9'751	10'590	11'109	11'475	11'418	11'822	11'340
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
1A2d Pulp, Paper and Print	TJ	11'667	11'287	12'698	12'477	13'303	11'785	10'958	11'273	11'116	10'874
Light fuel oil	TJ	539	781	986	927	862	953	1'051	992	1'035	1'122
Heavy fuel oil	TJ	5'227	4'717	4'307	3'672	3'338	3'119	2'972	3'178	3'149	2'997
Coal	TJ	1'014	619	112	0	0	0	0	0	0	0
Natural gas	TJ	2'802	3'273	5'582	6'354	7'663	6'356	5'494	5'578	5'321	5'060
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
1A2e Food Processing, Beverages and Tobacco	TJ	7'331	7'697	7'154	7'522	7'246	8'044	8'925	8'793	9'055	9'562
Light fuel oil	TJ	4'640	4'810	4'744	4'845	4'827	4'850	5'081	4'993	5'237	5'233
Heavy fuel oil	TJ	1'163	1'027	917	824	759	738	662	525	494	496
Coal	TJ	447	367	443	380	282	340	429	377	218	216
Natural gas	TJ	1'082	1'493	1'050	1'473	1'377	2'116	2'754	2'899	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
1A2f Other	TJ	49'870	50'410	48'920	47'807	47'889	47'095	46'920	48'052	50'252	52'210
Light fuel oil	TJ	16'988	19'280	19'767	18'905	18'307	17'516	19'010	21'290	23'700	24'480
Heavy fuel oil	TJ	10'398	10'130	10'387	8'396	9'584	7'256	6'663	5'692	5'467	5'502
Coal	TJ	12'581	9'651	7'450	6'618	6'918	7'047	4'401	3'963	3'624	3'587
Natural gas	TJ	3'384	4'638	4'286	6'171	5'403	6'795	7'225	7'802	8'100	9'628
Biomass	TJ	4'472	4'628	4'913	5'119	5'354	5'507	6'113	5'867	5'775	5'592
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
1A2 Manufacturing Industries and Constr. (Total)	TJ	95'344	97'731	95'790	97'370	98'382	99'422	100'410
Light fuel oil	TJ	33'476	34'688	34'121	34'627	33'620	33'352	32'967
Heavy fuel oil	TJ	7'315	7'134	6'044	5'515	5'721	5'703	5'727
Coal	TJ	6'160	6'284	5'838	5'931	5'773	6'671	7'351
Natural gas	TJ	34'798	35'252	34'349	35'311	36'778	37'440	38'089
Biomass	TJ	9'673	9'641	10'137	10'435	10'724	10'842	10'957
Other Fuels	TJ	3'922	4'732	5'301	5'549	5'767	5'415	5'319
1A2a Iron and Steel	TJ	3'736	3'920	3'877	3'920	3'556	3'373	3'445
Light fuel oil	TJ	813	826	817	801	774	710	731
Heavy fuel oil	TJ	122	127	117	118	114	101	100
Coal	TJ	273	371	455	485	192	226	247
Natural gas	TJ	2'529	2'597	2'489	2'516	2'476	2'335	2'368
Biomass	TJ	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0
1A2b Non-Ferrous Metals	TJ	1'103	1'012	1'103	1'185	1'273	1'265	1'110
Light fuel oil	TJ	271	259	280	284	274	264	236
Heavy fuel oil	TJ	1	1	1	1	1	1	1
Coal	TJ	0	0	0	0	0	0	0
Natural gas	TJ	831	752	822	900	998	1'000	872
Biomass	TJ	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0
1A2c Chemicals	TJ	14'989	15'918	15'339	14'943	15'187	15'381	16'313
Light fuel oil	TJ	3'036	3'204	3'106	3'039	3'080	3'122	3'279
Heavy fuel oil	TJ	264	333	179	117	144	152	259
Coal	TJ	112	95	86	79	74	70	70
Natural gas	TJ	11'578	12'285	11'967	11'708	11'889	12'036	12'705
Biomass	TJ	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0
1A2d Pulp, Paper and Print	TJ	11'117	11'189	11'706	11'593	10'534	10'769	9'557
Light fuel oil	TJ	1'089	1'041	1'078	1'029	999	987	954
Heavy fuel oil	TJ	2'527	2'622	2'471	2'374	2'269	2'205	2'354
Coal	TJ	0	0	0	0	0	0	0
Natural gas	TJ	5'807	6'080	6'415	6'305	5'237	5'524	4'174
Biomass	TJ	1'694	1'447	1'741	1'885	2'029	2'053	2'076
Other Fuels	TJ	0	0	0	0	0	0	0
1A2e Food Processing, Beverages and Tobacco	TJ	9'346	8'827	8'992	8'933	9'063	9'116	9'252
Light fuel oil	TJ	5'157	5'043	4'985	4'932	4'709	4'657	4'541
Heavy fuel oil	TJ	468	435	407	372	408	422	420
Coal	TJ	129	127	223	196	95	119	106
Natural gas	TJ	3'593	3'222	3'376	3'433	3'852	3'917	4'185
Biomass	TJ	0	0	0	0	0	0	0
Other Fuels	TJ	0	0	0	0	0	0	0
1A2f Other	TJ	55'052	56'865	54'773	56'795	58'769	59'519	60'733
Light fuel oil	TJ	23'111	24'315	23'855	24'541	23'785	23'612	23'227
Heavy fuel oil	TJ	3'933	3'616	2'869	2'532	2'787	2'820	2'593
Coal	TJ	5'647	5'691	5'074	5'171	5'412	6'255	6'928
Natural gas	TJ	10'460	10'317	9'279	10'450	12'324	12'627	13'785
Biomass	TJ	7'979	8'194	8'396	8'550	8'694	8'789	8'882
Other Fuels (waste incineration in cement industry)	TJ	3'922	4'732	5'301	5'549	5'767	5'415	5'319

The table above documents the increase of Natural Gas consumption for manufacturing industries by 96% from 1990 to 2006 as well as the net decrease of liquid fuel consumption by -14% and the decrease of coal consumption by -50% over this period. This shift in fuel mix is the reason for CO_2 emissions from the use of Gaseous, Liquid and Solid Fuels in category 1A2 being a key category 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 2005/1A2a.

Table 42 Activity data: Production in Iron and Steel that is used to calculate bottom-up emissions from sources in 1A2a (EMIS 2005/1A2a).

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**
1A2a Iron and Steel								
Iron foundries: cupol ovens	Gg	55	49	37	34	35	31	27
Steel plants: reheating furnaces	Gg	1'022	1'048	1'125	1'157	1'190	1'222	1'254

Activity data on cement production used for the calculation of emissions from fuel use in cement industry has been provided by the association of Swiss cement producers (Cemsuisse 2005) until this submission. For the present submission, data received directly from companies have been used, as documented in the EnAW database (EnAW 2007), and recalculations were made for the years 2004 and 2005 (See Table 70 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[10]: Estimates by FOEN experts, Cemsuisse (2007) and EnAW (2007). The activity data is used to calculate CO_2 emissions from "Other fuels" in 1A2f.

[10] As cited in the EMIS data base.

Table 43 Activity data: Amount of waste derived fuels ("Other fuels") in cement industry. Sources: Estimates by SAEFL experts (in *italics*), EKV (1991) , Cemsuisse (2007) and EnAW (2007).

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

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 2006 (in tons; and by 160% in energy units). This increase is the reason for CO_2 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 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 44 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	13'479	12'778	11'171	10'342	10'169	10'062
Cement fossil without waste	TJ	14'388	12'185	11'394	9'475	11'155	9'803	7'663	6'903	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	6'539	6'811	4'123	3'687	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
Cement industry								
Cement, total incl. waste	TJ	10'872	11'361	11'046	10'982	11'354	10'886	9'918
Cement fossil without waste	TJ	6'951	6'629	5'746	5'433	5'587	5'471	4'599
HFO	TJ	1'530	1'194	1'079	621	809	709	277
Coal	TJ	5'399	5'424	4'656	4'812	4'762	4'758	4'319
Gas	TJ	22	11	11	0	16	4	4
Cement, waste derived fuel	TJ	3'922	4'732	5'301	5'549	5'767	5'415	5'319
Cement waste biomass	TJ	850	1'698	1'835	2'098	2'026	1'657	1'656
Cement waste fossil	TJ	3'071	3'033	3'466	3'452	3'741	3'758	3'662

c) Transport (1A3)

Key category 1A3a
CO_2 from the combustion of Jet Kerosene of civil aviation (trend)

Key categories 1A3b
CO_2 from the combustion of Diesel Oil (level and trend)
CO_2 from the combustion of Gasoline (level and trend)
CH_4 from the combustion of Gasoline (trend)

Key category 1A3e
CO_2 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_2 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 IPCC Guidelines 2006 have been prepared by the Task Force on National Greenhouse Gas Inventoriesof the IPCC and accepted by the Panel but are not approved in detail (IPCC 2006). Formally, the method should be considered as a national method until approvement.

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_2O, 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, 2004–2006. 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 2007), 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 A2.5, more detailed descriptions of the emission modelling may be found in FOCA (2006).

Emission Factors

Kyoto gases:

- CO_2 :The value of 73.2 t/TJ is country specific and is based on measurements and analyses of fuel samples (see Table 25). Small yearly variations have been neglected so far.

- CH_4, NMVOC(country specific; CORINAIR): VOC emissions (see "Precursors" below) are split into CH_4 and NMVOC by a constant share of 0.1 (CH_4) and 0.9 (NMVOC)[11]. For CH_4, the average emission factor for domestic flights 2.1 kg/TJ in 2006, average LTO is 4.0 kg/TJ, cruise 0.90 kg/TJ (FOCA 2007).
- N_2O: The IPCC default value 2.3 kg/TJ is used for the whole period 1990-2006 (IPCC 1997b).

SO_2 (IPCC):

- The emission factor is taken from the IPCC Guidelines 1996, 23.0 kg/TJ, and is assumed to be constant over the period 1990–2006 (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 A2.5 Table "Aircraft Engine Combinations").

FOCA uses the following emission factors of NO_x, 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 Swiss aircraft data acquisition system.

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).

Activity Data

Scheduled and charter aviation

---

[11] 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.

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 (2006: 721’406 aircraft movements).

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 2000-2006, 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_2). 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.

Fuel consumption: Table 45 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 45 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 2006a, 2007).

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
	Fuel consumption in TJ						
Total domestic (1A3a)	2'539	2'296	2'028	1'951	1'963	1'699	1'658
Total international	63'687	60'097	55'468	49'763	46'896	47'671	50'109
Sum	66'225	62'393	57'495	51'714	48'859	49'370	51'766
1990 = 100%	146%	138%	127%	114%	108%	109%	114%

Road Transportation (1A3b)

Key categories 1A3b
CO_2 from the combustion of Diesel Oil (level and trend)
CO_2 from the combustion of Gasoline (level and trend)
CH_4 from the combustion of Gasoline (trend)

Methodology

CO_2
The CO_2 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 25). 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 2007).

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[12], 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 A2.6.

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_2 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

[12] 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.

traffic model. The resulting amount of “tank tourism” fuel is multiplied with mean emission factors to determine the related emissions of CH_4, N_2O, NO_x, CO, NMVOC, and SO_2. For CO_2, 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_4 and N_2O 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 the differences to F and I who use other emission factors (COPERT[13]) Nevertheless, the use of the mean Swiss emission factors seems to be the consistent approach.

Emission Factors

The emission factors for CO_2 are country specific and based on measurements and analyses of fuel samples (see Table 25). 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),
- 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 A2.6.

The following table gives a selection of mean emission factors. The CO_2 factors are constant over the whole period 1990–2006. 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_2O, 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_2O 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 A2.6.1. A separate table shows the details of the N_2O emission factors (Table 193).

[13] see Euopean Environment Agency http://reports.eea.europa.eu/TEC05/en

Table 46 Mean emission factors for road transport for passenger cars and heavy duty vehicles. For more details see Annex A2.6.1.

Gas	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Passenger Cars		t/TJ (= kg/GJ = g/MJ)									
CO2	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
CH4	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
N2O	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
NOx	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
SO2	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
Passenger Cars		t/TJ (= kg/GJ = g/MJ)						
CO2	gasoline	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
CH4	gasoline	0.0073	0.0065	0.0058	0.0052	0.0046	0.0041	0.0037
	Diesel	0.0006	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005
N2O	gasoline	0.0034	0.0032	0.0030	0.0027	0.0025	0.0023	0.0021
	Diesel	0.0010	0.0013	0.0016	0.0017	0.0019	0.0020	0.0020
NOx	gasoline	0.156	0.142	0.129	0.120	0.110	0.100	0.092
	Diesel	0.221	0.221	0.215	0.211	0.204	0.195	0.185
CO	gasoline	1.518	1.453	1.372	1.312	1.252	1.182	1.123
	Diesel	0.133	0.128	0.123	0.118	0.108	0.106	0.104
NMVOC	gasoline	0.142	0.127	0.111	0.100	0.090	0.081	0.074
	Diesel	0.026	0.025	0.024	0.023	0.021	0.021	0.020
SO2	gasoline	0.0067	0.0057	0.0048	0.0038	0.0004	0.0004	0.0004
	Diesel	0.0127	0.0117	0.0110	0.0093	0.0005	0.0005	0.0005

Gas	Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Heavy duty vehicles		t/TJ (= kg/GJ = g/MJ)									
CO2	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH4	Diesel	0.0020	0.0020	0.0019	0.0019	0.0018	0.0018	0.0018	0.0017	0.0016	0.0016
N2O	Diesel	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012	0.0012	0.0012
NOx	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
SO2	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
Heavy duty vehicles		t/TJ (= kg/GJ = g/MJ)						
CO2	Diesel	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH4	Diesel	0.001	0.001	0.001	0.001	0.001	0.001	0.001
N2O	Diesel	0.001	0.001	0.001	0.001	0.001	0.001	0.001
NOx	Diesel	0.911	0.893	0.859	0.827	0.786	0.750	0.711
CO	Diesel	0.172	0.160	0.157	0.155	0.151	0.150	0.145
NMVOC	Diesel	0.059	0.051	0.048	0.046	0.042	0.041	0.040
SO2	Diesel	0.013	0.012	0.011	0.009	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_2 emissions: The Swiss overall energy statistics gives the amount of 147 PJ of gasoline and 79 PJ of diesel oil in 2006 (SFOE 2007). From these numbers, the off-road consumption is subtracted. The result gives the inventory-relevant consumption for estimating the CO_2 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.

Table 47 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.

Activity data	Source category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		TJ									
Gasoline											
on-road consunp. (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	16.3	20.7	29.4	20.4	17.9	10.6	13.0	18.4	18.7	22.9
off-road consump. (models)	1A3a,c,d,e;1A4c;1A5	2.8	2.8	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
gasoline, diesel sold in Switzerl.	1A3; 1A4c; 1A5	156.5	163.0	168.8	156.5	156.5	151.7	155.6	161.5	162.8	168.2
Diesel											
on-road consunp. (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	-2.5	-2.3	-5.1	-7.0	-4.8	-4.2	-8.1	-7.3	-7.0	-6.4
off-road consump. (models)	1A3a,c,d,e;1A4c;1A5	11.9	12.2	12.4	12.6	12.9	13.1	13.3	13.5	13.7	13.9
gasoline, diesel sold in Switzerl.	1A3; 1A4c; 1A5	47.6	48.2	46.7	45.0	47.7	48.6	45.6	47.4	49.2	52.2
Total											
on-road consunp. (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	13.4	13.0	6.4	4.9	11.1	11.7	16.5
off-road consump. (models)	1A3a,c,d,e;1A4c;1A5	14.7	14.9	15.1	15.4	15.6	15.9	16.1	16.2	16.4	16.6
gasoline, diesel sold in Switzerl.	1A3; 1A4c; 1A5	204.1	211.1	215.5	201.5	204.2	200.3	201.2	208.9	212.0	220.3

Activity data	Source category	2000	2001	2002	2003	2004	2005	2006
		TJ						
Gasoline								
on-road consunp. (model)	1A3b	144.1	144.3	143.6	141.5	138.9	135.8	132.5
"tank tourism"	1A3b	21.5	16.5	14.1	15.4	15.1	13.4	12.1
off-road consump. (models)	1A3a,c,d,e;1A4c;1A5	2.7	2.7	2.7	2.7	2.7	2.7	2.7
gasoline, diesel sold in Switzerl.	1A3; 1A4c; 1A5	168.2	163.6	160.4	159.6	156.7	152.0	147.3
Diesel								
on-road consunp. (model)	1A3b	48.0	49.6	51.3	54.0	57.8	59.6	63.1
"tank tourism"	1A3b	-6.4	-7.1	-6.9	-6.1	-5.3	-1.1	1.3
off-road consump. (models)	1A3a,c,d,e;1A4c;1A5	14.1	14.1	14.2	14.3	14.3	14.4	14.5
gasoline, diesel sold in Switzerl.	1A3; 1A4c; 1A5	55.6	56.7	58.7	62.2	66.8	72.9	78.9
Total								
on-road consunp. (model)	1A3b	192.0	194.0	194.9	195.5	196.6	195.5	195.7
"tank tourism"	1A3b	15.1	9.4	7.2	9.3	9.8	12.3	13.4
off-road consump. (models)	1A3a,c,d,e;1A4c;1A5	16.8	16.9	16.9	17.0	17.1	17.1	17.2
gasoline, diesel sold in Switzerl.	1A3; 1A4c; 1A5	223.9	220.3	219.0	221.8	223.5	224.9	226.2

Further activity data needed for modelling the non-CO_2 emissions are the mileages (vehicle kilometres) per vehicle category in Table 48.

Table 48 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
	million vehicle-km						
PC	49'552	50'713	51'697	52'423	53'082	53'689	54'284
LDV	3'792	3'971	4'128	4'207	4'276	4'343	4'408
HDV	2'385	2'291	2'228	2'213	2'291	2'138	2'167
Coaches	101	97	98	96	95	94	94
Urban Bus	197	205	208	208	209	209	209
2-Wheelers	1'998	2'061	2'123	2'179	2'233	2'282	2'328
Sum	58'024	59'337	60'481	61'327	62'185	62'755	63'490
(1990=100%)	117%	119%	122%	123%	125%	126%	128%

In 2006, 85.5% of total vehicle kilometres are driven by passenger cars, 6.9% and 3.4% by light and heavy duty vehicles, respectively. The mileages increased for all vehicle categories (except coaches), totalling 28% in the period 1990–2006 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 49 indicating the specific fuel consumption per vehicle-km. For most vehicle categories, the specific consumption has decreased in the period 1990-2006 (between -8% and -22%); only two-wheelers have enhanced their average specific consumption (2%). On an average over the whole car fleet, a decrease of 13% has been reached.

Table 49 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
		specific fuel consumption (MJ/veh-km)						
PC	gasoline	2.97	2.94	2.92	2.90	2.87	2.85	2.83
	Diesel	2.88	2.78	2.70	2.65	2.61	2.57	2.53
LDV	gasoline	3.58	3.52	3.46	3.42	3.36	3.30	3.24
	Diesel	4.24	4.14	4.06	4.01	3.96	3.91	3.87
HDV	Diesel	10.00	10.19	10.17	10.15	10.13	10.25	10.23
Coach	Diesel	11.26	11.09	10.99	10.91	10.86	10.82	10.80
Urban Bus	Diesel	15.42	15.33	15.20	15.11	15.03	14.97	14.93
2-Wheeler	gasoline	1.28	1.28	1.27	1.27	1.26	1.24	1.23
Average		3.31	3.27	3.22	3.19	3.16	3.11	3.08
		94%	93%	91%	90%	90%	88%	87%

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 50 Vehicle stock numbers and average number of starts per vehicle per day (PC passenger cars, LDV light durty 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
	stock in 1000 vehicles						
PC	3'545	3'630	3'701	3'754	3'801	3'846	3'889
LDV	260	268	274	275	277	279	280
2-Wheelers	731	740	741	746	749	752	755
starts per vehicle per day							
PC	2.75	2.74	2.72	2.71	2.69	2.68	2.67
LDV	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

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 emissions of the whole off-road sector have undergone a complete revision beginning in 2005 and is still going on. Consumption and emission modelling results are not yet definite. Therefore, provisional numbers are used. 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 A2.7 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 2007). 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_2 is country specific and assumed to be constant in the period 1990-2006 with value 73.6 t/TJ (diesel oil, see Table 25, SFOE 2001).
- For SO_2 the emission factors country specific and are given in Table 184 in Annex A2.3, 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 2006.
- The emission factors for all other gases are country specific and are shown in Table 198in Annex A2.7.2. Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated as the difference of VOC and CH_4 emissions.
- For differences of the emission factors compared to IPCC default values, see Table 194 in the Annex A2.7.2.

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 195). The operating hours depend on the number of vehicles per age and size class. In 2005 e.g., 1255 vehicles were operating 0.77 million hours per year with an average number of 616 operating hours per year per vehicle (INFRAS 2007.) The resulting fuel consumption is shown in Table 51.

Table 51 Activity data (diesel oil consumption) for railways.

Railways	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Diesel (TJ)	876	899	922	945	968	991	997	1'003	1'010	1'016
1990=100%	100.0%	102.6%	105.2%	107.8%	110.4%	113.1%	113.8%	114.5%	115.2%	116.0%

Railways	2000	2001	2002	2003	2004	2005	2006
Diesel (TJ)	1'022	1'034	1'046	1'058	1'070	1'082	1'095
1990=100%	116.7%	118.0%	119.4%	120.8%	122.1%	123.5%	124.9%

Navigation (1A3d)

Methodology

The emissions of the whole off-road sector have undergone a complete revision beginning in 2005 and is still going on. Consumption and emission modelling results are not yet definite. Therefore, provisional numbers are used. All off-road categories like railways, navigation etc. are modelled by the same approach. The emissions are calculated with a Tier 2 method. Details of the emission modelling that hold for all off-road families are described in Annex A2.7 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 2007).

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_2 is country specific and is assumed to be constant in the period 1990-2006 with value 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 73.7 t/TJ for gas oil (Table 25, SFOE 2001).
- For SO_2 the emission factors are country specific and are given in Table 184 in Annex A2.3 (diesel oil, gasoline, gas oil).
- The emission factors for all other gases are country specific and are shown in Table 200 to Table 202 in Annex A2.7.2. Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated as the difference of VOC and CH_4 emissions.

Activity data

The numbers of vehicles and of operating hours are given in Annex A2.7.3 (INFRAS 2007). Table 52 shows the fuel consumption. In 2006, the fuel-split was 46%, 43% and 12% for diesel oil, gasoline and gas oil.

Table 52 Fuel consumption of navigation.

Navigation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Diesel (TJ)	753	741	729	717	705	693	697	702	706	711
Gasoline (TJ)	585	577	569	561	553	545	553	561	568	576
Gas oil (TJ)	166	169	172	175	178	181	181	181	181	182
Sum (TJ)	1'504	1'487	1'470	1'453	1'436	1'419	1'431	1'444	1'456	1'468
1990 = 100%	100%	99%	98%	97%	95%	94%	95%	96%	97%	98%

Navigation	2000	2001	2002	2003	2004	2005	2006
Diesel (TJ)	715	715	714	713	712	711	712
Gasoline (TJ)	583	598	612	627	641	656	662
Gas oil (TJ)	182	182	182	182	182	182	182
Sum (TJ)	1'480	1'494	1'508	1'521	1'535	1'548	1'555
1990 = 100%	98%	99%	100%	101%	102%	103%	103%

Military Aviation (Other Transportation 1A3e)

Key category 1A3e
CO_2 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 1990–2006 is known yearly since it is being copied from the logbooks of the military aircrafts (VTG 2006, 2006a, 2007). 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_x, 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 1996-2006, 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_2, CH_4, N_2O, NMVOC and SO_2 is also accomplished by FOEN.

Emission Factors

- CO_2: The emission factor of 73.2 t/TJ is country specific and is based on measurements and analyses of fuel samples (see Table 25, SFOE 2001).
- NO_x, 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 1996-2006, the values 1995 are used.
- CH_4, 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 1996-2006, the values 1995 are used. The division of

VOC into CH_4 and NMVOC is carried out by a constant split of 53% : 47% (country specific).

- N_2O: The IPCC default value 23 kg/TJ is used (IPCC 1997b) for the full period 1990–2006.
- SO_2: The emission factor is taken from the IPCC Guidelines 1996, 23.3 kg/TJ, and is assumed to be constant over the period 1990–2006 (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 53).

Table 53 Activity data (jet kerosene consumption) for military aviation. The data is provided annually by VTG (2006, 2006a, 2007).

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
fuel cons. (TJ)	1'793	1'755	1'837	1'641	1'488	1'621	1'672
1990 = 100%	66%	64%	67%	60%	54%	59%	61%

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

Key categories 1A4a
CO_2 from the combustion of Gaseous Fuels in the Commercial/Institutional Sector (level and trend)
CO_2 from the combustion of Liquid Fuels in the Commercial/Institutional Sector (level and trend)

Key categories 1A4b
CO_2 from the combustion of Gaseous Fuels in the Residential Sector (level and trend)
CO_2 from the combustion of Liquid Fuels in the Residential Sector (level and trend)

Key category 1A4c
CO_2 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_2 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_2 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 A2.2.1).

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 2007). Therefore the LFO emission factor for CO_2 (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_4, NO_x, 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_x emission factors, expert judgement has been used to estimate the fraction of low-NO_x burners.

Emission factors for CH_4, NO_x, CO and NMVOC for combined heat and power generation in turbines and engines are country specific based on comprehensive measurements (EMIS).

For N_2O emissions the default emission factors from IPCC 1997c have been used.

The coal emission factor for CO_2 (see table below) is the emission factor for hard coal. Unlike in previous submissions, lignite consumption is accounted for exclusively in cement production in category 1A2f. For net calorific values see Annex A2.2.1.

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 54 Emission Factors for 1A4a and 1A4b: Commercial/Institutional and Residential in “Other Sectors” for 2006.

Source/fuel	CO_2 t/TJ	CO_2 bio. t/TJ	CH_4 kg/TJ	N_2O kg/TJ	NO_x kg/TJ	CO kg/TJ	NMVOC kg/TJ	SO_2 kg/TJ
1A4 a Other Sectors: Commercial/Institutional								
LFO (weighted average)	73.50		1.03	0.60	32.80	11.38	6.09	34.74
LFO (heat only boilers)	73.50		1.00	0.60	31.00	11.00	6.00	34.74
LFO (turbines)	NO		NO	NO	NO	NO	NO	NO
LFO (engines)	73.50		4.40	0.60	272.00	62.00	17.60	34.74
Natural gas (weighted average)	55.00		7.38	0.10	25.34	17.01	1.95	0.50
NG (heat only boilers)	55.00		6.00	0.10	14.40	14.00	2.00	0.50
NG (turbines)	55.00		2.80	0.10	100.00	19.00	0.10	0.50
NG (engines)	55.00		24.00	0.10	155.00	53.00	1.40	0.50
Coal	NO		NO	NO	NO	NO	NO	NO
Biomass (wood)		92	120	1.6	150	2'000	40	20
Biomass (biogas)		55	6.00	0.10	14.40	14.00	2.00	0.50
1A4 b Other Sectors: Residential								
LFO (weighted average)	73.50		1.00	0.60	31.18	11.04	6.01	34.74
LFO (heat only boilers)	73.50		1.00	0.60	31.00	11.00	6.00	34.74
LFO (turbines)	NO		NO	NO	NO	NO	NO	NO
LFO (engines)	73.50		4.40	0.60	312.00	70.00	17.60	34.74
Natural gas (weighted average)	55.00		6.19	0.10	15.22	14.47	1.99	0.50
NG (heat only boilers)	55.00		6.00	0.10	14.40	14.00	2.00	0.50
NG (turbines)	55.00		2.80	0.10	100.00	19.00	0.10	0.50
NG (engines)	55.00		20.00	0.10	75.00	49.00	1.00	0.50
Coal	94.00		300	1.6	65	3'200	100	350
Biomass		92	120	1.6	150	2'000	40	20

Remark: In the table above, the CO_2 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_2 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 occurr (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 2007; Table 17).

During the in-country review in 2007, an error was identified that arose from an assumption that fugitive losses during the transmission and distribution of natural gas should be subtracted from the amount of gas that is combusted, generating CO_2 emissions. The error has been corrected. The affected category is 1A4b. For reasons of simplicity, the entire amount of leaking natural gas had been subtracted from 1A4b, as it is the category with the largest leakages. The amount of light fuel oil and natural gas that is used for co-generation in turbines and engines is taken from Kaufmann (2006).

Table 55 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	80'145	90'747	89'339	88'689	80'969	85'268	91'532	86'319	88'168	87'141
Light fuel oil	TJ	59'727	66'729	65'092	62'947	56'776	58'088	62'047	59'423	60'538	59'368
LFO heat only boilers	TJ	59'703	66'678	65'034	62'891	56'654	57'913	61'816	59'135	60'241	59'040
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	17'135	19'641	19'945	21'219	20'058	22'071	23'331	21'970	22'539	22'704
NG heat only boilers	TJ	16'858	19'206	19'385	20'593	19'235	20'900	21'920	20'505	20'939	20'993
NG turbines	TJ	85	114	109	106	107	78	21	5	12	4
NG engines	TJ	192	321	451	520	716	1'093	1'390	1'460	1'588	1'707
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	5'063	6'107	4'883	5'045	5'018
Biomass (biogas)	TJ	56	55	54	51	49	46	46	43	45	51
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	5	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	308	313	349	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
1A4a Commercial/Institutional	TJ	81'255	85'257	81'733	86'961	85'603	88'681	84'046
Light fuel oil	TJ	54'411	56'425	53'771	56'456	54'645	55'097	50'897
LFO heat only boilers	TJ	54'028	56'010	53'370	56'073	54'270	54'722	50'517
LFO turbines	TJ	0	0	0	0	0	0	0
LFO engines	TJ	383	414	401	383	375	375	380
Natural gas	TJ	22'620	24'072	23'483	25'398	25'938	26'990	25'987
NG heat only boilers	TJ	20'879	22'263	21'562	23'383	23'948	25'000	23'952
NG turbines	TJ	0	3	12	28	31	31	35
NG engines	TJ	1'741	1'806	1'909	1'987	1'959	1'959	2'000
Coal	TJ	0	0	0	0	0	0	0
Biomass (wood)	TJ	4'167	4'697	4'409	5'028	4'927	6'470	6'970
Biomass (biogas)	TJ	58	63	70	79	93	124	192
1A4b Residential	TJ	174'096	183'651	177'450	187'801	188'031	190'874	183'867
Light fuel oil	TJ	120'784	127'553	122'470	129'328	128'194	129'613	124'415
LFO heat only boilers	TJ	120'730	127'497	122'413	129'268	128'119	129'537	124'335
LFO turbines	TJ	0	0	0	0	0	0	0
LFO engines	TJ	54	56	57	59	75	75	80
Natural gas	TJ	36'000	37'666	37'449	39'961	41'253	42'358	40'649
NG heat only boilers	TJ	35'560	37'206	36'983	39'442	40'745	41'849	40'097
NG turbines	TJ	0	0	5	3	2	2	2
NG engines	TJ	440	460	461	516	507	507	550
Coal	TJ	121	121	121	121	374	374	374
Biomass	TJ	17'190	18'310	17'410	18'390	18'210	18'530	18'430

The table above documents the increase of Natural Gas consumption by 52% (1A4a) and 59% (1A4b) from 1990 to 2006 as well as the net decrease of liquid fuel consumption by -15.0% (1A4a) and -10% (1A4b) over the period. This shift in fuel mix is the reason for CO_2 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 emissions of the whole off-road sector have undergone a complete revision beginning in 2005 and is still going on. Consumption and emission modelling results are not yet definite. Therefore, provisional numbers are used. 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 A2.7 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 2007). 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 sub-section on oxidation factors in the beginning of Section 3.2.2).

Emission Factors drying of grass

The emission factors for CO_2 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_4, N_2O, CO and NMVOC are country specific based on comprehensive life cycle analysis of a drying unit, documented in the EMIS database (EMIS 2005/1A4c, 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_2 is country specific and is assumed to be constant in the period 1990-2006 with value 73.6 t/TJ for diesel oil and 73.9 t/TJ for gasoline (Table 25, SFOE 2001).
- For SO_2 the emission factors are country specific and are given in Table 184 in Annex A2.3 (diesel oil, gasoline).
- The emission factors for all other gases are country specific and are shown in Table 194 to Table 197 in the Annex.A2.7.2 (INFRAS 2007). Note that NMVOC is not modelled bottom-up. The NMVOC emissions are calculated as the difference of VOC and CH_4 emissions.

Activity Data

Drying of grass: Activity data on grass drying (in tons of dried grass) is extracted from the EMIS database (EMIS 2005/1A4c).

Off-road machinery: Activity data is shown in Annex A2.7.3 (INFRAS 2007). Not 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 56 Activity data in 1A4c Agriculture/Forestry.

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A4c Agriculture/Forestry	TJ	8'242	8'202	8'164	8'127	8'090	8'055	8'022	7'989	7'957	7'927
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	6'347	6'379	6'412	6'444	6'476	6'509	6'541	6'573	6'606	6'638

Source/Fuel	Unit	2000	2001	2002	2003	2004	2005	2006
1A4c Agriculture/Forestry	TJ	7'898	7'760	7'720	7'681	7'643	7'613	7'442
Drying of Grass	TJ	1'227	1'077	1'025	973	922	880	702
of which light fuel oil	TJ	753	661	629	597	566	540	430
of which natural gas	TJ	474	416	396	376	356	340	271
Machinery	TJ	6'670	6'683	6'696	6'708	6'721	6'733	6'741

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

Key category 1A5
CO_2 from the combustion of Liquid and Gaseous Fuels (level and trend)

Methodology

The emissions of the whole off-road sector have undergone a complete revision beginning in 2005 and is still going on. Consumption and emission modelling results are not yet definite. Therefore, provisional numbers are used. All off-road categories like railways, navigation etc. are modelled by the same approach. The emissions are calculated with a Tier 2 method. Details of the emission modelling that hold for all off-road families are described in Annex A2.7 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 2007). The revision affects the off-road families construction, garden/hobby, industry and military, which are summarised in 1A5b Other / Mobile (Off-road).

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_2 emissions are reported under 1A5b Gaseous Fuels whereas CH_4 and N_2O emissions are reported under1A5b Liquid Fuels.

Emission Factors

- The emission factors for CO_2 are country specific and are assumed to be constant in the period 1990-2006 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 25.
- For SO_2 the emission factors are country specific and are given in Table 184 in Annex A2.3.
- The emission factors for all other gases are country specific and shown in Table 194 to Table 197 in the Annex A2.7.2 (INFRAS 2007) The NMVOC emissions are calculated as the difference of VOC and CH_4 emissions.

Activity Data

Fuel consumption data is shown in Table 57. The underlying data like vehicle stock and operating hours are shown in Table 203 to Table 205 in Annex 2.7.

Table 57 Activity data (fuel consumption) and CO_2 emissions for off-road activities Construction, Garden/Hobby, Industry and Military (without Military Aviation, see 1A3e).

Off-road family	**Fuel**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
1A5b		**fuel consumption in TJ**									
Contruction	Diesel	3'910	4'035	4'160	4'284	4'409	4'534	4'597	4'659	4'722	4'785
	Gasoline	305	307	309	311	313	314	305	295	285	276
Garden/Hobby	Gasoline	689	705	721	736	752	767	781	796	810	825
Industry	Diesel	1'078	1'136	1'195	1'254	1'312	1'371	1'429	1'487	1'545	1'603
	Gasoline	70	76	82	88	94	100	106	112	118	123
	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	0.7	0.7	0.7

Off-road family	**Fuel**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1A5b		**fuel consumption in TJ**						
Contruction	Diesel	4'847	4'883	4'919	4'954	4'990	5'025	5'045
	Gasoline	266	265	264	262	261	260	259
Garden/Hobby	Gasoline	839	832	825	818	811	803	797
Industry	Diesel	1'661	1'665	1'668	1'671	1'674	1'678	1'674
	Gasoline	129	129	129	129	129	129	129
	CNG	316	316	317	317	318	318	318
Military	Diesel	50	50	49	49	49	48	48
	Gasoline	0.7	0.7	0.7	0.7	0.7	0.8	0.8

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 2006, too. 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 A1.2). In addition, correlation coefficients were implemented and adequate probability distributions were adopted: normal, lognormal and triangle distributions were chosen. See Table 174 and Table 175 for details.

a) Uncertainties

Uncertainties of activity data and emission factors are derived from a mixture of empirical data and expert judgment. Since the submission May 2006, 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_2 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 A2.4.1). 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_2 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 58 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	462'661	1.0	2'500	20	465'161	1.0	1
Gaseous fuels	Gas	113'290	5	0	0	113'290	5.0	2
Solid fuels	Kohle	6'570	5	-160	100	6'410	5.7	3
Other fuels	Müll- und Industrieabfälle	49'810	10	0	0	49'810	10.0	4

Comments:

1 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*sigma = 20%).

2 Col. D: 5% is GPG default value for developed countries (IPCC 2000 p. 2.1).

3 Col. D: 5% is GPG default value for developed countries (IPCC 2000 p. 2.1). - Col. G:expert estimate

4 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 58 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 an suitable “expansion factor” which is derived explicitly and described in Annex A1.2.

Data on stock changes is taken from the Swiss overall energy statistics (SFOE 2007; Table 4). This is also the case for coal, for which in the previous uncertainty analysis for the submission of May 2006 an expert estimate had been made instead for stock changes. 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_2 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_2 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 59 Results from the 1998 analysis of the low calorific values of liquid fuels in Switzerland (EMPA 1999).

Fuel	Net calorific value liquid fuels						
	Mean [GJ/t]	STD [GJ/t]	STD [%]	Uncertainty [%]	=(C*G)^2 [GJ^2/t^2]	No. of samples []	Share 2006 (approx.)
Heavy fuel oil	41.2	0.85	2.06	4.13	0.000119	6	1%
Light fuel oil	42.6	0.13	0.31	0.61	0.003749	10	47%
Diesel	42.8	0.10	0.23	0.47	0.000315	10	18%
Gasoline	42.5	0.29	0.68	1.36	0.009186	30	33%
Jet kerosene	43.0	0.25	0.58	1.16	0.000003	10	1%
Sum	42.6				0.013372	66	100%
Combined STD/Unc		0.116 =SQR(sum(E))	0.27	0.54			

Gaseous fuels: The uncertainty of the emission factor for CO_2 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_2, 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_2 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_2 emission factor[14].

Resulting uncertainty in CO_2 emissions in fuel combustion (1A)

Table 60 below provides the results of the quantitative Tier 1 analysis [following Good Practice Guidance; IPCC (2000): p. 6.13ff] estimating uncertainties of CO_2 emissions from fuel combustion activities.

Table 60 Results from Tier 1 uncertainty calculation and reporting for CO_2 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 2006 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combinded uncertainty as % of total CO2 combustion emission in year t	Type A sensitivity (CO2 from combustion)	Type B sensitivity (CO2 from combustion)	Uncertainty in trend in national emissions introduced by emission factor uncertainty (CO2 from combustion)	Uncertainty in trend in national emissions introduced by activity data uncertainty (CO2 from combustion)	Uncertainty introduced into the trend in total CO2 combustion emissions
			Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	%	%	%
1A	Gaseous fuels	CO2	3'696.03	6'113.68	5.0	4.6	6.8	0.962	0.0543	0.1485	0.25	1.05	1.08
1A	Liquid fuels	CO2	34'303.41	33'642.65	1.0	0.54	1.14	0.887	-0.0562	0.8172	-0.03	1.16	1.16
1A	Solid fuels	CO2	1'491.85	930.91	5.7	5.0	7.6	0.163	-0.0154	0.0226	-0.08	0.18	0.20
1A	Other fuels	CO2	1'676.60	2'487.90	10.0	30.0	31.6	1.822	0.0177	0.0604	0.53	0.85	1.01
Total CO2 Emissions Fuel			41'167.90	43'175.15									
Overall uncertainty CO2 combustion emissions in the year (%):								2.25	CO2 combustion emissions trend uncertainty (%):				1.89

The analysis results in an overall uncertainty of the CO_2 emissions from 1A Fuel Combustion of 2.25% for the year 2006 and in a trend uncertainty for the period 1990 to 2006 of 1.89%.

[14] Personal communication by R. Quartier, SAEFL, 23 February 2005.

Uncertainty in N_2O 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_2 emissions. Emission factor uncertainty for N_2O from municipal solid waste incineration is estimated at 80%.

Uncertainty in CH_4 emissions from Gasoline consumption in 1A3 Road Transportation

The uncertainty for the activity data is 10%. For the CH_4 emission factor, a value of 59.2% has been chosen leading to a combined uncertainty for the CH_4 emission of 60%. The values for the activity data and for CH_4 emission factor are taken from an extended uncertainty analysis (Kühlwein 2004).

Qualitative estimate of uncertainties of non-key category emissions in 1A Fuel Combustion

Non-CO_2 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_2 emissions from source categories 1A1, 1A2 and 1A4 based on expert judgement results in high confidence in estimations of SO_2 emissions, because of the high quality of activity data and emission factors. Uncertainty in emissions of other non-CO_2 gases are estimated to be medium: 30% for CH_4 and 80% for N_2O (see Table 11).

N_2O emissions in Road Transportation (1A3)

A preliminary uncertainty assessment for N_2O from source category 1A3 based on expert judgement results in a high uncertainty (150%, see Table 11).

b) Consistency and Completeness in 1A Fuel Combustion

Consistency:

- Time series for 1A1, 1A2, 1A3, 1A4 and 1A5 are all consistent.
- CO_2 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

As mentioned in Sections 1.3 and 1.4.3, the former modelling of the Swiss GHG emissions by means of “internal GHG inventory files” was replaced by the (redesigned) national air pollution database EMIS. For quality control reasons, all the emissions of the energy sector were not only calculated with EMIS but with the internal GHG inventory files, too. Both tools use the same input data (energy consumption and emission factors) but calculate independently the emission numbers. Differences in the emissions were analysed, methodical and technical errors could be identified and corrected. By iteration, a perfect congruence between the two emission results was finally achieved. This process is considered to be a rather rigorous test for the correctness and completeness of the energy-related emissions of the inventory.

At the level of total energy-related CO_2 emissions, another 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_2 emissions for the years 1990–2006 are negligible - indicating again 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.

Activity data

- In an independent Tier 3b calculation, EUROCONTROL performed a fuel calculation for Switzerlands international flights, based on collected flight plan data and single movements. The results for the years 2004, 2005 and 2006 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.
- 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.

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 FOEN specialists. Note that the emission factors and activity data used for the present emission modelling are provisional (INFRAS 2007).

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 2007, CEPE 2007). Sources 1A2 and 1A4a have been recalculated for 1990-2005.
- Fuel consumption of coal and heavy fuel oil has been corrected for source 1A2f to include data from the Swiss overall energy statistics instead of the model from Basics (2007). Emissions are slightly modified by the correction. For years in which estimates for heavy fuel oil and coal consumption for the bottom-up part in 1A2f exceeded the amount allocated top-down for 1A2f. It was interpreted that this was due to stock changes, and corresponding corrections were made.
- During the in-country review in 2007, an error was identified that arose from an assumption that fugitive losses during the transmission and distribution of natural gas should be subtracted from the amount of gas that is combusted, generating CO_2 emissions. The error has been corrected. The CO_2 emissions due to the consumption of natural gas in of category 1A4b are affected.
- The consumption of lignite is exclusively used in the cement industry. The whole amount of lignite has therefore been shifted from several categories into 1A2f. The emission factors for solid fuels were adapted correspondingly in all the sectors concerned.
- Emissions from landfill gas recovery in co-generation (6A) and emissions from fermentation engines (6D) have been moved into the energy sector (1A1a). Note that emissions of CH_4, N_2O and NMVOC associated with fermentation and generation of methane on landfills are still attributed to processes remaining in category 6D or 6A1.
- The method for subtracting Liechtenstein’s fuel consumption was slightly modified, leading to shifts among some categories. The net change in CO_2 is not affected by the reallocation, but some marginal changes occur for CH_4 and N_2O.
- Activity data for the amount of municipal solid waste used as a fuel in energy production in 1A1a has been corrected. Recalculations have been made for the years 1997-2005.
- Activity data for the amount of waste derived fuel in cement industry in 1A2f has been based on a new data source and recalculations were made for the years 2004 and 2005.

- Off-road emissions have been recalculated due to an update of the off-road database. 1A3c Railways, 1A3d Navigation, 1A4c agriculture/forestry machinery and 1A5 Other/Off-road are concerned.

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_2 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 started a project to compile data on fuel consumption and emission factors for small (piston) aircraft and helicopters for which no ICAO emission certification is necessary. The results will be used for further improving the emission modelling in future years.

Other Sectors (1A4)

No source specific improvements are planned.

Other: Off-road (1A5)

As mentioned above, the emissions of the whole off-road sector have undergone a complete revision. It will be finished in the next months in 2008. No substantial modifications of the results used for the present GHG inventory are expected. However, the definite emission results will be used for the next submission, which will lead to a recalculation.

3.3. Source Category 1B – Fugitive Emissions from Fuels

3.3.1. Source Category Description

Key category 1B2
Fugitive Emissions of CH_4 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 61 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 2007 EF: EMIS 2005/1B
1B2 b	Natural Gas	Emissions from gas pipelines and the compressor station in Ruswil, Lucerne.	AD: SFOE 2007, SGWA 2005, SGIA 2007 EF: Battelle 1994, Xinmin 2004, SGWA 2007
1B2 c	Venting / Flaring	The release/combustion of excess gas at the oil refinery	AD: SFOE 2007 EF: EMIS 2005/1B

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 CH_4 and NMVOC are reported.

For source 1B2b Natural Gas, the emissions of CH_4 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_2, CH_4, N_2O, NO_x, CO, NMVOC and SO_2 from a compressor station located in Ruswil are considered.

For source category 1B2c Venting/Flaring (Oil), CO_2 as well as CH_4, NO_x, CO and NMVOC are considered.

The indirect CO_2 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_2, CH_4 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 62; sources: Battelle 1994, Xinmin 2004, SGWA 2007). The CH_4-emissions due to gas meters are considered with the emission factor of 5.1 m^3 CH_4 per gas meter and year. The emission factors for 1B2b are calculated for each year separately.

Table 62 CH_4-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^3/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_2 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_2/Gg NMVOC for 1B2a (Oil) and 2.93 Gg CO_2/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 2007).

The activity data for methane of Natural Gas (source 1B2b) are provided by the Swiss gas gas and water industry association (SFOE 2007), 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 2007, SGIA 2007, SGWA 2005). 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 2007; Table 13).

3.3.3. Uncertainties and Time-Series Consistency

Uncertainty in fugitive CH_4 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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

3.3.5. Source-Specific Recalculations

3.3.6. No source-specific recalculations have been carried out.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 63 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, FOCA 2007

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_2O (IPCC default). The activity data of the bunker is summarised in Table 64 (see also Table 45).

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 2007). 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).

Table 64 International bunker fuels. Consumption of kerosene in TJ. (Note that very small differences 1990-2006 compared to earlier submissions happen due to changes in the method of subtracting Liechtenstein's kerosene consumption, see Sect. 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**
	Fuel consumption in TJ						
Total international	63'687	60'097	55'468	49'763	46'896	47'671	50'109
1990 = 100%	152%	143%	132%	119%	112%	114%	120%

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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 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_2 Emissions from Biomass

A description of the methodology for calculating CO_2 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_2 emissions from energy related MSW incineration in Table 1.A(a) of the CRF. Also CO_2 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), from 6B (Wastewater Handling) and 6D (composting and fermentation of waste) are not foreseen for reporting in the CRF.

Therefore, the CO_2 emissions from biomass in the CRF are incomplete. The following table provides an overview of effective biomass CO_2 emissions in Switzerland 2006 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_2 emissions do not count for the national total emissions and are a memo item only.

Table 65 Effective biomass CO_2 emissions in Switzerland and their representation in the CRF.

Biomass CO_2 emissions	Unit	Value 2006	Note
1A1 Energy Industries (without MSW incineration)	Gg	48	Included in CRF
1A1 Energy generation from MSW Incineration	Gg	2'776	Not included in CRF
1A2d Use of waste derived fuels in cellulose production	Gg	167	Included in CRF
1A2f Manufacturing Ind. and Constr. - Other (excluding waste fuels in cement prod.)	Gg	736	Included in CRF
1A2f Use of waste derived fuels in cement production	Gg	152	Not included in CRF
1A3 Transport	Gg	NO	
1A4 Other Sectors (Commercial/Institutional, Residential)	Gg	2'347	Included in CRF
2D2 Industrial Processes, Food and Drink	Gg	14	Not included in CRF
2G Industrial Processes, Other	Gg	0.04	Not included in CRF
3D Other (consumption of tabacco)	Gg	14	Not included in CRF
4F Agriculture, Burning of Residues	Gg	116	Not included in CRF
6A Solid Waste Disposal on Land	Gg	47	Not included in CRF
6B Wastewater Handling	Gg	300	Not included in CRF
6C Waste Incineration (without MSW incineration)	Gg	112	Included in CRF
6D Other Waste (compost and fermentation of waste)	Gg	365	Not included in CRF
Total biomass combustion CO_2 emissions included in CRF	Gg	3'411	
Total energy related biomass combustion CO_2 emissions included in CRF 1A	Gg	3'299	See table "Summary 2" in CRF
Total biomass CO_2 emissions in Switzerland 2006	Gg	7'194	

3.6. Comparison of Sectoral Approach with Reference Approach

The apparent consumption, the net carbon emissions, and the effective CO_2 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 2007) and from the yearly report of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2007).. These statistics account for production, imports, exports, transformation and stock changes.

The Reference approach covers the CO_2 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 1990–2006. The CO_2 emissions agree very well, for all years the differences are between 0.74% and 1.75%. For the energy consumption the differences are somewhat larger and lie between 1.41% and 2.76%. The reason for this difference is caused by the CRF system for feedstocks: The carbon stored of bitumen is reported in table 1A(d) and is taken into account in the Reference Approach table 1A(b). However, the charging to account for the corresponding energy consumption of this bitumen feedstock – also reported in table 1A(d) – is not foreseen in CRF table 1A(b); this leads to a somewhat higher difference for energy consumption. The graphs in the following figure show the systematic difference between the two parameters and simultaneously the good correlation between them (correlation coeff. r = +0.70).

Table 66 Differences in energy consumption and CO_2 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.

Difference between Reference and Sectoral Approach										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	%									
Energy Consumption	2.12	2.34	2.27	2.12	2.51	2.76	2.13	1.98	2.47	1.75
CO_2 Emissions	0.95	1.16	1.24	1.14	1.45	1.75	1.14	1.04	1.69	0.81

	2000	2001	2002	2003	2004	2005	2006
	%						
Energy Consumption	2.02	2.01	1.64	1.86	2.13	1.41	1.98
CO_2 Emissions	1.09	1.11	0.74	0.84	1.35	1.06	1.73

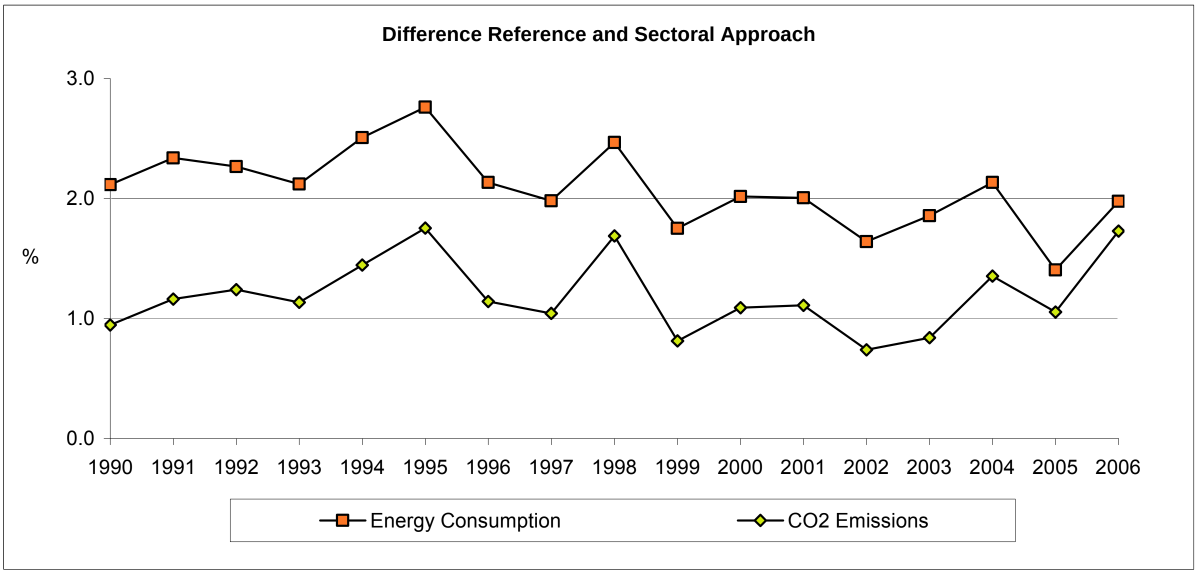


Figure 20 Time series for the differences between Reference and Sectoral Approach. Numbers are taken from Table 66.

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_2 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).

4. Industrial Processes

4.1. Overview

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 category 1 Energy.

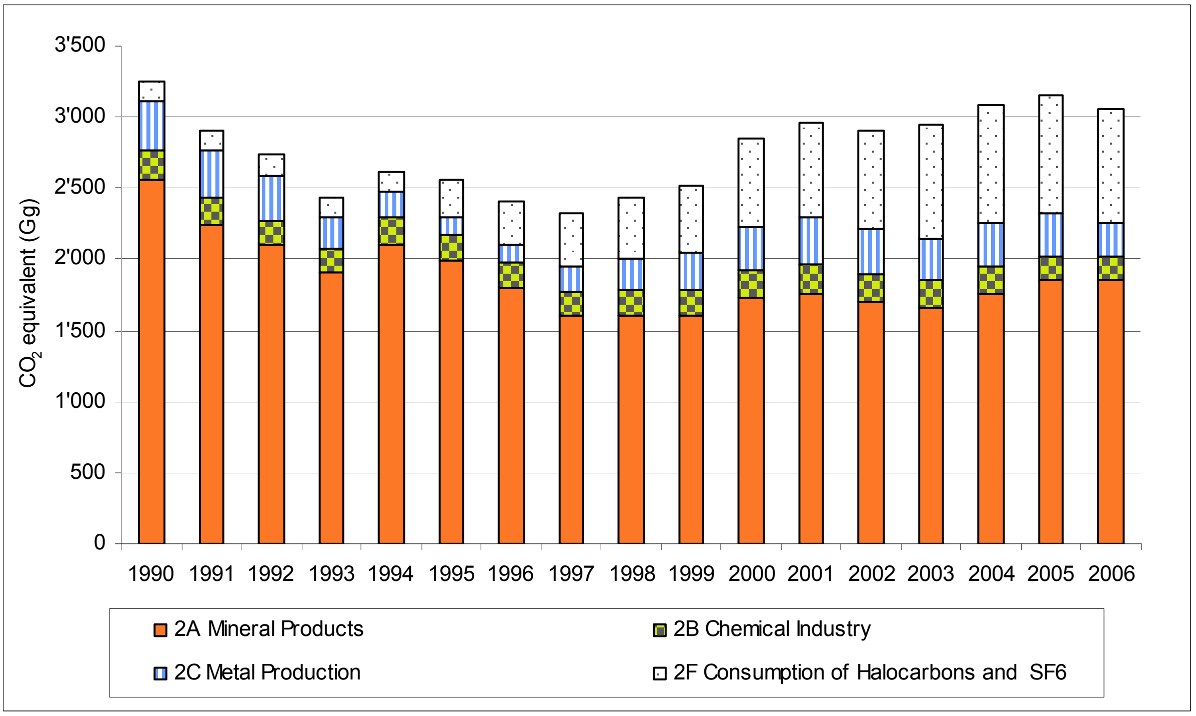


Figure 21 Switzerland's GHG emissions of source category 2 "Industrial Processes" 1990–2006. The emissions of the source category 2G "Other" are small (about 3.4 Gg) compared to the other source categories in category 2 and are not shown in the figure.

Mineral Products (sub-category 2A) remain the dominant source amongst the Industrial Processes although its emissions have decreased by over -27% in the period 1990-2006. Consumption of Halocarbons and SF_6 (sub-category 2F) are of increasing importance. The emissions of synthetic gases have increased by a factor of 3.4 in the same period (see Figure 22), primarily because of the change from CFC to HFC in a lot of technical applications.

Table 67 GHG emissions of source category 2 "Industrial Processes" 1990-2006 by gases in CO_2 equivalent (Gg).

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	2'831	2'500	2'362	2'117	2'283	2'108	1'925	1'748	1'768	1'813
CH_4	9.1	8.7	8.3	8.0	7.7	7.3	7.3	7.2	7.2	7.2
N_2O	174	172	151	144	168	165	160	141	150	153
Synth. gases	244	231	224	169	159	278	318	425	504	550
Sum	3'258	2'912	2'745	2'438	2'617	2'560	2'411	2'321	2'429	2'523

Gas	2000	2001	2002	2003	2004	2005	2006
	CO2 equivalent (Gg)						
CO_2	1'950	1'986	1'939	1'915	2'018	2'116	2'074
CH_4	7.2	7.2	7.2	7.1	7.1	7.1	7.1
N_2O	167	176	182	163	171	145	144
Synth. gases	722	788	784	864	899	891	836
Sum	2'846	2'958	2'913	2'949	3'095	3'159	3'061

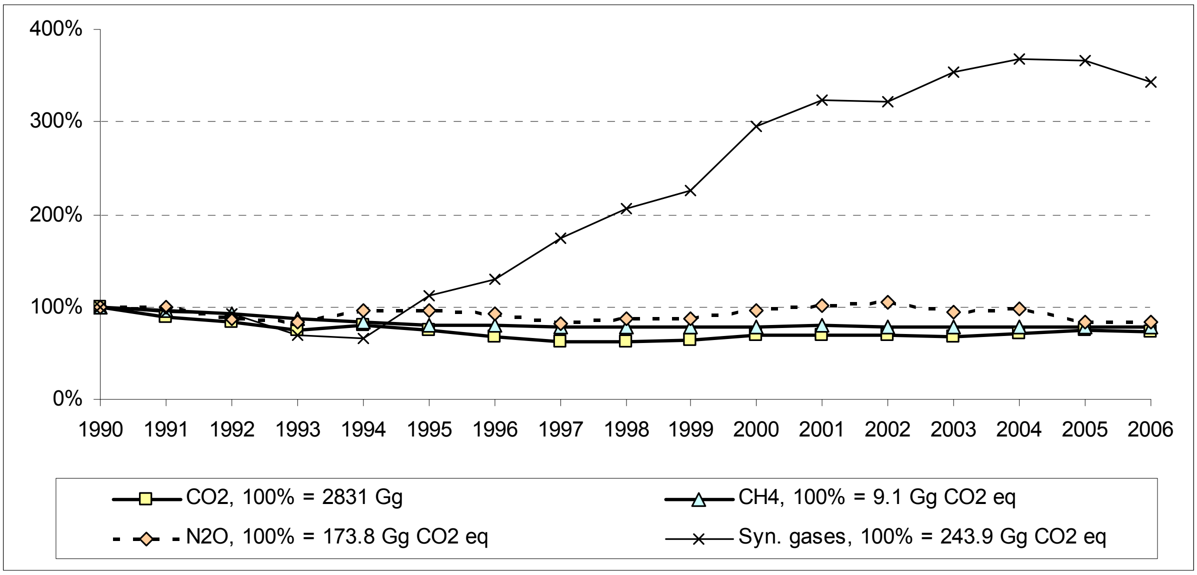


Figure 22 Relative trends of the greenhouse gases of source category 2 "Industrial Processes" in the period 1990-2006. The base year 1990 represents 100%.

The CO_2 emissions have declined to 73% whereas the synthetic gases have increased to 344% in the period 1990-2006.

4.2. Source Category 2A – Mineral Products

4.2.1. Source Category Description

Key category 2A1
Non-energy CO_2 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 68 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 2007 EMIS 2005/2A1 EF: calcination-CO_2: WBCSD 2001; EF Other gases: EMIS 2005/2A1
2A2	Lime Production	Emissions from calcination process in lime production.	AD: EMIS 2005/2A2 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 2005/2A5 EF: Industry data
2A5	Asphalt Roofing	Included in 2G	
2A6	Road Paving with Asphalt	Emissions from road paving	AD: EMIS 2005/2A6 EF: EMIS 2005/2A6
2A7	Other	Not occurring in Switzerland	

4.2.2. Methodological Issues

a) Cement Production (2A1)

Methodology

Calcination: For the CO_2 emissions in Cement Production (2A1) from calcination the Tier 2 approach of IPCC Good Practice Guidance is used. Emissions of CO_2 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_2 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_2 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_2 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_2 from decomposition of $MgCO_3$. 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_2 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).

Calcination emission factors for CH_4, CO, NMVOC and SO_2 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_2, NO_x, CO, NMVOC and SO_2 per ton of cement are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2005/2A1, see Section 1.4.3).

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

Table 69 Emission Factors for 2A1 Cement Production for 2006 (cem.: cement).

2A1 Cement Production	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
	kg/t *clinker*	kg/t cem.			kg/t cem.	kg/t cem.	kg/t cem.
Calcination	525	0.0057			0.80	0.046	0.38
	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 70 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
2A1 Cement Production								
Cement production	Gg	3'754	3'891	3'771	3'592	3'957	4'136	4'143
Clinker production	Gg	3'214	3'275	3'150	3'081	3'265	3'442	3'452

The table above shows that Swiss cement production in 2006 was 19% lower than in 1990. This decline results in category 2A1 being a key category regarding trend.

b) Lime Production

Methodology

For CO_2 emissions in Lime Production (2A2) the approach of IPCC 1997c is used. Emissions of CO_2 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_2 per ton of lime produced is country specific and amounts to 560 kg/t. It takes into consideration measurements and data from the two existing plants, the European BREF default value and expert estimates, documented in the EMIS database (EMIS 2005/2A2, 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 2005/2A2, see Section 1.4.3). Annual lime production is estimated at 82'867 t in 2006.

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. Emissions of NMVOCs are calculated by multiplying the annual amount of asphalt roofing products (level of activity) by the emission factor. 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 2005/2A5, see Section 1.4.3).

Activity Data

Activity data is based on industry and expert estimates, documented in the EMIS database (EMIS 2005/2A5, 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 NMVOCs 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 0.46 kg/t (2006). The emission factor includes emissions from both ground paint and asphalt products. It is based on measurements, industry data and expert estimates, documented in the EMIS database (EMIS 2005/2A6, 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, documented in the EMIS database (EMIS 2005/2A6, see Section 1.4.3).

4.2.3. Uncertainties and Time-Series Consistency

Uncertainty in non-energetic CO_2 emissions from Cement Production in 2A1

Estimate of uncertainty of CO_2 emissions from clinker calcination follows the steps in Table 3.2 in IPCC Good Practice Guidance (IPCC 2000: p. 3.15). As CO_2 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_2 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_2 emissions is high.

The time series is consistent.

4.2.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

4.2.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

4.2.6. Source-Specific Planned Improvements

In the calculation of the CO_2 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 country specific data on CaO content. Also, it is planned to take into account possible non-carbonate feeds (e.g. from raw materials).

4.3. Source Category 2B – Chemical Industry

4.3.1. Source Category Description

Source category 2B "Chemical Industry" is **not a key category.**

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 71 Specification of source category 2B “Chemical Industry”.

2B	Source	Specification	Data Source
2B1	Ammonia Production	Emissions from the production of Ammonia, including NH_3 emissions	AD, EF: EMIS 2005/2B1
2B2	Nitric Acid Production	Emissions from the production of Nitric Acid	AD, EF: Industry data, EMIS 2005/2B2
2B3	Adipic Acid Production	Not occurring in Switzerland	
2B4	Carbide Production	Emissions from the production of Silicon Carbide	AD, EF: EMIS 2005/2B4
2B5	Other	Emissions from the production of Organic Chemicals (Ethylene, PVC, Formaldehyde, Acetic Acid)	AD, EF: EMIS 2005/2B5

4.3.2. Methodological Issues

a) Ammonia Production (2B1)

Methodology

For CO_2, NO_x, CO, NMVOC and SO_2 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_2, NO_x, CO, NMVOC and SO_2 per ton of Ammonia produced are country specific based on measurements, data from industry and expert estimates, documented in the EMIS database (EMIS 2005/2B1, see Section 1.4.3).

Activity Data

Activity data on annual production of 40'000 tons of ammonia in 1990 has been provided by industry, as documented in the EMIS database (EMIS 2005/2B1, see Section 1.4.3). The level of production is assumed to remain constant since then.

b) Nitric Acid Production (2B2)

Methodology

For N_2O and NO_x 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_2O and NO_x 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 2006:

Table 72 Emission Factors for 2B2 Nitric Acid Production in 2006.

2B2 Nitric Acid Production	N_2O	NO_x
	kg/t	kg/t
Nitric Acid Production	5.0	0.89

The emission factor for NO_x has been provided by industry. The emission factor for N_2O was not available from plant operators; therefore an older value of 5 kg of N_2O per ton of nitric acid has been assumed (EMIS 2005/2B2). 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 from 1990 has been provided by industry (EMIS 2005/2B2).

c) Carbide Production (2B4)

Methodology

For CO_2 and SO_2 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_2 emissions from 2 Industrial Processes.

Emission Factors

Emission factors for CO_2 and SO_2 are from EMIS (EMIS 2005/2B4).

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_4, CO, NMVOC and SO_2 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_4, CO, NMVOC and SO_2 are country specific based on measurements and data from industry and expert estimates, documented in the EMIS database (EMIS 2005/2B5, see Section 1.4.3).

Activity Data

Activity data on annual production have been provided by industry as documented in the EMIS database (EMIS 2005/2B5).

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_2O 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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

4.3.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

4.3.6. Source-Specific Planned Improvements

The CO_2 emission factor for 2B1 Ammonia Production will be subject to further revision in future submissions. The N_2O 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 categories 2C3
CO_2 emissions from Aluminium Production (trend)
PFC emissions from Aluminium Production (trend)

Key category 2C_o (2C Metal Production without 2C3 Aluminium Production)
CO_2 emissions from Metal Production without Alumnium Production (trend)

Source category 2C “Metal Production” comprises non-energy emissions from the production of iron and steel, ferroalloys, aluminium as well as from the use of SF_6 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 reminder of the sources in 2C and defined as Metal Production without Aluminium Production. CO_2 emissions in 2C_o occur mainly in 2C1, Iron and Steel Production. Other CO_2 emissions in 2C_o occur only in 2C5 and contributed only 1% to total CO_2 emissions in 2C_o in 2006.

Table 73 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. Also included are emissions from the production of Ferroalloys including consumption of fossil fuels.	AD, EF: EMIS 2005/2C1
2C2	Ferroalloys Production	Included in 2C1.	
2C3	Aluminium Production	Emissions from the production of Aluminium	AD: Industry Data, www.alu.ch EF for PFC: Industry Data EF other gases: EMIS 2005/2C3
2C4	Use of SF_6 in Aluminium and Magnesium Foundries	Emissions from use of SF_6 in Aluminium and Magnesium Foundries	AD, EF: Industry Data, www.alu.ch EF: Carbotech 2008
2C5	Other	Emissions from the production of non-ferrous metals	AD, EF: Industry Data, EMIS 2005/2C5

4.4.2. Methodological Issues

Methodology

In Iron and Steel Production (2C1) a country specific approach is used to calculate CO_2, NO_x, CO, NMVOC and SO_2 emissions, based on CORINAIR and documented in the EMIS database (EMIS 2005/2C1). The emissions are calculated by multiplying the annual production output of steel or iron (level of activity) by emission factors. CO_2 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_2 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_2, NO_x, CO, NMVOC and SO_2 emissions, based on CORINAIR. The emissions are calculated by multiplying the annual production output of aluminium (level of activity) by emission factors.

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 kg_{PFC}/t_{AL}) (based on IAI 2005, reduced by 0.1 kg_{PFC}/t_{AL} for technical progress since 2004) with a correction factor of 0.25 is being used. This results to 0.035 kg_{PFC}/t_{AL} and the ratio of 90% CF_4 and 10% C_2F_6 is being applied. Emissions are calculated by multiplying annual production by emission factors.

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 SF_6 as per the import statistic is reported as actual emission.

In the production of non-ferrous metals (2C5), a country specific approach is used to calculate CO_2, NO_x, CO, NMVOC and 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 CO_2, NO_x, CO, NMVOC and 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).

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 kg CO_2 per ton of steel produced is used (EMIS 2005/2C1). For the years 1990-1998, a lower emission factor of 100 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. CO_2 emissions also occur in cupola furnaces for iron production, the activity data of which are also included here, but those CO_2 emissions are accounted for exclusively in category 1A2.

For CO_2 emissions from Aluminium Production (2C3), an emission factor of 1.6 ton CO_2 per ton of aluminium is used (EMIS 2005/2C3). This 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 CO_2-EF is calculated with 0.43 tons of anode per ton of aluminium; it is assumed that the anode consists completely out 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 since 1990 by a factor of more than 4 due to technical efforts to reduce emissions (Alcan 2003).

The factors according to Table 74 are used.

Table 74 PFC emissions factors for aluminium production in Switzerland.

Gas	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CF_4	kg/t	0.1530	0.1373	0.1215	0.1058	0.0900	0.0833	0.0765	0.0698	0.0630	0.0540
C_2F_6	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
CF_4	kg/t	0.0360	0.0360	0.0360	0.0360	0.0338	0.0315	0.0315
C_2F_6	kg/t	0.0040	0.0040	0.0040	0.0040	0.0038	0.0035	0.0035

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 2005/2C, see Section 1.4.3). 2C1 Iron and Steel production have been updated for the years 2003-2005. Previously, an extrapolation had been made for these years. Now new data is available for 2006 (EMIS 2005/2C1), and the years 2003-2005 have been interpolated.

Since 1995 data on aluminium production is based on data published regularly by the Swiss Aluminium Association (www.alu.ch). For earlier years, the data provided directly from aluminium industry is used.

SF_6 is used in Swiss magnesium foundries since 1997 and is presently used in two factories. The factories report directly the use of SF_6.

Activity data for source categories 2C1 Iron and Steel and 2C3 Aluminium are given in the following table:

Table 75 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 Iron	Gg	90	72	68	54	55	60	51	53	57	56
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
2C Metal Production								
2C1 Iron	Gg	55	49	37	34	35	31	27
2C1 Steel	Gg	1'022	1'048	1'125	1'157	1'190	1'222	1'254
2C3 Aluminium	Gg	36	36	40	44	45	45	12

The table above shows that aluminium production 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. This decline results in CO_2 and PFC emissions from category 2C3 being a key category regarding trend (however not regarding level). Activity data for iron production shown in this table refers to electric arc furnaces. Activity increased by 13% from 1990 to 2006. Together with the increase of the CO_2 emission factor by 40%, this results in an increase of related CO_2 emissions by 58%. This explains why CO_2 emissions from category 2C_o increased by 58% and why this category became a key category regarding trend accordingly. For iron production, activity data is shown here for cupola furnaces. CO_2 emissions occur also in cupola furnaces for iron production, but are accounted for exclusively in category 1A2.

4.4.3. Uncertainties and Time-Series Consistency

Uncertainty in CO_2 and PFC emissions from Aluminium Production in 2C3

Production data of aluminium industry stems directly from the industry association with high confidence (estimated uncertainty 5%). For emission factors of CO_2 and PFC no default values are provided in IPCC 2000. The uncertainty for CO_2 emissions is roughly estimated as 30%. For PFC emissions, an uncertainty of 49% (with normal distribution) is assumed, which is a result of the Monte Carlo simulation of the emissions of synthetic gases (Carbotech 2008, see also Table 12).

Uncertainty in CO_2 emissions from Metal Production without Aluminium Production (2C_o)

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 2005/2C1). The uncertainty for the emission factor is estimated to be 40% (EMIS 2005/2C1).

Uncertainty in use of SF_6 in Aluminium and Magnesium Foundries 2C4

For use of SF_6 in Aluminium and Magnesium Foundries, an uncertainty of 7.8% (with normal distribution) is assumed, which is a result of the Monte Carlo simulation of the emissions of synthetic gases (Carbotech 2008).

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 check between EMIS and Internal GHG Files (Section 1.4.3) and 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 have been updated for the years 2003-2005. Previously, an extrapolation had been made for these years. Now new data is available for 2006, and the years 2003-2005 have been interpolated. See also Chapter 9.

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.

It will be evaluated if activity data for 2C1 Iron and Steel production can be improved for the years 2003-2005, since CO_2 emissions from 2C_o have become a key category and 2C1 accounts for 99% of these emissions.

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 76 Specification of source category 2D “Other Production”.

2D	**Source**	**Specification**	**Data Source**
2D	Other Production	Pulp and Paper, Food and Drink	AD, EF: EMIS 2005/2D

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_2 are not reported in the CRF and emissions of non-biogenic CO_2 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 2005/2D, 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 2005/2D, 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 check between EMIS and Internal GHG Files (Section 1.4.3) and 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_6

No emissions occurring in this sector within Switzerland. There is no production of HFC, PFC or SF_6 in Switzerland.

4.7. Source Category 2F – Consumption of Halocarbons and SF_6

4.7.1. Source Category Description

Key category 2F1
HFC emissions from Consumption of Halocarbons and SF_6; Refrigeration and Air Conditioning Equipment (level and trend)

Key category 2F_o (HFC sources from 2F without 2F1)
HFC emissions from Consumption of Halocarbons and SF_6 (trend)

Source category 2F comprises HFC, PFC and SF_6 emissions from consumption of the applications listed below.

Table 77 Specification of source category 2F "Consumption of Halocarbons and SF_6". Data source "import statistics": Carbotech (2008).

2F	Source	Specification	Data Source
2F1	Refrigeration and Air Conditioning Equipment	Emissions from Refrigeration and Air Conditioning Equipment	AD: Various national statistics[15] 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_6 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.

[15] e.g. statistics on registration of cars and trucks, import statistics on synthetic gases (Carbotech 2007)

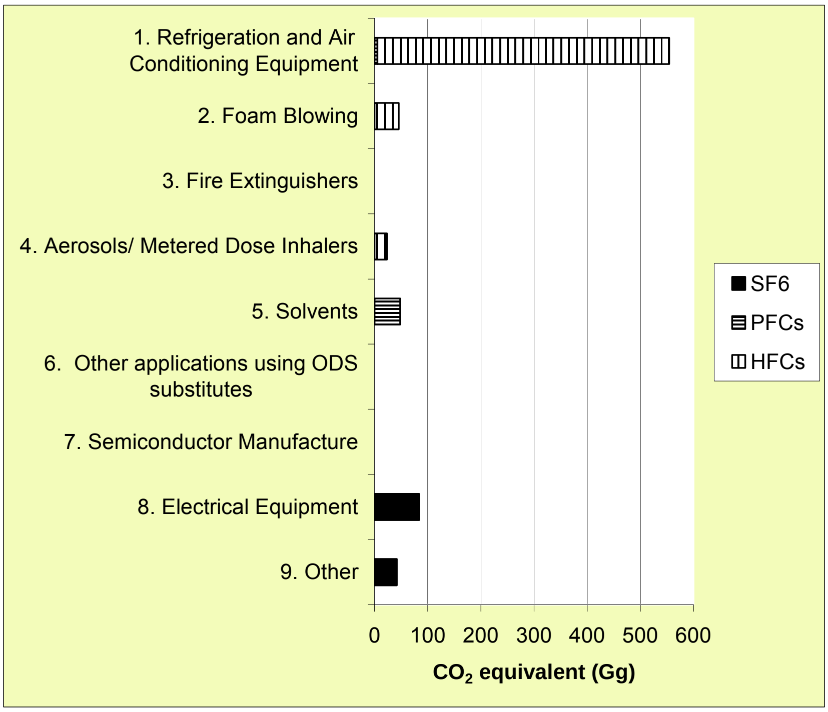


Figure 23 Distribution of emissions under source category 2F “Consumption of Halocarbons and SF_6“ (2006 data).

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 A3.1 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 78). Detailed documentation of the individual data models is available from Carbotech (2008) 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 78 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 78 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	12	NR	1	10 (5)	100	10
Transport Refrigeration / Trucks	8	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	0.78	NO	8.5 (3)	60	100 (30)
Mobile Air Conditioning / Trucks	10	1.1	NO	10 (8.5)	35	100 (30)
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.

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 A3.1. Car air-conditioning accounts for approx. 24% of the total emissions (CO_2 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 79 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	HFC 134a HFC 152a	50	6.5	10	10 / 0.7** 100 / 0**	35% 0%
PU spray		50	10.6 / 4.6 /4.6 *	0.7	95 / 2.5 **	0
Sandwich Elements		50	3	10	0.5	65

* Data for 1990 / 2000 / 2006

** Data for 1st year / following years

NR Not relevant, because no substances according to this protocol has been used, all emissions occur outside Switzerland during production

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_2. XPS foams are 100% imported. From 2000 onwards there is no production of XPS in Switzerland.

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_6 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_6 emissions were considered for semiconductor manufacturing in 2006. 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_2F_6, CF_4 and only for 2002 C_3F_8) and SF_6 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_6 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 0.25%/a (2006). 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 personel at the data supplier.

Activity Data

Activity data is based on industry information. The wide annual fluctuation of SF_6 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 windows and a small amount of unallocated SF_6 from the SWISSMEM mass balance (see above under 2F8) and since 2003 further applications such as laboratory and syntheses use. The unallocated emissions of SF_6 from the SWISSMEM mass balance have been assigned to cables and electrical control systems using a Tier 2 approach. For laboratory and syntheses uses no modelling has been possible due to lack of information. Therefore, only the activity data is reported.

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.

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 2008). 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 81 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 2008.

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 80.

The introduction of this uncertainty in the Monte Carlo analysis resulted in some applications in higher uncertainties compared to those reported in the previous years. This does however not mean that the uncertainty of the data has increased. It only means that the error estimation has improved.

Table 80 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 – 2006	-10%	+10%	

The following table summarises the results for the application-specific emission models. The “value 2006” represents the actual emissions in Gg CO_2 equivalent for the specific application as used for calculating the 2006 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
- Solvent
- Aerosols.

Medium uncertainties of 14% to 20% have been calculated for the following applications:.

- Mobile Air Condition
- Stationary Air Condition

These two applications make a contribution to the total GHG potential of the synthetic gases of about 31%. So it seems to be important to make an effort in reducing these uncertainties. More detailed information and therefore less uncertainties is to be expected for the next years regarding stationary air-conditioning and commercial and industrial refrigeration due to the new declaration of products with more than 3 kg refrigerant.

For the model calculations of stocks, uncertainties result with a maximum of 38% for R134a in Commercial/ Industrial Refrigeration and 32% for domestic refrigeration. 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 81 Summary of results for model parameter “emissions” from Monte Carlo Analysis for 2006 data on selected emission sources.

Application	Model para-meter	value 2006 Gg CO_2 eq.	Average Gg CO_2 eq.	Median Gg CO_2 eq.	min. Gg CO_2 eq.	max. Gg CO_2 eq.	Uncer-tainty %
Commercial / Industrial Refrigeration	Emissions in Gg CO_2 eq.	272	343	337.4	186.8	572.6	39.8
Mobile Air-Conditioning		178	194.3	192.1	150	259	20.8
Stationary Air-Conditioning		81.4	101.3	101.0	71.8	135.6	19.2
Transport Refrigeration		18.8	17.9	17.8	11.9	24.6	22
Domestic Refrigeration		4.8	7.1	4.3	0.7	37.4	*)
Total HFC from 2F1		***554***	***664***	***658***	***490***	***902***	***18.4***
2F2 Foam Blowing		45.6	66.0	64.2	36.3	148.1	38
2F4 Aerosol		23.0	21.41	21.34	8.63	40.19	40
2F5 Solvents		48.0	41.77	41.61	23.04	63.88	26
2F8 Electric equipment		83.9	102.68	102.63	86.56	118.58	10
2F9 Other		41.9	43.27	43.08	-0.12	88.44	54
Total HFC from 2F_o		***63.3***	***67***	***66***	***36***	***170***	***19***
Total HFC from 2F		***618***	***732***	***726***	***552***	***979***	***17.2***
Total PFC from 2F		***53.4***	***53.9***	***53.9***	***40.9***	***70.3***	***15.2***
Total SF_6 from 2F		***126***	***122***	***122***	***74***	***172***	***22.4***

*) very asymetric distribution, therefore no indication of a standard deviation.

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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

4.7.5. Source-Specific Recalculations

Table 82 Summary of recalculations in source category 2F.

Category	Remarks
Commercial Refrigeration	According to information from the declaration of equipment with more than 3 kg refrigerant which was introduced in the year 2006, it was possible to do a better modelling of the distribution of the gases to different applications. The assumptions were approved by different experts.
Air-Conditioning	According to information from the declaration of equipment with more than 3 kg refrigerant which was introduced in the year 2006, it was possible, to do a better modelling of the distribution of the gases to different application
Heat pumps	According to information from the declaration of equipment with more than 3 kg refrigerant which was introduced in the year 2006, it was possible, to do a better modelling of the distribution of the gases to different application.
General refrigeration	Due to new information data on buses was added to the model. The data is provided by experts and manufacturers, wherever no data was available the data for trucks was used.
Mobile air condition	Specific data on buses was collected and used.

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_6 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 personel at the data supplier it was 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 83 Specification of source category 2G “Other”.

2G	Source	Specification	Data Source
2G	Other	Emissions from the production of roofing fabrics, 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 2005/2G

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_2, CH_4, NO_x, CO, NMVOC and SO_2 emissions. The emissions are calculated by multiplying the annual production output (level of activity) by emission factors.

Emission Factors

The emission factor for CO_2, CH_4, NO_x, CO, NMVOC and SO_2 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 2005/2G, 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 2005/2G, 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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

4.8.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

4.8.6. Source-Specific Planned Improvements

There are no planned improvements.

5. Solvent and Other Product Use

5.1. Overview

Emissions within this sector comprise NMVOC emissions from the use of solvents and other related compounds. It also includes indirect CO_2 emissions from the atmospheric decomposition of NMVOC.

Further included are evaporative emissions of N_2O, NO_x, CO and SO_2 arising from other types of product use (firework, impregnation of mineral wool) and N_2O emissions from medical use. The disposal of solvents is reported in category 6 Waste (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_2 emissions from Solvent and Other Product Use (trend).

N_2O emissions from source category 3 were a key category regarding trend in the previous submission (FOEN 2007). They are no longer a key category, because after a slight increase of N_2O emissions in this category compared to 2005, their overall decrease since 1990 is now smaller compared to the previous submission.

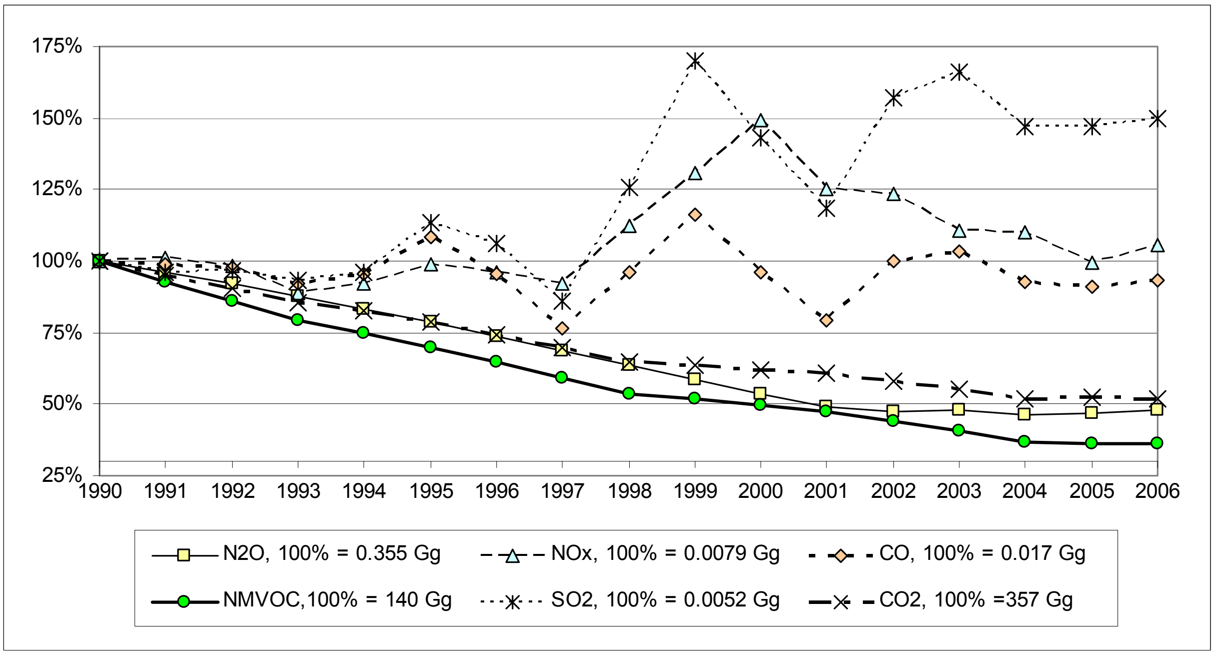


Figure 24 Overview over emissions in category 3 Solvent and Other Product Use in Switzerland. Note that NMVOC and N_2O evolve highly correlated with CO_2 emissions.

Table 84 Emissions of source category 3 Solvent and Other Product Use.

Gas	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	Gg	357	339	324	304	294	281	265	248	232	227
N_2O	t	355	342	327	311	295	279	261	243	226	208
NO_X	t	7.9	8.0	7.8	7.0	7.3	7.8	7.6	7.3	8.8	10.3
CO	t	17	17	17	16	16	18	16	13	16	20
NMVOC	Gg	140	131	121	111	105	98	91	83	76	73
SO_2	t	5.2	5.0	5.0	4.8	5.0	5.9	5.5	4.5	6.5	8.8

Gas	unit	2000	2001	2002	2003	2004	2005	2006
CO_2	Gg	222	217	207	197	186	186	186
N_2O	t	191	174	168	170	164	167	170
NO_X	t	11.8	9.9	9.7	8.7	8.7	7.8	8.3
CO	t	16	13	17	18	16	15	16
NMVOC	Gg	70	67	62	57	51	51	51
SO_2	t	7.4	6.1	8.1	8.6	7.6	7.6	7.8

NMVOC emissions have diminished since 1990 by -64% mainly due to two reduction efforts: The limitation of the application of NMVOC 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_2 and N_2O emissions decreased significantly. The other emissions have increased since 1990 or remained stable.

CO, NO_x and SO_2 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_x emissions differ from CO and SO_2: 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 NMVOC emissions from paints, lacquers, thinners and related materials used in coatings in industrial, commercial and household applications. Also, it includes indirect CO_2 emissions resulting from post-combustion of NMVOCs to reduce NMVOCs in exhaust gases.

Table 85 Specification of source category 3A "Paint Application".

	Source	Specification	Data Source
3A	Paint Application	Paint application in households, industry and construction	AD, EF: EMIS 2005/3A, FOEN 2007g

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_2 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 NMVOCs 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_2 emissions resulting from post-combustion of NMVOCs. 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 2005/3A).

For paint application in households, as the most important source, the emission factor of 124 kg NMVOC/t paint for the year 2006 is based on expert estimates (EMIS 2005/3A).

The emission factor for the indirect CO_2-emissions from NMVOC for 3A is 2.35 Gg CO_2/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 households, as the most important source, the activity data equals the consumption of 20'000 t paint in 2006 (EMIS 2005/3A).

5.2.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (EMIS) results in medium confidence in emissions estimates.

The uncertainty of total CO_2 emissions from the entire category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate). The uncertainty of N_2O 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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

5.2.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

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_2 emissions resulting from post-combustion of NMVOCs to reduce NMVOCs in exhaust gases.

Table 86 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 2005/3B, FOEN 2007g

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_2 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 NMVOCs 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_2 emissions resulting from post-combustion of NMVOCs. 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 2005/3B).

Degreasing of metal is the most important source in 3B. Its emission factor of 345 kg NMVOC per ton of solvent for 2006 is based on an industry survey (EMIS 2005/3B).

The emission factor for the indirect CO_2-emissions from NMVOC for 3B is 2.24 Gg CO_2 per Gg NMVOC (RIVM 2005[16]: 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 (5'888 t solvent in 2006), as the most important source, is based on an industry survey (EMIS 2005/3B).

[16] There seems to be a typo in the relevant section of the RIVM 2005 regarding the Emission Factor for the indirect CO_2-emissions from NMVOC for 3B.

5.3.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (EMIS 2005/3B) results in medium confidence in emissions estimates.

The uncertainty of total CO_2 emissions from the entire category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate). The uncertainty of N_2O 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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

5.3.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

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_2 emissions resulting from post-combustion of NMVOCs to reduce NMVOCs in exhaust gases.

Table 87 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 2005/3C, FOEN 2007g

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_2 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 NMVOCs 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_2 emissions resulting from post-combustion of NMVOCs. 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_2 emissions from NMVOC for 3C is 2.31 Gg CO_2 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 2005/3C).

Fine chemical production is the most important source category in 3C (emissions 1'218 t NMVOC in 2006). Data for this source provided by industry refers directly to the emissions for this category without distinction between actvitiy data and emission factors (EMIS 2005/3C). 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_2 emissions from the entire category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate). The uncertainty of N_2O 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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

5.4.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

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_2O, NO_x, CO and SO_2 are relevant. Also, 3D includes indirect CO_2 emissions resulting from post-combustion of NMVOCs to reduce NMVOCs in exhaust gases.

The application of N_2O in households and hospitals and CO_2 from the impregnation of mineral wool and the use of fireworks are the only direct greenhouse gas emission considered in this category.

Table 88 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_2O in households and in hospitals; other use of gases; production of perfume /aroma and cosmetics; use of fireworks.	AD, EF: industry data, EMIS 2005/3D, FOEN 2007g

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_2 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 NMVOCs 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_2 emissions resulting from post-combustion of NMVOCs. 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 2005/3D). The NMVOC emissions from the production of cosmetics, perfume and aroma are calculated per employee, documented in the EMIS database.

Emission factors for N_2O, NO_x, CO and SO_2 are country specific based on data from industry and expert estimates, documented in the EMIS database (EMIS 2005/3D).

The emission factor for the indirect CO_2-emissions from NMVOC for 3D is 2.53 Gg CO_2/Gg NMVOC (RIVM 2005: p. 5-2ff.).

The emission factor for house cleaning, the most important source, is 1'200 g/inhabitant in 2006, based on Theloke et al. 2000, documented in EMIS (EMIS 2005/3D).

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 (7'557'000 in 2006).

5.5.3. Uncertainties and Time-Series Consistency

The uncertainty assessment (EMIS) results in medium confidence in emissions estimates.

The uncertainty of total CO_2 emissions from the entire category 3 Solvent and Other Product Use is estimated to be 50% (expert estimate). The uncertainty of N_2O 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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

5.5.5. Source-Specific Recalculations

The number of inhabitants was slightly modified; numbers are now consistently based on data from the Swiss overall energy statistics (SFOE 2007). 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.

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 agriculture sector (Sectoral Report for Agriculture, Table 4 in the Common Reporting Format). The following source categories are reported:

- CH_4 emissions from enteric fermentation in domestic livestock,
- CH_4, N_2O and NO_x emissions from manure management,
- N_2O, NO_x and NMVOC emissions from agricultural soils,
- CH_4, N_2O, NO_x, CO, NMVOC and SO_2 emissions from field burning of agricultural residues.

Total greenhouse gas emissions from agriculture in 2006 were 5'288 Gg CO_2 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 2006 were enteric fermentation emitting 2'303 Gg CO_2 equivalents, followed by agricultural soils with 2'066 Gg CO_2 equivalents.

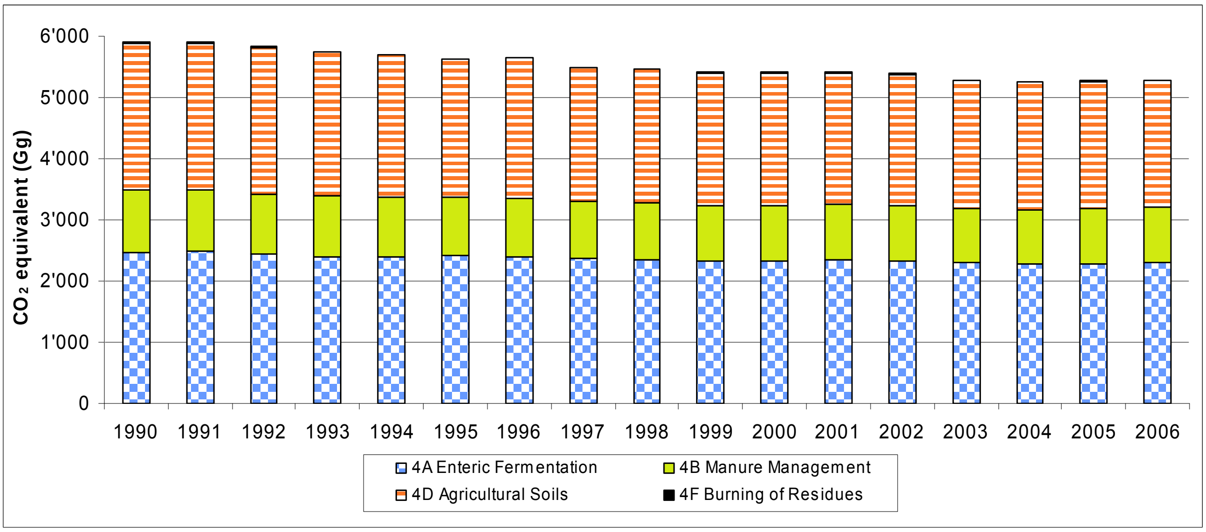


Figure 25 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture1990-2006.

Main greenhouse gases are CH_4 and N_2O. No CO_2 emissions are reported in the agricultural sector. CO_2 emissions from soils are reported under Land Use, Land-use Change and Forestry. CO_2 emissions from energy use in agriculture are reported under 1A4c Energy; Others Sectors, Agriculture/Forestry/Fishing.

Table 89 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture1990-2006.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	0	0	0	0	0	0	0	0	0	0
CH_4	3'042	3'048	2'999	2'957	2'950	2'961	2'938	2'890	2'873	2'838
N_2O	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
	CO_2 equivalent (Gg)						
CO_2	0	0	0	0	0	0	0
CH_4	2'835	2'867	2'846	2'803	2'775	2'796	2'815
N_2O	2'577	2'549	2'545	2'481	2'483	2'484	2'473
Sum	5'411	5'416	5'391	5'285	5'259	5'281	5'288

CH_4 and N_2O 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 two years CH_4 emissions increased again due to slightly higher livestock numbers (mainly cattle). Emission factors did not change significantly.

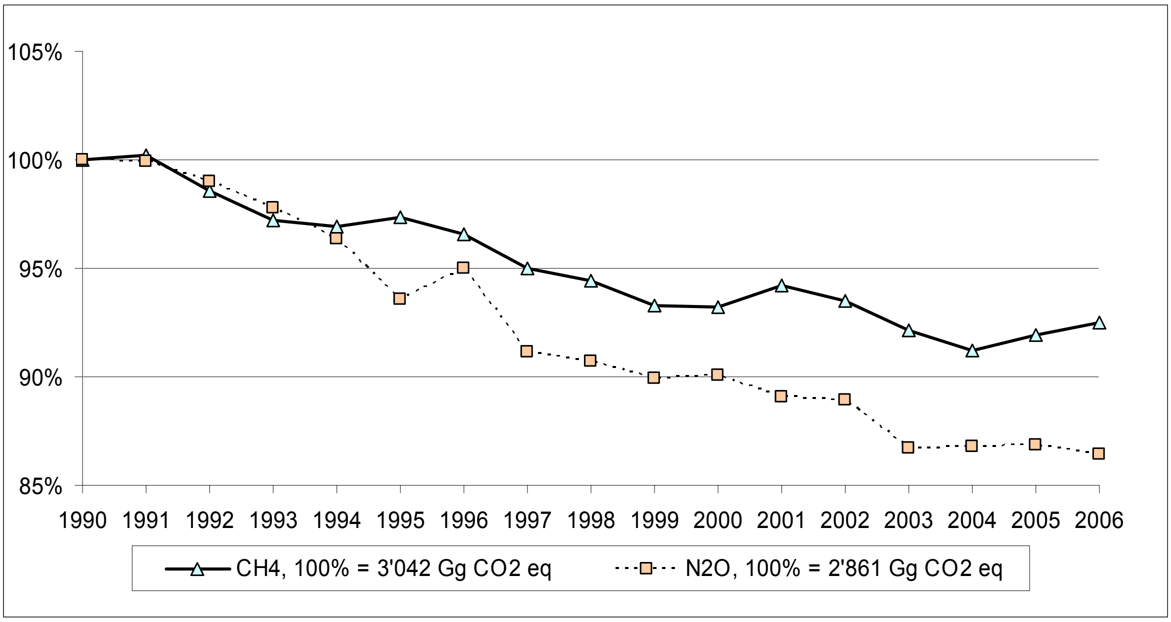


Figure 26 Trend of the greenhouse gases of the agricultural sector 1990-2006. The base year 1990 represents 100%.

Among the key categories of the Swiss inventory, five are out of the agricultural sector:

Key category 4A
CH_4 emissions from Enteric Fermentation (level and trend)

Key categories 4B
CH_4 emissions from Manure Management (level and trend)
N_2O emissions from Manure Management (level)

Key category 4D1
N_2O emissions from Agricultural Soils; Direct Soil Emissions (level and trend)

Key category 4D3
N_2O emissions from Agricultural Soils; Indirect Soil Emissions (level and trend)

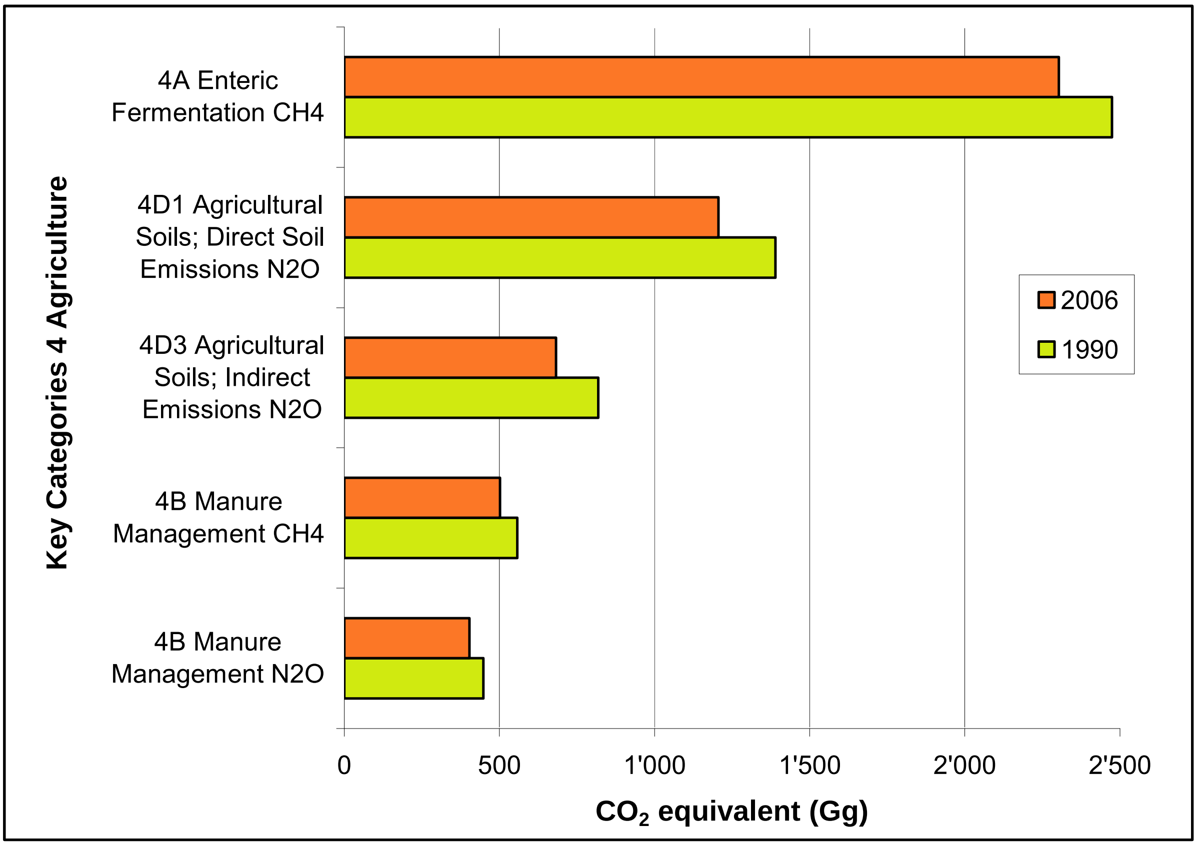


Figure 27 Key sources in Agriculture (emissions in CO_2 equivalents per source category). 4A: Enteric fermentation. 4B: Manure management. 4D: Agricultural soils.

6.2. Source Category 4A – Enteric Fermentation

6.2.1. Source Category Description

Key category 4A
CH_4 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 two years livestock numbers were slightly increasing (mainly cattle). Emissions from cattle contribute to almost 92% of the emissions from enteric fermentation.

Table 90 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 2007 Net energy and metabolisable energy (calves) from RAP 1999 EF: Soliva 2006
		Mature non-dairy cattle	
		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)	
4A3 4A4	Sheep Goats		AD: Livestock data, net energy, and feed intake losses from SBV 2007 EF: Soliva 2006
4A6 4A7 4A8	Horses Mules and asses Swine		AD: Livestock data, digestible energy and feed intake losses from SBV 2007 EF: Soliva 2006
4A9	Poultry		AD: Livestock data; metabolisable energy and feed intake losses from SBV 2007 EF: Hadorn and Wenk 1996; 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_4 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_4 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 (2007) and from RAP (1999). The method is described in detail in Soliva (2006).

Different energy levels (Figure 28) are used to express the energy conversion from energy intake to the energy required for maintenance and performance.

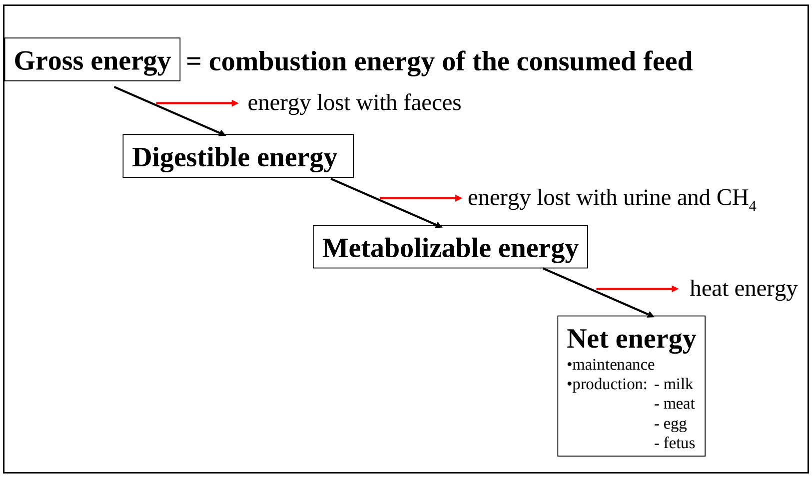


Figure 28 Levels of feed energy conversion. Reference: Soliva 2006.

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). Exceptions in the cattle category are the 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. Calculation for NE, DE and ME consumption was used for the livestock categories sheep, goats, horses, mules and asses, swine and poultry, respectively.

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 91 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 Ym** (%) 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 ($Y_{poultry}$ = 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.

$$EF = \frac{GE * Y_m * 365\, days / y}{55.65\ MJ / kg\, CH_4}$$

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 92 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 (2007) 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									
Cattle											
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
	Calves on milk	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*	*47.6*
	Pre-weaned calves	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*	*55.7*
	Breeding calves	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*	*26.9*
	Breeding cattle 1 (4-12 months)	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*	*89.2*
	Breeding cattle 2 (more than one year)	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*	*129.1*
	Fattening calves	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*	*55.6*
	Fattening cattle	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*	*124.6*
Sheep		20.8	21.4	21.7	21.1	23.2	24.3	21.4	21.8	21.6	22.8
Goats		31.7	32.0	32.3	32.5	33.2	34.8	32.4	29.3	29.2	28.9
Horses		145.3	135.1	133.4	134.8	153.3	176.8	131.9	133.9	134.1	136.0
Mules and Asses		162.0	158.1	159.7	164.7	161.0	156.1	118.3	115.0	110.3	103.1
Swine		35.2	36.0	36.2	35.9	36.8	40.4	37.2	37.0	36.5	36.4
Poultry		1.8	1.9	1.9	1.6	1.7	1.8	1.7	1.8	1.7	1.7

Gross Energy intake		2000-2006						
		2000	2001	2002	2003	2004	2005	2006
		MJ/head/day						
Cattle								
Mature dairy cattle		273.4	275.0	275.6	276.6	279.1	279.3	279.3
Mature non-dairy cattle		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
	Calves on milk	47.6	47.6	47.6	47.6	47.6	47.6	47.6
	Pre-weaned calves	55.7	55.7	55.7	55.7	55.7	55.7	55.7
	Breeding calves	26.9	26.9	26.9	26.9	26.9	26.9	26.9
	Breeding cattle 1 (4-12 months)	89.2	89.2	89.2	89.2	89.2	89.2	89.2
	Breeding cattle 2 (more than one year)	129.1	129.1	129.1	129.1	129.1	129.1	129.1
	Fattening calves	55.6	55.6	55.6	55.6	55.6	55.6	55.6
	Fattening cattle	124.6	124.6	124.6	124.6	124.6	124.6	124.6
Sheep		22.1	22.8	22.6	22.3	23.0	22.4	22.7
Goats		31.9	31.9	30.9	31.4	30.9	30.7	30.5
Horses		137.5	139.4	138.1	138.9	139.7	141.2	140.8
Mules and Asses		103.5	98.9	94.5	91.5	89.2	86.1	85.0
Swine		35.2	35.2	35.0	35.0	35.0	34.5	33.5
Poultry		1.7	1.7	1.7	1.7	1.6	1.6	1.8

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 5’690 kg per year in 2006). 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 92 (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 93) 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 1998).

Activity data

The activity data input has been obtained from statistics published by the Swiss Farmers Union (SBV 2007). The following data were used:

Table 93 Activity for calculating methane emissions from enteric fermentation (SBV 2007).

Population Size		1990-1999									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		1'000 head									
Cattle		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
	Calves on milk	*122*	*123*	*123*	*125*	*123*	*120*	*134*	*132*	*137*	*116*
	Pre-weaned calves	*i.e*	*i.e*	*i.e*	*i.e*	*i.e*	*i.e*	*i.e*	*i.e*	*i.e*	*33*
	Breeding calves	*214*	*204*	*197*	*184*	*183*	*166*	*155*	*139*	*136*	*72*
	Breeding cattle 1 (4-12 months)	*132*	*133*	*127*	*125*	*118*	*129*	*131*	*121*	*118*	*147*
	Breeding cattle 2 (more than one year)	*404*	*400*	*397*	*381*	*379*	*378*	*383*	*372*	*350*	*305*
	Fattening calves	*88*	*79*	*71*	*76*	*79*	*82*	*75*	*68*	*66*	*48*
	Fattening cattle	*100*	*96*	*87*	*92*	*101*	*110*	*105*	*97*	*97*	*162*
Sheep		395	409	415	424	405	387	419	420	422	424
Goats		68	65	58	57	55	53	57	58	60	62
Horses		45	49	52	54	48	41	43	46	46	49
Mules and Asses		7	7	8	8	8	8	8	9	10	11
Swine		1'787	1'723	1'706	1'692	1'569	1'446	1'379	1'395	1'487	1'453
Poultry		5'932	5'642	5'499	6'410	6'431	6'241	6'425	6'537	6'724	6'886

Population Size		2000-2006						
		2000	2001	2002	2003	2004	2005	2006
		1'000 head						
Cattle		1'588	1'611	1'594	1'570	1'545	1'555	1'567
Mature dairy cattle		669	669	658	638	621	621	618
Mature non-dairy cattle		45	51	58	65	70	78	87
Young cattle		874	891	878	867	854	856	861
	Calves on milk	103	115	114	114	111	106	101
	Pre-weaned calves	36	40	47	52	57	62	67
	Breeding calves	76	78	76	73	71	75	77
	Breeding cattle 1 (4-12 months)	161	160	154	147	143	147	147
	Breeding cattle 2 (more than one year)	352	350	345	337	326	318	320
	Fattening calves	43	40	38	39	36	35	35
	Fattening cattle	105	109	104	105	109	112	114
Sheep		421	420	430	445	441	446	451
Goats		62	63	66	67	71	74	76
Horses		50	50	51	53	54	55	56
Mules and Asses		12	12	13	14	15	16	16
Swine		1'498	1'548	1'557	1'529	1'538	1'609	1'635
Poultry		6'983	6'939	7'339	7'585	8'061	8'256	7'665

The Swiss Farmers Association 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 16 years, which is a result of an ongoing process to a less intensive form of animal husbandry due to ecological and economic 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 with regard to the cattle population. Only in the last two years livestock numbers were slightly increasing (mainly cattle).

The numbers of sheep, goats and horses were increasing. Also the number of swine is increasing again after a decrease until 1996 – a process that can be observed also in many other European countries (SBV 2004: p.69). After a rapid increase the number of poultry decreased between 2005 and 2006 by approximately 7%. Most likely, this is 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 date from ART was used (ART 2007):

Table 94 Input data for the uncertainty analysis of the source category 4A “Enteric Fermentation” (ART 2007).

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_4 /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 1990–2006 is 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 calculation of the whole time series (refer to chapter 6.2.5). IPCC tables with data for estimating emission factors for cattle (such as weight, weight gain, milk production) were filled in and compared with IPCC default values (refer to Table 208 in Annex 4). Livestock data was compared with the livestock data provided to the FAO and checked for plausibility (FAO 2007). No inconsistency could be observed in this quality control process.

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 since the definitive input data from the Swiss Farmers Union were now available and replace the estimates generated by linear extrapolation.

6.2.6. Source-Specific Planned Improvements

Quality control procedures will be further improved in the next submission. Emission factors will be compared with other national and international studies and checked for plausibility.

6.3. *Source Category 4B – Manure Management*

6.3.1. Source Category Description

Key categories 4B
CH_4 emissions from Manure Management (level and trend)
N_2O emissions from Manure Management (level)

CH_4 and N_2O emissions from manure management are reported. All emissions from manure management are declining since 1990, mainly due to a reduction of the cattle population.

Table 95 Specification of source category 4B “Manure Management (CH_4)”. (AD: Activity data; EF: Emission factors).

4B	Source	Specification	Data Source
4B1	Cattle	Mature dairy cattle	AD: SBV 2007 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 2007 EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006
4B7	Mules and Asses		AD: SBV 2007 EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006
4B9	Poultry		AD: SBV 2007 EF: IPCC 2000; IPCC 1997c; FAL/RAC 2001; Menzi et al. 1997; Soliva 2006

Table 96 Specification of source category 4B “Manure Management (N_2O)”.

4B	Source	Specification	Data Source
4B11 4B12	Liquid Systems Solid storage and dry lot		AD: SBV 2007; 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_4 and N_2O 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_4 and N_2O emissions.

Calculation of CH_4 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_2O 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 categories for sheep, swine and goats as provided by FAL/RAC (2001) do not correspond to the categories of the Swiss Farmers Union (SBV 2007). 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. Other sheep such as lambs or rams are not included.
- One goat place corresponds to one (female) goat older 1.5 years. All goats younger than 1.5 years are not included[17].

a) CH_4 Emissions

Methodology

Calculation of CH_4 emissions from manure management is based on IPCC Tier 2 (IPCC 2000: equation 4.17).

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).

No country specific values for the **daily excretion of VS** are available in Switzerland. 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 VS for cattle sub-categories were estimated according to IPCC (2000: equation 4.16: p. 4.31).

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.

---

[17] 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.

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 97 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 (2007) (refer to chapter 6.2.2 for details)..

b) N_2O Emissions

Methodology

For calculation of N_2O emissions the country specific method IULIA is applied. IULIA is an IPCC-derived method for the calculation of N_2O 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_2O 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 98 Emission factors for calculating N_2O emissions from manure management (IPCC 1997c: p. 4.104).

Source	**Emission factor per animal waste management system (kg N_2O-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 2007). These input data are converted into the following livestock categories (Walther et al. 1994, FAL/RAC 2001).

Table 99 Activity data for calculating N_2O emissions from manure management (SBV 2007).

Population Size		1990-1999									
		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
		1'000 head									
Cattle											
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
	Calves on milk and pre-weaned calves	*122*	*123*	*123*	*125*	*123*	*120*	*134*	*132*	*137*	*150*
	Breeding cattle 1st year	*346*	*337*	*324*	*308*	*302*	*295*	*286*	*260*	*254*	*219*
	Breeding cattle 2nd year	*253*	*252*	*251*	*239*	*239*	*239*	*243*	*233*	*217*	*188*
	Breeding cattle 3rd year	*151*	*148*	*147*	*142*	*141*	*139*	*140*	*139*	*133*	*118*
	Fattening calves	*88*	*79*	*71*	*76*	*79*	*82*	*75*	*68*	*66*	*48*
	Fattening cattle	*100*	*96*	*87*	*92*	*101*	*110*	*105*	*97*	*97*	*162*
Sheep		395	409	415	424	405	387	419	420	422	424
	Sheep places	*191*	*201*	*201*	*211*	*201*	*191*	*208*	*208*	*209*	*222*
Goats		68	65	58	57	55	53	57	58	60	62
	Goat places	40	38	34	33	32	31	33	34	35	37
Horses		45	49	52	54	48	41	43	46	46	49
	Pre-weaned foals	*4*	*4*	*5*	*5*	*5*	*5*	*4*	*4*	*4*	*4*
	Foals 1 year	*3*	*3*	*3*	*4*	*4*	*3*	*3*	*3*	*3*	*IE*
	Foals 2 years	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*IE*
	Foals < 3 years	*5*	*6*	*6*	*7*	*7*	*6*	*6*	*6*	*6*	*7*
	Horses 3 years	*2*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*3*	*IE*
	Horses more than 4 years	*24*	*26*	*28*	*28*	*23*	*18*	*20*	*24*	*25*	*IE*
	Breeding mares and studs	*9*	*9*	*10*	*11*	*10*	*9*	*9*	*9*	*9*	*IE*
	Other horses	*36*	*39*	*41*	*43*	*36*	*30*	*32*	*36*	*36*	*38*
Mules and Asses		7	7	8	8	8	8	8	9	10	11
	Mules and asses < 1 year	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*IE*
	Mules and asses > 1 year	*6*	*7*	*7*	*7*	*7*	*7*	*7*	*8*	*9*	*IE*
Swine		1'787	1'723	1'706	1'692	1'569	1'446	1'379	1'395	1'487	1'453
	Fattening pig places	1'012	977	960	931	844	757	769	769	827	830
	Breeding pig places	184	179	178	179	168	156	142	148	156	139
Poultry		5'932	5'642	5'499	6'410	6'431	6'241	6'425	6'537	6'724	6'886
	Young hens	719	664	710	719	732	714	732	733	793	761
	Laying hens	3'083	2'645	2'536	2'518	2'226	2'118	2'226	2'278	2'270	2'223
	Broilers	2'020	2'199	2'096	2'990	3'293	3'231	3'293	3'342	3'502	3'747
	Other poultry	110	134	158	183	180	177	174	184	158	155

Population Size		2000-2006						
		2000	2001	2002	2003	2004	2005	2006
		1'000 head						
Cattle								
Mature dairy and mature non-dairy cattle		714	720	716	703	691	699	705
Young cattle		874	891	878	867	854	856	861
	Calves on milk and pre-weaned calves	*139*	*155*	*161*	*166*	*168*	*168*	*169*
	Breeding cattle 1st year	*236*	*238*	*230*	*220*	*215*	*222*	*223*
	Breeding cattle 2nd year	*222*	*219*	*219*	*213*	*205*	*205*	*210*
	Breeding cattle 3rd year	*130*	*130*	*126*	*124*	*121*	*113*	*110*
	Fattening calves	*43*	*40*	*38*	*39*	*36*	*35*	*35*
	Fattening cattle	*105*	*109*	*104*	*105*	*109*	*112*	*114*
Sheep		421	420	430	445	441	446	451
	Sheep places	*217*	*217*	*220*	*229*	*227*	*229*	*231*
Goats		62	63	66	67	71	74	76
	Goat places	37	38	39	40	42	44	45
Horses		50	50	51	53	54	55	56
	Pre-weaned foals	*4*	*4*	*3*	*3*	*3*	*3*	*3*
	Foals 1 year	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*
	Foals 2 years	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*
	Foals < 3 years	*6*	*6*	*6*	*6*	*6*	*6*	*6*
	Horses 3 years	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*
	Horses more than 4 years	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*
	Breeding mares and studs	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*
	Other horses	*40*	*40*	*42*	*43*	*44*	*46*	*47*
Mules and Asses		12	12	13	14	15	16	16
	Mules and asses < 1 year	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*
	Mules and asses > 1 year	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*	*IE*
Swine		1'498	1'548	1'557	1'529	1'538	1'609	1'635
	Fattening pig places	851	868	874	857	859	907	901
	Breeding pig places	145	149	148	144	146	151	154
Poultry		6'983	6'939	7'339	7'585	8'061	8'256	7'665
	Young hens	832	745	754	809	853	868	888
	Laying hens	2'150	2'069	2'154	2'117	2'089	2'189	2'147
	Broilers	3'808	3'993	4'298	4'518	4'971	5'060	4'481
	Other poultry	193	132	132	140	148	139	148

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 207 in Annex A4). 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_2O 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 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 date from ART was used (ART 2007):

Table 100 Input data for the uncertainty analysis of the source category 4B “Manure Management” (ART 2007).

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_4 (head)	-6.4%	+6.4%	±6.4%
Activity data N_2O (liquid systems, kg N)	-29.9%	+29.2%	±29.5%
Activity data N_2O (solid storage, kg N)	-29.9%	+29.2%	±29.5%
Emission factor CH_4 (kg CH_4 /head/yr)	-54.7%	+53.5%	±54.1%
Emission factor N_2O (liquid systems, kg N_2O-N / kg N)	-100%	+0%	±50%
Emission factor N_2O (solid storage, kg N_2O-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_2O), 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 1990–2006 is consistent.

6.3.4. Source-Specific QA/QC and Verification

For CH_4 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_4 estimations (Soliva 2006a). For N_2O 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 or daily excretion of volatile solids) were filled in and compared with IPCC default values (refer to Table 209 in Annex 4).

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.

6.3.5. Source-Specific Recalculations

A recalculation was carried out for the year 2005 since the definitive input data from the Swiss Farmers Union were now available and replace the estimates generated by linear extrapolation.

6.3.6. Source-Specific Planned Improvements

Quality control procedures will be further improved in the next submission. Emission factors will be compared with other national and international studies and checked for plausibility.

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 Association (SBV 2005). 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_2O emissions from Agricultural Soils; Direct Soil Emissions (level and trend).

Key category 4D3
N_2O emissions from Agricultural Soils; Indirect Soil Emissions (level and trend).

The source category 4D includes the following emissions: Direct N_2O emissions from soils and from animal production (emission from pasture range and paddock), indirect N_2O emissions, NO_x emissions from soils and NMVOC emissions.

Direct and indirect N_2O emissions as well as NO_x emissions are decreasing since 1990 in almost all sub-categories.

Table 101 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 form pasture range and paddock, N-fixing pasture range and paddock	AD: SBV 2007; FAL/RAC 2001; Leifeld et al. 2003; Menzi et al. 1997; Schmid et al. 2000; Walther et al. 1994; EF: IPCC 1997c (N_2O); IPCC 2000
4D2	Animal production	Only emissions from pasture range and paddock	AD: SBV 2007; 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 2007; FAL/RAC 2001; Prasuhn and Braun 1994; Braun et al. 1994; Schmid et al. 2000; Walther et al. 1994 EF: IPCC 2000
4D4	Other (sewage sludge and compost used for fertilizing)		AD: SBV 2007 EF: IPCC 1997c

6.5.2. Methodological Issues

Methodology

For calculation of N_2O emissions from agricultural soils the national method IULIA is applied. IULIA is an IPCC-derived method for the calculation of N_2O 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_2O emissions in Switzerland.

The N_2O emissions, which are considered within the calculation, are displayed in the following figure.

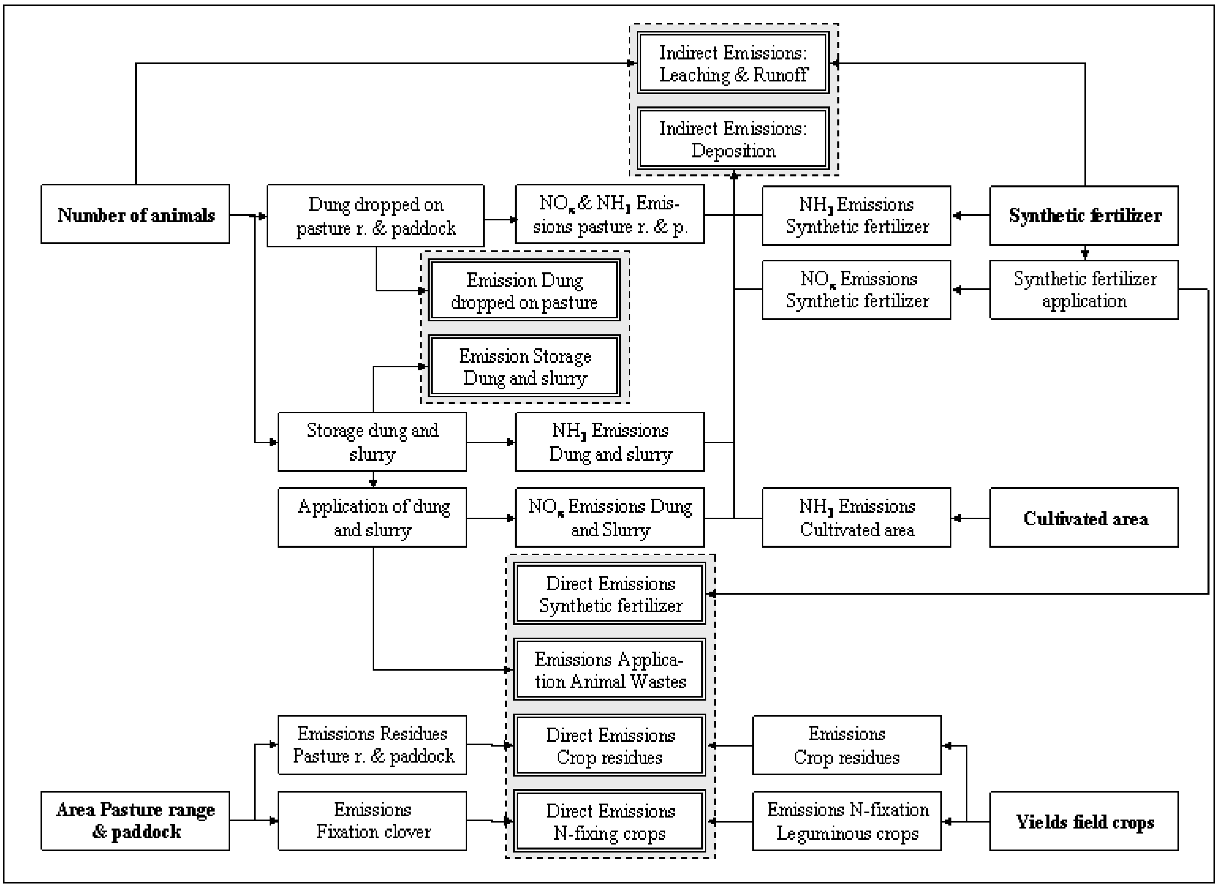


Figure 29 Diagram of the N_2O emissions in Agriculture (Berthoud 2004).

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 on 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_2O emissions are quite moderate. In total IULIA estimations of the N_2O emissions from agriculture are 14% lower than the IPCC estimations (Schmid et al. 2000: p. 75).

Direct emissions from soil (4D1)

Calculation of direct N2O 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 (2007). From the amount of nitrogen in fertilizer losses to the atmosphere in form of NH3 are subtracted and the rest is multiplied with the corresponding emission factor. NOx emissions are not subtracted since they occur mainly after the fertilizer application. The basis for N2O-emissions is the mineral fertilizer including the nitrogen that will be lost as NOx later (Berthoud 2004).
- According to the method IULIA losses to the atmosphere are set to 6% (NH3) instead of the IPCC value of 10% for NH3 and NOx (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 pastures minus ammonia volatilization from solid and liquid manure. The losses (to the atmosphere) as ammonia are specified for each management category instead of using a fixed ratio of 20% (Schmid et al. 2000: p. 66). NOx emissions are not subtracted since they occur after the application of animal wastes. For details regarding the volatized N refer to Table 103.
- 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 2005), 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_{CR}: Amount of nitrogen in crop residues returned to soils (t N)
  E_{Cr}: Amount of crop yields for culture Cr (t)
  Y_{Cr}: Standard values for arable crop yields for culture Cr (t/ha)
  NR_{Cr}: 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 (2007).
- 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 102 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 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_2O 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_2O 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_2O emissions from **deposition** are based on NH_3 and NO_x emissions. Losses to the atmosphere are calculated according to Menzi et al. (1997) and Schmid et al. (2000). For NH_3 emissions specific losses for all livestock categories are assumed. Furthermore, it is estimated that 6% of nitrogen in mineral fertilizer is emitted as NH_3 and 1.5 kg NH_3 -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_x (Schmid et al. 2000: p. 66, EMEP/CORINAIR, EEA 2005). Details about the amount of volatized N (NH_3 and NO_x) are provided in the following table.

Table 103 Overview of the volatized N (NH_3- and NO_x-) from animal wastes and fertilizer for 2006. The total amount of volatized N appears under the indirect emissions (atmospheric deposition) in the CRF, table 4D. Sources: SBV 2007; FAL/RAC 2001; Schmid et al. 2000; Menzi et al. 1997.

		N excretion (t N) / N content 2006	Losses NH3 (%)	Emissions NH3 (t N) 2006	Losses NOx (%)	Emissions NOx (t N) 2006	Volatized N total (NH3, NOx in t) 2006
Cattle							
Mature dairy and mature non-dairy cattle		75'189	32	24'060	0.7	526	24'587
Young cattle		26'282	26	6'833	0.7	184	7'017
	Calves on milk and pre-weaned calves	2'191	37	811	0.7	15	826
	Breeding cattle 1st year	5'580	22	1'228	0.7	39	1'267
	Breeding cattle 2nd year	8'408	22	1'850	0.7	59	1'909
	Breeding cattle 3rd year	6'056	22	1'332	0.7	42	1'375
	Fattening calves	282	37	104	0.7	2	106
	Fattening cattle	3'765	37	1'393	0.7	26	1'419
Sheep							
	Sheep places	2'767	14	387	0.7	19	407
Goats							
	Goats places	724	29	210	0.7	5	215
Horses		2'386	32	764	0.7	17	780
	Pre-weaned foals	53	32	17	0.7	0	17
	Foals 1 year	IE	32	IE	0.7	IE	IE
	Foals 2 years	IE	32	IE	0.7	IE	IE
	Foals < 3 years	269	32	86	0.7	2	88
	Horses 3 years	IE	32	IE	0.7	IE	IE
	Horses more than 4 years	IE	32	IE	0.7	IE	IE
	Breeding mares and studs	IE	32	IE	0.7	IE	IE
	Other horses	2'064	32	660	0.7	14	675
Mules and Asses		412	32	132	0.7	3	135
	Mules and asses < 1year	IE	32	IE	0.7	IE	IE
	Mules and asses > 1 year	IE	32	IE	0.7	IE	IE
Swine		17'114	46	7'872	0.7	120	7'992
	Fattening pig places	11'719	46	5'391	0.7	82	5'473
	Breeding pig places	5'395	46	2'482	0.7	38	2'519
Poultry		3'826	51	1'951	0.7	27	1'978
	Young hens	302	54	163	0.7	2	165
	Laying hens	1'525	54	824	0.7	11	834
	Broilers	1'793	48	861	0.7	13	873
	Other poultry	207	48	99	0.7	1	101
Total animals				42'210		901	43'111
Mineral fertilizer, compost and sewage sludge (t N)		55'100	6	3'306	0.7	386	3'692
NH3 emissions from cropland (ha)		1'061'585	2	1'592			1'592
Total				47'108		1'287	48'395

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_2O 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_x emissions

NO_x emissions are estimated to be 0.7% of total nitrogen from animal manure and mineral fertilizer. This factor is based on the CORINAIR Emission Inventory Guidebook 2003 (EEA 2005). 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 is taken from SBV (2007).

Emission factors

The following IPCC default emission factors for calculating N_2O emissions from agricultural soils are used.

Table 104 Emission factors for calculating N_2O 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
Direct emissions	
Synthetic fertilizer	0.0125 kg N_2O -N/kg N
Animal excreta nitrogen used as fertilizer	0.0125 kg N_2O -N/kg N
Crop residue	0.0125 kg N_2O -N/kg N
N-fixing crops	0.0125 kg N_2O -N/kg N
Organic soils	8 kg N_2O-N/ha/year
Residues meadows and pasture	0.0125 kg N_2O -N/kg N
N-fixing meadows and pasture	0.0125 kg N_2O -N/kg N
Indirect emissions	
Leaching and run-off	0.025 kg N_2O -N/kg N
Deposition	0.01 kg N_2O -N/kg N
Animal production	
Pasture, range and paddock	0.02 kg N_2O -N/kg N/a
Other (sewage sludge and compost used for fertilizing)	0.0125 kg N_2O –N/kg N

Activity data

Activity data for calculation of direct soil emissions has been provided by SBV (2007) (use of synthetic fertilizer, crops produced, area of pasture range and paddock), FAL/RAC (2001: p. 48/49), Schmid et al. (2000), Walther et al. (1994) (nitrogen excretion), and Leifeld et al. (2003) (revised area of cultivated organic soils).

The relevant activity data for calculating N_2O emissions from soils is displayed in the following table. Additional information is given Table 210 in Annex 4.

Table 105 Activity data for calculating N_2O 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									
Direct emissions											
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
Indirect emissions											
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
	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
Deposition	Emissions NH3 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 NOx from fertilizers and animal wastes	*1'570*	*1'570*	*1'550*	*1'501*	*1'458*	*1'420*	*1'438*	*1'359*	*1'355*	*1'354*
	Sum volatized N (NH3 and Nox) 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
Animal production											
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		2000-2006						
		2000	2001	2002	2003	2004	2005	2006
		Value						
Direct emissions								
Fertilizers (t N/yr)		60100	64200	62800	58400	57800	56600	55100
	Mineral fertilizer (t N/yr)	*53000*	*57100*	*55700*	*53200*	*53600*	*52400*	*51400*
	Sewage sludge (t N/yr)	*4000*	*4000*	*4000*	*2000*	*1000*	*1000*	*500*
	Compost (t N/yr)	*3100*	*3100*	*3100*	*3200*	*3200*	*3200*	*3200*
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	72713	71259	71085	70140	69796	70900	71332
N-fixing crops	N fixation peas, dry beans, soybeans and leguminous vegetables (t N/yr)	797	722	1119	1224	1294	1147	1071
Crop residue	N from crop residues (t N/yr)	14911	12893	14225	12250	14532	13927	13001
Organic soils	Area of cultivated organic soils (ha)	17000	17000	17000	17000	17000	17000	17000
N-fixing meadows and pasture	Area of meadows and pasture (ha)	806369	809441	809597	812624	812370	807793	807982
	N fixation meadows and pasture (t N/yr)	32060	31120	31143	31485	31623	31089	31189
Residues meadows and pasture	Area of meadows and pasture (ha)	806369	809441	809597	812624	812370	807793	807982
	N from residues meadows and pasture (t N/yr)	23075	22217	22220	22321	22334	22174	22189
Indirect emissions								
Leaching and run-off	N excretion of all animals (t N/yr)	132267	128988	128606	126880	126137	127985	128698
	Fertilizer (t N/yr)	60100	64200	62800	58400	57800	56600	55100
	N from fertilizers and animal wastes that is lost through leaching and run off (t N/yr)	38473	38638	38281	37056	36787	36917	36760
Deposition	Emissions NH3 from fertilizers and animal wastes	*48129*	*47328*	*47194*	*46379*	*46217*	*46897*	*46987*
	Emissions NOx from fertilizers and animal wastes	*1347*	*1352*	*1340*	*1297*	*1288*	*1292*	*1287*
	Sum volatized N (NH3 and Nox) from fertilizers, animal wastes and cropland (t N/yr)	49476	48680	48534	47676	47505	48189	48274
Animal production								
Pasture, range and paddock	N excretion on pasture range and paddock (t N/yr)	17515	16695	16525	16274	15988	15980	16081

The following table gives an overview on the different N amounts in 2006 that end up in N_2O emissions in the CRF tables.

Table 106 Overview on the N amounts in the subcategories of Agricultural Soils that end up in N_2O emissions. The N excretion is multiplied with the emission factors from Table 104 and the factor 44/28 for the conversion into N_2O. 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 105.

Summary of N_2O emissions from agricultural soils 2006	**N excretion & emission (kg N a^{-1})**	**Emission factors**	**Emissions (t N)**	**Emissions (t N_2O)**	**Emissions (Gg N_2O)**
Direct emissions	**187'114'570**		**2'475**	**3'889**	**3.89**
Synthetic fertilizers	48'316'000	0.0125	604	949	0.95
Animal wastes applied to soils	71'331'956	0.0125	892	1'401	1.40
N-fixing crops	32'260'320	0.0125	403	634	0.63
Fixation cropland	*1'071'000*	*0.0125*	*13*	*21*	*0.02*
Fixation meadows and pasture	*31'189'000*	*0.0125*	*390*	*613*	*0.61*
Crop residues	35'189'294	0.0125	440	691	0.69
Crop residues cropland	*13'001'000*	*0.0125*	*163*	*255*	*0.26*
Crop residues meadows and pasture	*22'189'000*	*0.0125*	*277*	*436*	*0.44*
Cultivation of histosol (ha)	17'000	8	136	214	0.21
Animal Production (pasture range and paddock)	**16'081'272**	**0.02**	**322**	**505**	**0.51**
Indirect emissions	**85'033'297**		**1'402**	**2'203**	**2.20**
Deposition	48'273'714	0.0100	483	759	0.76
Leaching and run-off	36'759'583	0.0250	919	1'444	1.44
Other (fertilization with compost and sewage sludge)	**3'478'000**	**0.0125**	**43**	**68**	**0.07**
Total	**291'707'139**		**4'242**	**6'665**	**6.67**

6.5.3. Uncertainties and Time-Series Consistency

For the uncertainty analysis the following input data from ART was used (ART 2007):

Table 107 Input data for the uncertainty analysis of the source category 4D “Agricultural Soils”. (ART 2007).

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_2O-N / kg N)	-80%	+80%	±80%
Emission factor 4D1 (organic soils, kg N_2O-N / kg N)	-75%	+87.5%	±81.3%
Emission factor 4D2 (kg N_2O-N / kg N)	-75%	+50%	±62.5%
Emission factor 4D3 (deposition, kg N_2O-N / kg N)	-80%	+100%	±90%
Emission factor 4D3 (leaching and run-off, kg N_2O-N / kg N)	-92%	+380%	±236%
Emission factor 4D4 (sewage sludge and compost, kg N_2O-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.

Time series between 1990 and 2006 is consistent.

Time series 1990-2006 is 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).

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 following reasons:

- A recalculation was carried out for the year 2005 since the definitive input data from the Swiss Farmers Union were now available and replace the estimates generated by linear extrapolation.
- In the former submission the amount of sewage sludge and compost for agricultural applications was not reported in the CRF tables from 1995 onwards. This mistake was corrected in the current submission.

6.5.6. Source-Specific Planned Improvements

Quality control procedures will be further improved in the next submission. Emission factors will be compared with other national and international studies and checked for plausibility.

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_4, N_2O, NO_x, 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 2002). See also EMIS 2005/4F.

Table 108 Emission factors for calculating emissions from burning of branches in agriculture and forestry (EEA 2002).

Emissions from burning of branches in agriculture and forestry	**Emission factor** kg/t dry matter
CH_4	6.8
N_2O	0.18
NO_x	3.6
CO	104.0
NMVOC	9.5
SO_2	0.7

Activity data

Activity data is taken from the SFSO (2003).

Table 109 Activity data for calculating emissions from burning of branches in agriculture and forestry (SFSO 2003). 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 is consistent.

6.7.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the check between EMIS and Internal GHG Files (chapter 1.4.3) and the general QA/QC measures described in chapter 1.6.1 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

Methodology

This chapter includes information about the estimation of greenhouse gas emissions and removals from land use, land-use change and forestry (LULUCF). The data acquisition and calculations are based on the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC 2003) completed by country specific methodologies.

The land areas in the period 1990-2006 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 approximately 23% 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 1990-2006, 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 (see Table 111). A further spatial stratification reflects the criteria ‘altitude’ (3 zones), ‘geomorphologic and climatic conditions’ (adopting the 5 regions of the National Forest Inventory) and ‘soil type’ (mineral, organic).

CO_2 emissions

Table 110 and Figure 30 summarize the CO_2 emissions and removals in consequence of carbon losses and gains for the years 1990-2006. The total net removals/emissions of CO_2 from 1990 to 2006 vary between -5’669 Gg (1999) and 1’484 Gg (2003).

In Table 110 and Figure 31, three components of the CO_2 balance are differentiated:

- Increase of living biomass on forest land: growth of biomass on forest land remaining forest land; it represents the largest sink of carbon.
- Decrease of living biomass on forest land: decrease of carbon in living biomass (by harvest and mortality) on forest land remaining forest land; it represents the largest source of carbon.
- Land-use change and soil:balance of carbon removals/emissions due to land-use changes and use of soils (especially of organic soils), and due to agricultural lime application. In the period under investigation this accumulative component persistently represents a souce of carbon.

In forests, growth of biomass exceeds the harvesting and mortality rate, except in 2003 when growth was significantly reduced by summer heat and drought. Compared to CO_2 fluxes involved in forest biomass dynamics, the net CO_2 emissions arising from all land-use changes and from the use of soils are relatively small (see Figure 31).

Table 110 Switzerland's CO_2 emissions and removals (Gg) of source category 5 „Land Use, Land-Use Change and Forestry" 1990-2006. Positive values refer to emissions; negative values refer to removals from the atmosphere. In this table, emissions of CH_4 and N_2O are not included.

LULUCF	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Gg CO_2									
Total Sector 5: LULUCF	-2'594	384	-219	-4'356	-4'367	-3'786	-2'888	-3'268	-1'654	-5'669
Increase of living biomass in forest	-13'860	-11'056	-11'671	-14'484	-14'490	-14'203	-12'844	-13'099	-11'736	-16'134
Decrease of living biomass in forest	10'173	10'272	10'278	9'113	9'126	9'412	8'921	8'820	9'027	9'496
Land-use change and soils	1'093	1'167	1'175	1'015	997	1'005	1'036	1'011	1'055	969

LULUCF	2000	2001	2002	2003	2004	2005	2006	Mean 1990-2006
	Gg CO_2							
Total Sector 5: LULUCF	833	-1'172	-1'244	1'484	-1'362	-859	-2'237	-1'940
Increase of living biomass in forest	-12'523	-14'846	-14'786	-9'752	-12'225	-12'161	-13'970	-13'167
Decrease of living biomass in forest	12'248	12'629	12'474	10'113	9'791	10'228	10'683	10'165
Land-use change and soils	1'108	1'045	1'068	1'122	1'072	1'074	1'051	1'062

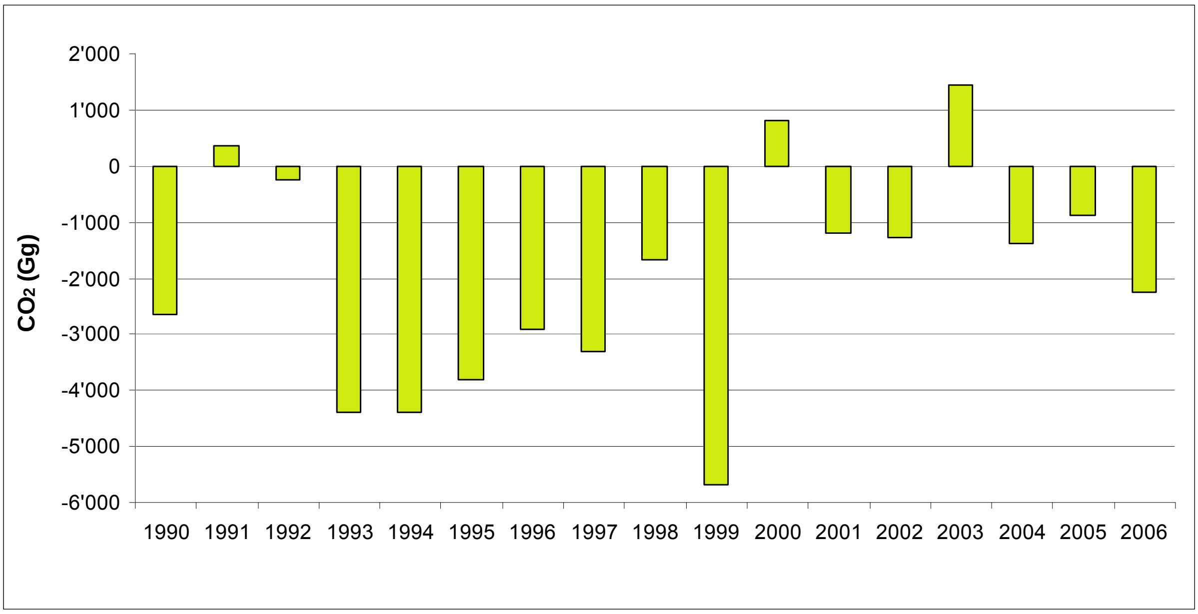


Figure 30 Switzerland's net CO_2 balance of source category 5 "Land Use, Land-Use Change and Forestry" 1990–2006 in Gg CO_2. Positive values refer to emissions, negative values refer to removals.

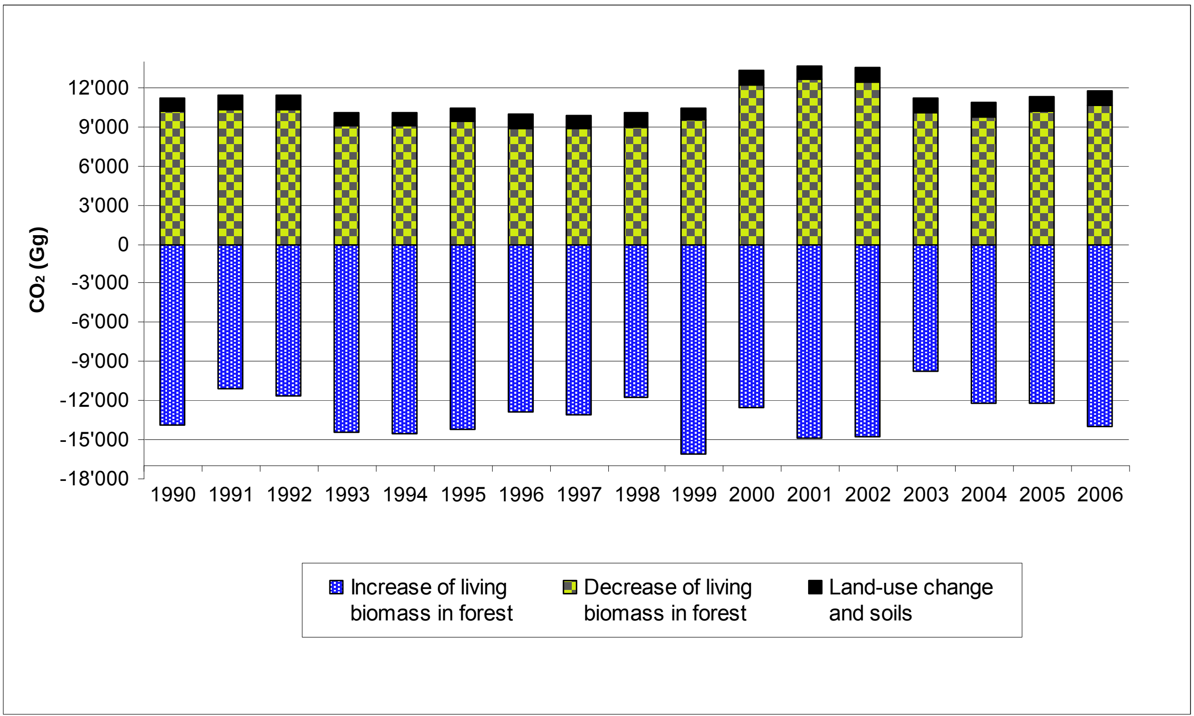


Figure 31 The CO_2 removals due to the increase (growth) of living biomass on forest land, the CO_2 emissions due to the decrease (harvest and mortality) of living biomass on forest land and the net CO_2 emissions due to land-use changes and from use of soils, 1990–2006.

Non-CO_2 emissions

The non-CO_2 emissions are very small. Between 1990 and 2006 annual CH_4 emissions add up to less than 0.6 Gg, and N_2O emissions equal at maximum 0.04 Gg. Those emissions arise from soil disturbance associated with land-conversion to cropland (CRF Table 5 III) and wildfires on forest land (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_2 equivalent removal/emission 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

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 111). 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 ($deltaC_l$), in dead organic matter ($deltaC_d$) and in soil ($deltaC_s$) 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.

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

Table 111 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	affor	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	unprod	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)	perm	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	unprod, stony	36
	Unproductive Grassland	unmanaged grass vegetation	unprod	37
D. Wetlands	Surface Waters	lakes and rivers	surface	41
	Unproductive Wetland	reed, unmanaged wetland	unprod	42
E. Settlements	Buildings and Constructions	areas without vegetation such as houses, roads, construction sites, dumps	build	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

On this basis, the carbon stock changes in living biomass ($deltaC_l$), in dead organic matter ($deltaC_d$) and in soil ($deltaC_s$) 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 removals and emissions 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):

$$deltaC_{l,i,ba} = [\; increaseC_{l,i,a} - decreaseC_{l,i,a} + W_l * (stockC_{l,i,a} - stockC_{l,i,b}) \;] * A_{i,ba} \qquad (7.2.1)$$

$$deltaC_{d,i,ba} = [\; changeC_{d,i,a} + W_d * (stockC_{d,i,a} - stockC_{d,i,b}) \;] * A_{i,ba} \qquad (7.2.2)$$

$$deltaC_{s,i,ba} = [\; changeC_{s,i,a} + W_s * (stockC_{s,i,a} - stockC_{s,i,b}) \;] * A_{i,ba} \qquad (7.2.3)$$

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
$A_{i,ba}$:	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 = {11,12,13})
$W_s = 0.5$	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.I). 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 7.7.2).

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.

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 deltaC are accordingly summarised. Positive values of $deltaC_{l,i,ba}$ are inserted in the column "Gains" and negative values in column "Losses", respectively (besides $increaseC_{l,i,CC}$ and $decreaseC_{l,i,CC}$ if land-use does not change).

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 ($stockC_{s,i,a}$ – $stockC_{s,i,b}$) 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, and land converted to grassland. Accordingly, the CRF tables 5A2, 5B2 and 5C2 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. In order to achieve an optimal transparency in the development of this category no conversion time is applied to CC11 in the CRF Table 5A.

There is no consistant data on land-use changes before 1990, but it is well known (ARE/SAEFL 2001, FOEN 2008b) 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 2007a) 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 1990-2006 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)

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 approximately 23% of the Swiss territory are available for all three time slices (AREA1-AREA2-AREA3; SFSO 2007a).

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) implementing the main categories proposed by IPCC as well as country specific sub-divisions (see Table 111). The sub-divisions were defined with respect to optimal distinction of biomass densities, carbon turnover, and soil carbon contents.

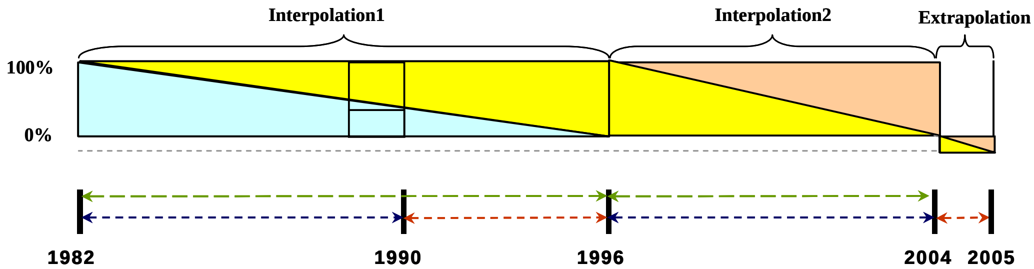
The first digit of the CC-code represents the main category, whereas the second digit stands for the respective sub-division.

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.

Example "status 1990" (Figure 32): A hectare has been assigned to the land-use category "cropland" (CC 21) in AREA1. A land-use change to "shrubs in settlements" (CC 53) has been discovered 14 years later (1996) in AREA2.



Definitions interpolation:

ydiff = 1996 - 1982
ybefore1990 = 1990 - 1982
yafter1990 = 1996 - 1990

Calculation formulas :	„Status 1990" :
Percentage „shrubs in settlements 1990" = (ybefore1990 / ydiff) *100 [%]	57.14 %
Percentage „cropland 1990" = (yafter1990 / ydiff) *100 [%]	42.86 %

Definitions extrapolation:

ydiff = 2004 - 1996
ybefore2005 = 2005 - 1996
yafter2005 = 2004 - 2005

Calculation formulas :	„Status 2005" :
Percentage „buildings & constructions 2005" = (ybefore2005 / ydiff) *100 [%]	112.5 %
Percentage „shrubs in settlements 2005" = (yafter2004 / ydiff) *100 [%]	-12.5 %

Figure 32 Hypothetical linear development of land-use changes between AREA1, AREA2 and AREA3 considering as example a hectare changing from "cropland" to "shrubs in settlements" and then from "shrubs in settlements" to "buildings and constructions". For 2005, a linear extrapolation has been carried out.

The "status 1990" is determined by calculating the fractions of the two land-use categories for the year 1990. A linear development from "cropland" to "shrubs in settlements" during the whole interim period is assumed. Thus, in 1990 the hectare is split up in two fractions: 57.14% is "shrubs in settlements" and 42.86% is "cropland". The same procedure can be applied for two survey dates between AREA2 and AREA3.

At present, AREA3 comprehends aerial photos from only two years (2004-2005). Therefore, the land-use changes in 2006 (and partly in 2005) had to be extrapolated from the linear development detected between AREA2 and AREA3 (see Figure 32: example "status 2005").

The status for each individual year in the period 1990-2006 for the whole Swiss territory results from the summation of the fractions of all hectares per CC (considering the spatial strata where appropriate) (see Table 113 and Table 114).

When extrapolating the land-use changes as illustrated in Figure 32 a decreasing trend of a land-use category may lead to a negative total area of that category in a specific stratum, mainly if the frequency of that category is already low at the beginning of the extrapolation period. In 2005 and 2006, this occured in a few cases (e.g. afforestations above 1200 m altitude in the NFI-region 3), resulting in a total negative area of -22.2 ha. This methodology-cal artefact was corrected by manually setting the negative areas to zero and by reducing accordingly the area of productive forest in order to keep the overall area of the country constant.

7.2.3. Spatial Stratification

In order to quantify carbon stocks and increases/decreases, a further spatial stratification of the 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. The NFI regions were adopted from EAFV/BFL (1988):

1. Jura
2. Central Plateau
3. Pre-Alps
4. Alps
5. Southern Alps.

Altitude data were available on a hectare-grid from the Swiss Federal Statistical Office (SFSO 1997) and 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 33).

For Cropland and Grassland under cultivation, it was important to differentiate two soil types (organic and mineral soils) and also 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 33. The codes F1 and Q3 represent organic soils (Histosols) in the Central Plateau and in Alpine valleys, respectively.

Thus, 30 different strata (i) would be theoretically possible. Not all of them, but 20 have been defined and used for the calculation of LULUCF-associated C removals and emissions (see below).

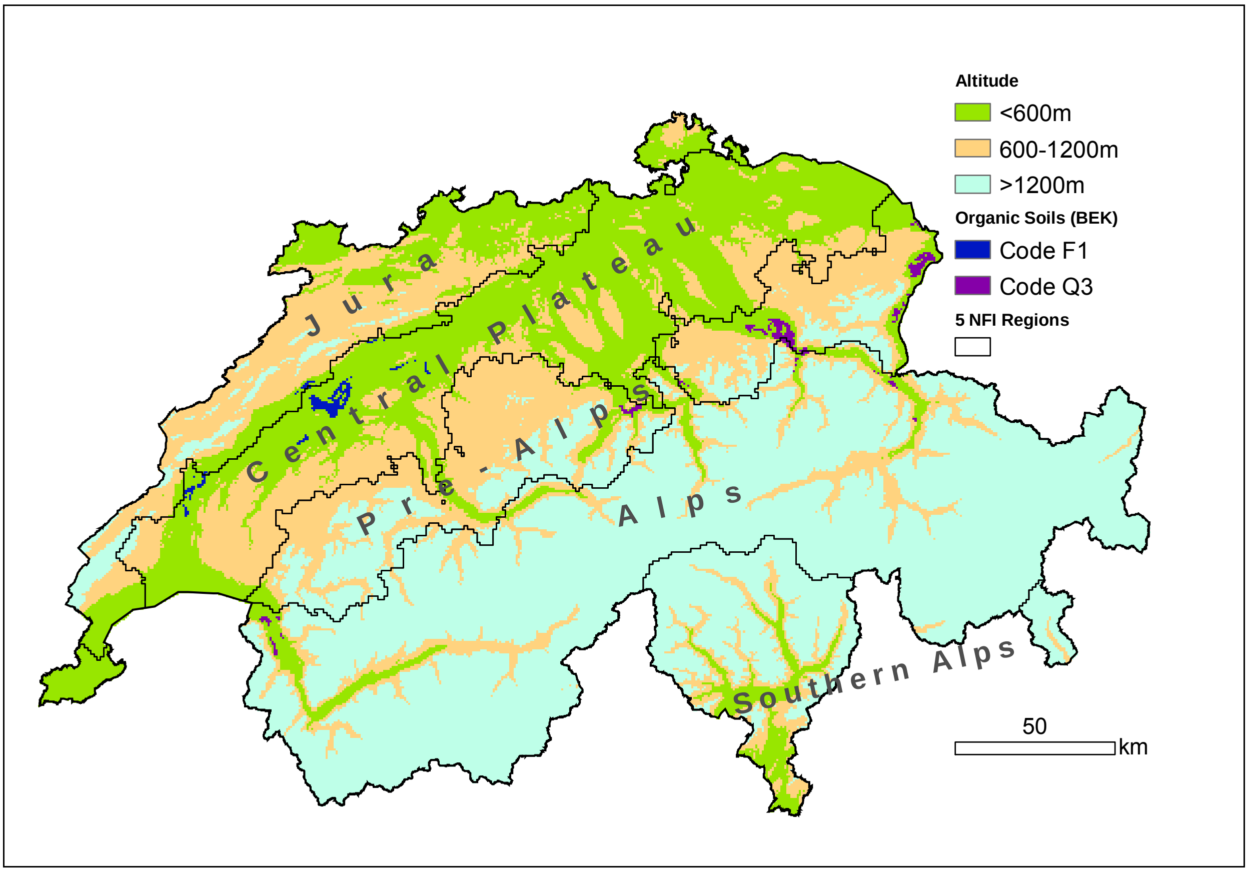


Figure 33 Map showing the spatial stratification according to altitude, soil type and NFI region.

7.2.4. Spatial Extrapolation of Land-Use Statistics

The land-use survey AREA3 has been launched in 2004. Presently, a sample region covering approximately 23% of the Swiss territory has been evaluated (see Figure 34). 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 112; see FOEN 2006b for details).

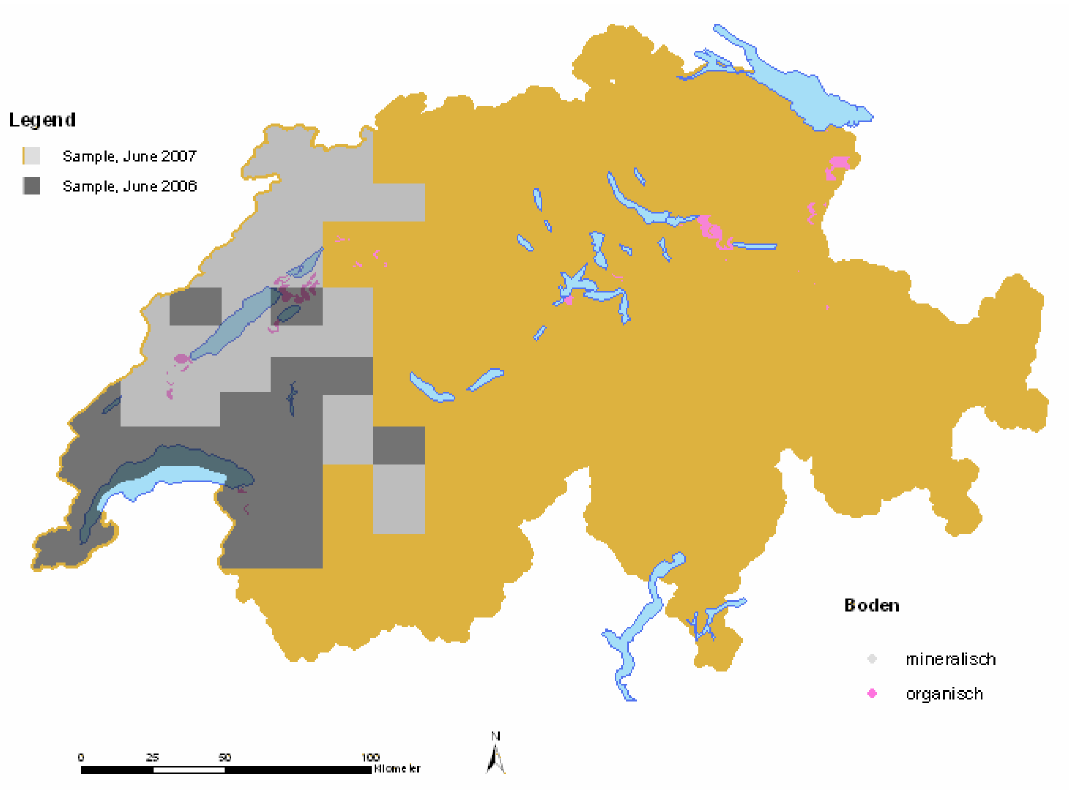


Figure 34 Map showing the regions that have already been evaluated in the land-use survey AREA3 (as of June 2007). Dark grey is the sample area that had been available for the previous submission (FOEN 2007). Light grey is the additional sample area added in this submission. The locations of organic soils are shown in pink.

A spatial extrapolation of the AREA-derived CC data in the sample region (23%) to the total Swiss territory has been carried out, using ASCH2 as a reference basis. First, the CC data in the sample region ($AREA_{samp}$) were interpolated in time for each year (see Figure 32), 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 112). 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 112.

Table 112 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	12	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	Shrub Vegetation	32
			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		
	Unproductive Grassland	33	97	Unproductive grass and shrubs	30		
					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	Herbaceaus 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		
			49	Surroundings of unspecified 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, screes	61		
					61	Other Land	61

In this extrapolation approach the whole Swiss territory is divided into three main sub-regions (see Figure 35):

- Sample region (samp): CC data are available on hectare-basis for AREA1, AREA2 and AREA3. Coverage: 23% 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 ASCH2 survey (LUcode categories) is used instead. Coverage: 9% of Swiss territory. Changes in land-use are neglected in the substitution region.

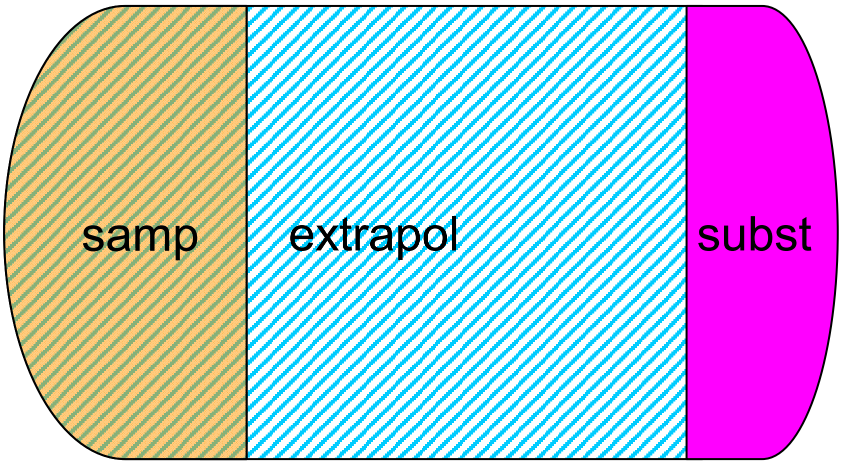


Figure 35 Scheme showing the three sub-regions of Switzerland used for the extrapolation: sampling region of AREA (samp), extrapolation region (extrapol, diagonal shading) and substitution region (subst).

As the spatial stratification is needed for the computation of CO_2 equivalent removals/ emissions 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 36). 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 36) 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

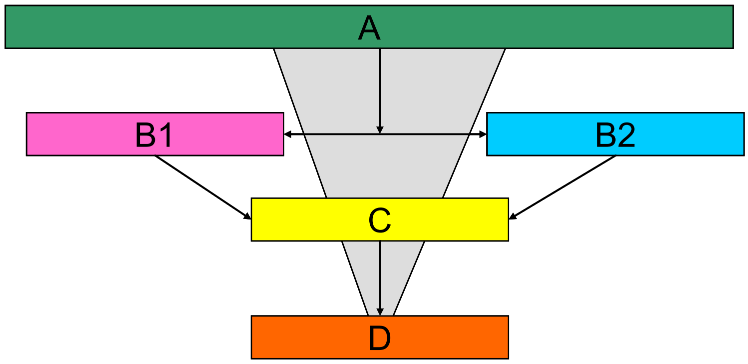


Figure 36 Extrapolation cascade for calculating area expansion factors (AEF) at different levels of differentiation.

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 36. 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 112).

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 36). ‘Maincat’ denotes the main land-use category according to Table 112:

$$AEF(maincat) = ASCH2_{extrapol}(maincat) / ASCH2_{samp}(maincat) \quad (7.2.8)$$

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 36), 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:

$$F(yr) = ASCH2_{extrapol} / [\ \Sigma\ AREA_{extrapol}(CC,i,yr)\ ] \quad (7.2.10)$$

With the presently available sample data, the values of F(yr) are between 1.092 and 1.094.

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 113 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 shown for the year 1990 as an example. This table gives also an overview of the size of the spatial strata.

Table 114 shows the overall trends of land-use changes between 1990 and 2006. For example, the area of afforestations (CC 11) decreased by 83% during this period, while the area of productive forests (CC 12) increased by 2%.

Table 113 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
Altitude																			
<600	1.3	232.0	0.8	341.3	120.7	2.6	34.2	27.6	0.5	1.1	3.2	150.0	5.1	118.0	50.2	2.5	23.0	1.9	1116.0
601-1200	1.4	538.5	11.1	147.1	417.3	6.6	8.9	41.3	0.2	2.5	2.4	9.2	3.8	51.8	20.3	1.2	6.1	9.5	1279.4
>1200	1.3	393.1	102.4	0.2	489.3	54.5	11.8	39.7	0.1	65.7	52.0	5.8	14.3	13.1	3.4	0.2	1.3	485.1	1733.0
	4.0	1163.5	114.3	488.6	1027.2	63.7	55.0	108.6	0.8	69.3	57.6	165.0	23.2	182.9	73.8	4.0	30.5	496.5	4128.4
Soil																			
mineral	4.0	1162.4	114.3	472.2	1025.5	63.6	54.8	108.3	0.8	69.2	57.4	164.5	22.9	181.1	73.1	3.9	30.3	496.3	4104.7
organic	0.0	1.1	0.0	16.3	1.7	0.1	0.1	0.3	0.0	0.1	0.2	0.5	0.3	1.8	0.7	0.1	0.2	0.1	23.7
	4.0	1163.5	114.3	488.6	1027.2	63.7	55.0	108.6	0.8	69.3	57.6	165.0	23.2	182.9	73.8	4.0	30.5	496.5	4128.4
NFI-region																			
1	1.0	216.2	5.7	77.4	145.8	1.1	7.3	13.2	0.1	0.3	0.9	25.9	1.4	30.0	12.9	0.5	5.1	0.6	545.6
2	0.8	247.9	0.3	360.1	152.4	1.3	17.3	28.2	0.5	0.3	1.6	75.9	4.2	93.4	38.9	1.6	17.5	0.9	1043.0
3	1.0	225.5	11.1	30.4	283.7	8.8	1.1	20.2	0.0	7.6	9.1	33.6	14.0	21.1	7.4	0.5	2.5	17.3	694.9
4	1.1	351.1	62.6	16.4	407.3	42.1	15.2	24.9	0.1	50.7	35.7	16.2	3.2	30.2	10.4	1.1	3.4	417.8	1489.3
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
	4.0	1163.5	114.3	488.6	1027.2	63.7	55.0	108.6	0.8	69.3	57.6	165.0	23.2	182.9	73.8	4.0	30.5	496.5	4128.4

Table 114 Statistics of land use (CC) for the whole period 1990-2006 (in kha) and relative change (%) between 1990 and 2006.

CC:	11	12	13	21	31	32	33	34	35	36	37	41	42	51	52	53	54	61	Sum
Year:																			
1990	4.0	1163.5	114.3	488.6	1027.2	63.7	55.0	108.6	0.8	69.3	57.6	165.0	23.2	182.9	73.8	4.0	30.5	496.5	4128.4
1991	3.9	1165.4	114.8	487.7	1025.0	63.2	55.1	107.7	0.7	69.0	57.5	164.9	23.2	184.7	74.4	4.0	30.9	496.0	4128.4
1992	3.8	1167.4	115.3	486.8	1022.7	62.8	55.3	106.9	0.7	68.8	57.4	164.9	23.2	186.4	75.0	4.1	31.3	495.5	4128.4
1993	3.6	1168.8	115.5	486.0	1021.5	62.6	55.2	106.1	0.6	68.7	57.3	164.9	23.2	188.0	75.6	4.1	31.5	495.1	4128.4
1994	3.4	1169.9	115.7	484.3	1021.5	62.5	55.1	105.4	0.6	68.7	57.2	164.9	23.2	189.5	76.1	4.1	31.6	494.6	4128.4
1995	3.1	1170.9	116.0	482.5	1021.8	62.4	55.0	104.7	0.6	68.6	57.2	164.9	23.2	191.0	76.8	4.2	31.6	494.1	4128.4
1996	2.9	1171.8	116.2	480.8	1022.1	62.3	54.8	104.0	0.6	68.6	57.1	164.9	23.2	192.4	77.4	4.2	31.5	493.5	4128.4
1997	2.7	1172.8	116.5	479.0	1022.5	62.1	54.7	103.3	0.6	68.5	57.0	164.8	23.2	193.9	78.0	4.2	31.5	493.0	4128.4
1998	2.5	1173.8	116.8	477.2	1022.8	62.0	54.6	102.6	0.5	68.5	57.0	164.8	23.2	195.3	78.7	4.3	31.5	492.4	4128.4
1999	2.2	1174.7	117.0	475.4	1023.1	61.9	54.4	101.9	0.5	68.4	56.9	164.8	23.2	196.8	79.3	4.3	31.5	491.9	4128.4
2000	2.0	1175.7	117.3	473.6	1023.4	61.8	54.3	101.3	0.5	68.4	56.8	164.8	23.2	198.2	79.9	4.3	31.5	491.4	4128.4
2001	1.8	1176.7	117.6	471.8	1023.7	61.6	54.2	100.6	0.5	68.3	56.7	164.8	23.2	199.7	80.5	4.3	31.5	490.8	4128.4
2002	1.6	1177.6	117.8	470.1	1024.0	61.5	54.0	99.9	0.5	68.3	56.7	164.8	23.2	201.1	81.2	4.4	31.5	490.3	4128.4
2003	1.3	1178.6	118.1	468.3	1024.3	61.4	53.9	99.2	0.5	68.2	56.6	164.8	23.2	202.6	81.8	4.4	31.5	489.8	4128.4
2004	1.1	1179.6	118.3	466.5	1024.6	61.3	53.8	98.5	0.4	68.2	56.5	164.8	23.2	204.0	82.4	4.4	31.5	489.2	4128.4
2005	0.9	1180.5	118.6	464.7	1024.9	61.2	53.6	97.8	0.4	68.1	56.5	164.8	23.2	205.5	83.1	4.5	31.5	488.7	4128.4
2006	0.7	1181.5	118.9	462.9	1025.2	61.0	53.5	97.2	0.4	68.1	56.4	164.7	23.2	206.9	83.7	4.5	31.5	488.1	4128.4
Change:	-83	2	4	-5	0	-4	-3	-11	-48	-2	-2	0	0	13	13	14	3	-2	

The mean annual rates of change in the whole country (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 disappear 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 115.

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 (not shown here, internal document).

Table 115 Mean annual rates of land-use change in 1990 and 2006 (change matrices). Units: ha/year, rounded values.

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		418	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	421
	12	7		111	8	139	80	6	77	0	9	16	9	5	133	35	11	19	69	736
	13	14	495		0	205	36	1	49	0	3	0	1	1	7	0	0	2	11	825
	21	8	3	0		605	7	269	51	1	7	1	6	2	730	403	22	25	20	2159
	31	182	199	376	804		764	150	492	1	61	43	3	6	901	561	31	48	81	4702
	32	26	818	618	2	197		21	183	0	9	14	5	0	27	9	4	3	29	1966
	33	1	0	0	147	45	3		19	0	1	1	0	0	67	42	3	4	13	347
	34	29	500	37	152	735	54	35		2	6	21	4	1	190	113	7	71	12	1969
	35	0	0	0	14	9	0	5	34		0	0	0	0	3	1	0	0	0	67
	36	2	15	23	3	198	138	1	17	0		125	1	0	10	1	0	0	55	588
	37	6	29	9	0	16	230	2	48	0	8		1	0	10	1	0	0	18	378
	41	0	9	0	1	2	8	1	5	0	2	1		36	12	2	1	0	86	168
	42	5	45	10	2	5	3	0	6	0	0	0	6		5	2	1	0	0	90
	51	40	21	1	93	172	12	12	9	0	3	2	5	3		308	66	51	3	801
	52	7	6	0	19	38	4	3	3	0	0	1	1	3	374		68	450	0	977
	53	6	9	0	4	7	1	1	1	0	0	0	0	2	50	28		41	0	149
	54	2	6	0	1	2	1	1	3	0	0	0	0	0	80	146	5		0	245
	61	4	79	12	15	112	95	30	36	0	284	75	52	1	9	1	0	1		807
	increase	339	2653	1195	1265	2487	1437	537	1034	4	394	300	93	59	2609	1654	219	718	398	17396

2006		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		341	0	0	2	2	0	0	0	0	0	0	0	3	0	0	0	1	349
	12	2		259	2	169	91	2	76	0	13	22	15	14	97	33	14	15	48	871
	13	6	486		0	298	50	0	42	0	5	1	1	5	3	1	0	1	7	905
	21	5	1	0		1680	8	159	26	1	4	10	6	11	564	309	22	3	6	2814
	31	20	113	321	413		578	55	300	1	56	14	3	5	711	397	22	12	52	3075
	32	3	528	473	3	155		3	135	0	8	10	3	0	15	5	2	2	15	1359
	33	0	1	0	169	84	8		12	0	3	1	0	1	54	35	2	3	22	397
	34	5	323	34	55	639	50	8		1	6	18	5	2	121	83	5	34	16	1405
	35	0	0	0	2	3	0	3	11		0	0	0	0	1	1	0	0	0	21
	36	0	13	18	4	102	124	1	21	0		72	2	0	3	0	0	0	27	387
	37	3	15	5	1	3	148	0	40	0	13		1	1	5	2	0	0	11	248
	41	0	3	1	0	1	8	0	2	0	2	2		10	4	1	0	0	65	99
	42	1	33	7	0	0	1	0	1	0	1	1	5		2	0	0	0	1	53
	51	14	12	0	72	148	9	7	6	0	4	5	5	3		273	60	28	5	652
	52	6	5	0	16	41	5	1	3	0	0	2	0	1	379		58	266	0	783
	53	3	14	0	2	13	3	2	1	0	0	1	0	1	49	34		45	0	167
	54	1	6	0	0	3	0	0	4	0	0	1	0	0	100	284	13		0	410
	61	1	60	10	17	58	103	14	28	0	279	32	64	0	8	2	0	0		676
	increase	69	1954	1127	757	3399	1189	255	707	3	396	190	112	54	2119	1459	198	408	276	14671

7.2.6. Carbon Emission Factors and Stocks at a Glance

Table 116 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 1990-2006 with the exception of the carbon stock, increase and decrease of living biomass of CC 12 (productive forest). The deduction of the annually changing data of CC 12 – according to specific climate conditions and harvesting statistics – is described in Chapter 7.3.2.f. The data can be found in Table 117.

Table 116 Carbon stocks and changes in biomass, dead organic matter and soils for the combination categories (CC), disaggregated for altitude, NFI region, and soil type. These values are valid for the whole period 1990-2006 with the exception of stockCl, increaseCl and decreaseCl of CC 12, which change annually (numbers here are for the year 1990; cf. Table 117.

land-use code CC	altitude zone z	NFI region	soil type	carbon stock in living biomass (stockCl,i)	carbon stock in dead organic matter (stockCd,i)	carbon stock in soil (stockCs,i)	growth of living biomass (increaseCl,i)	harvesting of living biomass (decreaseCl,i)	net change in dead organic matter (changeCd,i)	net change in soil (changeCs,i)
	Strata			t C ha-1			t C ha-1 yr-1			
11	1	1	n.s.	12.35	0	75.00	2.56	0	0	0
	1	2	n.s.	12.35	0	62.60	2.56	0	0	0
	1	3	n.s.	12.35	0	75.30	2.56	0	0	0
	1	4	n.s.	12.35	0	72.10	2.56	0	0	0
	1	5	n.s.	12.35	0	109.00	2.56	0	0	0
	2	1	n.s.	6.70	0	75.00	1.70	0	0	0
	2	2	n.s.	6.70	0	62.60	1.70	0	0	0
	2	3	n.s.	6.70	0	75.30	1.70	0	0	0
	2	4	n.s.	6.70	0	72.10	1.70	0	0	0
	2	5	n.s.	6.70	0	109.00	1.70	0	0	0
	3	1	n.s.	2.41	0	75.00	0.85	0	0	0
	3	2	n.s.	2.41	0	62.60	0.85	0	0	0
	3	3	n.s.	2.41	0	75.30	0.85	0	0	0
	3	4	n.s.	2.41	0	72.10	0.85	0	0	0
	3	5	n.s.	2.41	0	109.00	0.85	0	0	0
12	1	1	n.s.	129.10	12.04	75.00	3.56	-2.41	0	0
	1	2	n.s.	136.68	11.22	62.60	5.57	-4.35	0	0
	1	3	n.s.	156.80	21.85	75.30	4.49	-3.05	0	0
	1	4	n.s.	95.38	40.91	72.10	3.36	-2.43	0	0
	1	5	n.s.	73.88	27.43	109.00	1.73	-1.06	0	0
	2	1	n.s.	124.71	11.89	75.00	3.44	-2.40	0	0
	2	2	n.s.	149.71	11.17	62.60	5.67	-4.07	0	0
	2	3	n.s.	152.16	21.41	75.30	4.18	-3.11	0	0
	2	4	n.s.	100.95	40.15	72.10	2.63	-1.82	0	0
	2	5	n.s.	69.74	27.36	109.00	1.86	-0.83	0	0
	3	1	n.s.	84.98	11.88	75.00	1.92	-1.50	0	0
	3	2	n.s.	93.50	11.16	62.60	1.66	-0.95	0	0
	3	3	n.s.	116.23	21.38	75.30	2.52	-2.06	0	0
	3	4	n.s.	94.53	39.62	72.10	1.90	-1.66	0	0
	3	5	n.s.	78.26	26.36	109.00	1.51	-0.48	0	0
13	1	1	n.s.	41.41	9.7	75.00	0	0	0	0
	1	2	n.s.	42.07	9.5	62.60	0	0	0	0
	1	3	n.s.	41.41	17.4	75.30	0	0	0	0
	1	4	n.s.	36.50	33.4	72.10	0	0	0	0
	1	5	n.s.	34.81	22.3	109.00	0	0	0	0
	2	1	n.s.	43.48	9.7	75.00	0	0	0	0
	2	2	n.s.	41.41	9.5	62.60	0	0	0	0
	2	3	n.s.	43.01	17.4	75.30	0	0	0	0
	2	4	n.s.	34.61	33.4	72.10	0	0	0	0
	2	5	n.s.	30.19	22.3	109.00	0	0	0	0
	3	1	n.s.	43.32	9.7	75.00	0	0	0	0
	3	2	n.s.	11.60	9.5	62.60	0	0	0	0
	3	3	n.s.	26.23	17.4	75.30	0	0	0	0
	3	4	n.s.	16.76	33.4	72.10	0	0	0	0
	3	5	n.s.	19.07	22.3	109.00	0	0	0	0
21	n.s.	n.s.	0	5.66	0	53.40	0	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					
altitude zones:		*NFI-regions:*		*soil type:*	
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	

On organic soils, a value of 240 t C ha^{-1} for stockC_s was assumed for all land-use categories, even where this is not explicitly indicated in Table 116, 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^{-1} (for cropland), resulting in a carbon change of 53.4 T C ha^{-1}. If the former CC appears to be situated on an organic soil, the carbon change in soil results in 0 t C ha^{-1}.

In the CRF Table 5.A all forest land is reported in the columns for mineral soils, as the present soil data do not allow to distinguish organic and mineral soils for forests.

While the carbon data for forests are derived from monitoring data of NFI 1 and NFI 2, 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 an in soils) is explained in detail in the following chapters.

Table 117 Annually changing carbon data for productive forest (CC 12) – carbon stock, increase of living biomass and decrease of living biomass – disaggregated for altitude and NFI region, for the period 1990-2006.

carbon stock in living biomass (stockCl,i) [t C ha^{-1}]

land-use code CC	altitude zone z	NFI region	soil type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
12	1	1	n.s.	129.10	129.78	130.96	132.42	133.50	134.94	135.70	136.75	137.99	139.99	140.65	141.75	144.16	144.50	145.71	147.33	149.20
	1	2	n.s.	136.68	136.25	136.13	137.71	139.11	140.02	141.00	141.60	141.53	143.54	142.14	141.06	140.40	139.17	139.17	138.90	139.64
	1	3	n.s.	156.80	157.70	158.70	161.08	163.31	165.14	166.40	168.16	169.19	171.38	170.94	171.73	172.24	172.24	173.11	173.62	174.52
	1	4	n.s.	95.38	95.36	95.29	96.37	97.70	98.77	99.39	100.52	100.67	102.05	102.29	103.81	105.22	105.57	105.87	106.49	106.87
	1	5	n.s.	73.88	74.88	76.18	77.45	78.17	79.08	79.77	80.16	80.97	81.92	82.81	83.57	84.64	84.39	84.74	85.28	85.37
	2	1	n.s.	124.71	125.04	126.16	127.56	128.82	129.83	130.84	131.90	132.56	133.72	134.36	135.40	136.69	137.31	138.56	139.31	140.31
	2	2	n.s.	149.71	149.58	149.89	151.76	153.44	154.81	156.10	157.08	157.37	159.67	158.66	157.97	157.58	156.44	156.71	156.68	157.67
	2	3	n.s.	152.16	152.72	153.40	155.52	157.51	159.22	160.46	162.21	163.33	165.54	164.81	164.90	164.52	164.10	164.50	164.73	165.50
	2	4	n.s.	100.95	101.06	100.91	102.04	103.44	129.62	105.53	106.77	107.59	109.50	110.41	112.25	113.79	114.46	115.20	116.19	117.09
	2	5	n.s.	69.74	70.98	72.38	73.67	74.70	75.79	76.81	77.74	78.65	79.63	80.71	81.82	83.06	83.54	84.31	85.29	85.91
	3	1	n.s.	84.98	85.51	86.17	87.10	87.86	88.59	89.28	90.00	90.35	91.04	91.42	92.14	92.74	93.26	94.07	94.59	95.02
	3	2	n.s.	93.50	93.79	94.19	95.00	95.76	96.42	97.06	97.61	98.01	98.91	98.91	98.97	99.07	99.02	99.34	99.56	100.07
	3	3	n.s.	116.23	116.44	116.47	117.59	118.71	119.64	120.45	121.57	122.22	123.44	122.63	122.35	121.63	120.79	120.85	120.93	121.35
	3	4	n.s.	94.53	94.23	93.73	94.08	94.94	95.78	96.41	97.22	97.83	98.88	99.62	100.79	101.71	102.02	102.61	103.21	103.69
	3	5	n.s.	78.26	79.42	80.52	81.82	82.95	83.84	84.90	85.81	86.71	88.03	89.43	90.77	92.25	92.94	93.89	94.15	95.04

growth of living biomass (increaseCl,i) [t C ha^{-1} yr^{-1}}

land-use code CC	altitude zone z	NFI region	soil type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
12	1	1	n.s.	3.56	3.02	3.46	3.71	3.44	3.89	3.22	3.49	3.69	4.51	3.32	3.56	4.71	2.36	3.28	3.80	4.26
	1	2	n.s.	5.57	3.74	4.01	5.35	5.35	4.97	4.86	4.46	3.83	6.14	4.63	5.31	5.59	3.34	4.34	4.43	5.69
	1	3	n.s.	4.49	3.92	3.98	5.09	4.90	4.63	4.00	4.55	3.88	5.20	3.47	4.97	4.64	3.38	4.13	3.91	4.62
	1	4	n.s.	3.36	2.57	2.63	3.57	3.71	3.28	2.79	3.23	2.77	4.11	2.88	3.66	3.47	2.51	2.54	2.94	2.90
	1	5	n.s.	1.73	2.06	2.44	2.56	2.12	2.39	2.24	2.05	2.58	2.72	2.58	2.36	2.61	1.31	1.90	2.07	1.80
	2	1	n.s.	3.44	2.61	3.30	3.50	3.50	3.35	3.27	3.29	2.89	3.45	3.21	3.42	3.51	2.46	3.22	2.88	3.34
	2	2	n.s.	5.67	3.79	4.17	5.35	5.35	5.15	4.85	4.51	3.84	6.08	4.71	5.42	5.65	3.21	4.41	4.44	5.67
	2	3	n.s.	4.18	3.66	3.77	4.74	4.54	4.34	3.82	4.32	3.75	5.02	3.41	4.74	4.42	3.40	3.95	3.78	4.41
	2	4	n.s.	2.63	2.19	2.00	2.92	2.98	3.48	2.26	2.54	2.27	3.43	2.34	3.09	2.74	1.96	2.04	2.30	2.25
	2	5	n.s.	1.86	2.05	2.27	2.28	2.11	2.22	2.23	2.22	2.29	2.35	2.34	2.29	2.37	1.64	1.93	2.12	1.91
	3	1	n.s.	1.92	1.92	1.96	2.14	2.08	2.11	1.98	1.99	1.59	1.99	1.93	2.16	1.93	1.56	1.98	1.84	1.87
	3	2	n.s.	1.66	1.21	1.31	1.60	1.60	1.54	1.43	1.33	1.18	1.72	1.38	1.56	1.61	1.00	1.32	1.32	1.63
	3	3	n.s.	2.52	2.28	2.10	2.80	2.73	2.58	2.42	2.69	2.27	2.95	1.98	2.94	2.68	1.84	2.48	2.45	2.76
	3	4	n.s.	1.90	1.65	1.51	1.94	2.23	2.12	1.83	1.92	1.77	2.27	1.86	2.19	1.91	1.39	1.66	1.65	1.54
	3	5	n.s.	1.51	1.57	1.52	1.80	1.69	1.47	1.68	1.61	1.61	2.02	1.96	1.81	1.90	1.16	1.44	0.77	1.43

harvesting of living biomass (decreaseCl,i) [t C ha^{-1} yr^{-1}}

land-use code CC	altitude zone z	NFI region	soil type	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
12	1	1	n.s.	-2.41	-2.33	-2.28	-2.25	-2.36	-2.45	-2.45	-2.45	-2.45	-2.51	-2.65	-2.47	-2.30	-2.02	-2.06	-2.19	-2.39
	1	2	n.s.	-4.35	-4.18	-4.14	-3.76	-3.96	-4.06	-3.87	-3.87	-3.90	-4.13	-6.04	-6.38	-6.26	-4.56	-4.34	-4.70	-4.94
	1	3	n.s.	-3.05	-3.01	-2.98	-2.70	-2.68	-2.80	-2.74	-2.78	-2.85	-3.02	-3.92	-4.17	-4.13	-3.39	-3.26	-3.40	-3.72
	1	4	n.s.	-2.43	-2.59	-2.69	-2.50	-2.38	-2.21	-2.16	-2.10	-2.62	-2.73	-2.64	-2.13	-2.07	-2.15	-2.25	-2.31	-2.52
	1	5	n.s.	-1.06	-1.06	-1.14	-1.29	-1.40	-1.47	-1.56	-1.66	-1.77	-1.77	-1.69	-1.60	-1.55	-1.56	-1.56	-1.53	-1.71
	2	1	n.s.	-2.40	-2.28	-2.19	-2.10	-2.24	-2.34	-2.26	-2.24	-2.22	-2.29	-2.56	-2.38	-2.21	-1.84	-1.96	-2.14	-2.34
	2	2	n.s.	-4.07	-3.91	-3.87	-3.47	-3.67	-3.79	-3.56	-3.54	-3.55	-3.77	-5.72	-6.11	-6.04	-4.35	-4.14	-4.48	-4.67
	2	3	n.s.	-3.11	-3.10	-3.09	-2.62	-2.56	-2.63	-2.58	-2.57	-2.63	-2.81	-4.14	-4.65	-4.80	-3.82	-3.54	-3.56	-3.64
	2	4	n.s.	-1.82	-2.08	-2.15	-1.78	-1.58	-1.90	-1.39	-1.30	-1.45	-1.52	-1.43	-1.25	-1.20	-1.29	-1.30	-1.31	-1.35
	2	5	n.s.	-0.83	-0.81	-0.86	-0.99	-1.08	-1.13	-1.21	-1.30	-1.37	-1.37	-1.27	-1.18	-1.13	-1.16	-1.16	-1.15	-1.28
	3	1	n.s.	-1.50	-1.39	-1.30	-1.21	-1.32	-1.38	-1.29	-1.27	-1.25	-1.30	-1.55	-1.44	-1.33	-1.04	-1.17	-1.31	-1.44
	3	2	n.s.	-0.95	-0.92	-0.91	-0.79	-0.84	-0.88	-0.80	-0.78	-0.77	-0.83	-1.37	-1.50	-1.51	-1.06	-1.00	-1.09	-1.12
	3	3	n.s.	-2.06	-2.07	-2.07	-1.68	-1.62	-1.65	-1.61	-1.57	-1.61	-1.74	-2.78	-3.23	-3.41	-2.67	-2.42	-2.37	-2.33
	3	4	n.s.	-1.66	-1.95	-2.01	-1.59	-1.37	-1.28	-1.20	-1.11	-1.16	-1.22	-1.13	-1.02	-0.98	-1.08	-1.07	-1.06	-1.05
	3	5	n.s.	-0.48	-0.41	-0.42	-0.50	-0.56	-0.58	-0.63	-0.70	-0.71	-0.70	-0.57	-0.47	-0.42	-0.47	-0.49	-0.50	-0.55

7.3. Source Category 5A – Forest Land

7.3.1. Source Category Description

Key category 5A1
CO_2 from Forest Land remaining Forest Land (level and 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 diffenrent forest types are allocated to afforestations (CC 11), productive forest (CC 12) and unproductive forest (CC 13) based on AREA categories (see Table 111; 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 and the second Swiss National Forest Inventory (NFI, see Table 118). The NFI 1 was conducted between 1983 and 1985 (EAFV/BFL 1988), the NFI 2 was conducted between 1993 and 1995 (Brassel and Brändli 1999). During the year 2008, first results from the third NFI (2004-2006) will be available.

Table 118 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) 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 (BEFs), tree species, and inter-annual growth variability.

To find explanatory variables that significantly reduce the variance of gross growth and BEFs 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 119 and Table 120). Therefore, growing stock, gross growth, harvesting, as well as BEFs were estimated and applied separately for these spatial strata.

Table 119 Analysis of variance of gross growth. Explanatory variables: Tree species, production region, and altitude.

	F value	p-value
Coniferous/Deciduous	421	<0.0001
Production region	45	<0.0001
Altitude	34	<0.0001

Table 120 Analysis of variance of BEFs. Explanatory variables: Tree species, production region, and altitude.

	F value	p-value
Coniferous/Deciduous	18'832	<0.0001
Production region	2'434	<0.0001
Altitude	103	<0.0001

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. If species specific measures for growing stock, gross growth, harvesting and BEFs are to be applied, the total forest area has to be divided according to the species mixture and the emission factor per stratum has to be calculated as a 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).

$R_{ci} = BA_{ci} / BA_i$ i = spatial strata

As both species add up to 1 (or 100%) the rate of deciduous forest area (R_d) is:

$R_{di} = 1 - R_{ci}$ i = spatial strata

The weights for each spatial stratum are displayed in Table 121.

Table 121 Ratio of coniferous and deciduous species (source: NFI 2; Brassel and Brändli 1999).

NFI region	Altitude [m]	Coniferous	Deciduous
1	<601	0.352	0.648
	601-1200	0.581	0.419
	>1200	0.751	0.249
2	<601	0.558	0.442
	601-1200	0.646	0.354
	>1200	0.902	0.098
3	<601	0.395	0.605
	601-1200	0.713	0.287
	>1200	0.925	0.075
4	<601	0.369	0.631
	601-1200	0.652	0.348
	>1200	0.962	0.038
5	<601	0.060	0.940
	601-1200	0.152	0.848
	>1200	0.810	0.190

To correct growth averaged for 10 years 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 largely. 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 meant that the single strata became very small. Therefore, 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 mixed forests 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 data were following: Below 601 m, 43% of Alpine forest area is situated in the eastern Alps and 57% in the western Alps. Between 601 and 1200 m, 56% of Alpine forest area is situated in the eastern Alps and 44% in the western Alps.

c) Biomass Expansion Factors

In the Swiss NFI, growing stock, gross growth, cut and mortality is expressed as round wood over bark. Round wood over bark was expanded to total biomass as done in Thürig et al. (2005) by applying allometric single-tree functions to all trees measured at the NFI 2. The functions were parameterized in following studies: 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). Additional allometric functions were used to estimate the volume of coarse roots, based on data from 100 trees, as well as of foliages, based on samples from 400 trees (Perruchoud et al. 1999). BEFs were then calculated for each spatial stratum as the ratio between round wood over bark (t ha^{-1}) and the total above- and belowground biomass (t ha^{-1}). Table 122 shows the BEFs for coniferous and deciduous species stratified for production region, Alpine climate region and elevation. In some spatial strata, the number of measured trees was not sufficient to estimate robust BEFs. Therefore, coniferous trees below 1200 m in the Southern Alps and deciduous trees above 600 m on the Central Plateau, respectively, were pooled for estimating BEFs.

Table 122 Biomass expansion factors (BEFs) to convert round-wood over bark (t C ha^{-1}) to total biomass (t C ha^{-1}) for conifers and deciduous species, respectively. In the Alps (production region 4) below 1200 m, BEFs are separated for eastern and western Alps.

<table>
<tr><th rowspan="2">NFI region</th><th rowspan="2">Altitude [m]</th><th colspan="2">Conifers</th><th colspan="2">Deciduous species</th></tr>
<tr><th>Number of trees</th><th>BEFs</th><th>Number of trees</th><th>BEFs</th></tr>
<tr><td rowspan="3">1</td><td><601</td><td>801</td><td>1.47</td><td>1371</td><td>1.50</td></tr>
<tr><td>601-1200</td><td>2855</td><td>1.50</td><td>2392</td><td>1.50</td></tr>
<tr><td>>1200</td><td>549</td><td>1.60</td><td>225</td><td>1.55</td></tr>
<tr><td rowspan="3">2</td><td><601</td><td>2965</td><td>1.46</td><td>2447</td><td>1.54</td></tr>
<tr><td>601-1200</td><td>2563</td><td>1.47</td><td rowspan="2">1504</td><td rowspan="2">1.55</td></tr>
<tr><td>>1200</td><td>106</td><td>1.65</td></tr>
<tr><td rowspan="3">3</td><td><600</td><td>129</td><td>1.48</td><td>239</td><td>1.49</td></tr>
<tr><td>601-1200</td><td>4220</td><td>1.48</td><td>1980</td><td>1.49</td></tr>
<tr><td>>1200</td><td>2909</td><td>1.59</td><td>241</td><td>1.56</td></tr>
<tr><td>4 east</td><td><601</td><td>97</td><td>1.43</td><td>73</td><td>1.52</td></tr>
<tr><td>4 west</td><td><601</td><td>45</td><td>1.44</td><td>104</td><td>1.57</td></tr>
<tr><td>4 east</td><td>601-1200</td><td>1574</td><td>1.49</td><td>806</td><td>1.56</td></tr>
<tr><td>4 west</td><td>601-1200</td><td>976</td><td>1.48</td><td>622</td><td>1.57</td></tr>
<tr><td>4</td><td>>1200</td><td>8556</td><td>1.57</td><td>327</td><td>1.62</td></tr>
<tr><td rowspan="3">5</td><td><601</td><td rowspan="2">260</td><td rowspan="2">1.54</td><td>547</td><td>1.64</td></tr>
<tr><td>601-1200</td><td>1225</td><td>1.67</td></tr>
<tr><td>>1200</td><td>1576</td><td>1.61</td><td>369</td><td>1.70</td></tr>
</table>

d) Wood Densities

To convert round wood over bark (m^3 ha^{-1}) into t ha^{-1} it was multiplied by a species-specific density. Table 123 shows the applied densities.

Table 123 Wood densities for coniferous and deciduous trees (Vorreiter 1949).

	Wood density [t m^{-3}]
Coniferous trees	0.4
Deciduous trees	0.55

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)

Growing stock, gross growth, cut and mortality for productive forests (without afforestations) were derived from those 5’425 sample plots measured at both NFI 1 and NFI 2 (Kaufmann 2001). All values derived from the NFI 1 and 2 are related to round wood over bark (with stock, without branches) and are given in m^3 ha^{-1} per spatial stratum (Table 124 and Table 125).

Table 124 Growing stock, gross growth, cut and mortality for coniferous trees (related to coniferous forest area). In the Alps (production region 4) below 1200 m, data are separated for eastern and western Alps.

NFI region	Altitude [m]	Growing stock 1985 [m^3 ha^{-1}]	Growing stock 1995 [m^3 ha^{-1}]	Gross growth [m^3 ha^{-1} 10.1yr^{-1}]	Cut and mortality [m^3 ha^{-1} 10.1yr^{-1}]
	<601	354.12	381.29	96.96	69.73
1	601-1200	372.1	393.62	97.35	75.82
	>1200	255.32	265.31	61.42	52.01
	<601	414.9	425.15	144.14	133.34
2	601-1200	458.41	477.94	146.7	127.01
	>1200	282.75	291.16	34.55	26.14
	<601	473.58	506.79	132.36	99.14
3	601-1200	482.43	515.95	132.71	98.85
	>1200	356.09	372.59	76.12	59.58
4 east	<601	346.60	352.32	52.87	47.15
4 west	<601	171.38	202.15	75.19	44.42
4 east	601-1200	370.39	386.05	85.09	69.43
4 west	601-1200	260.16	276.19	71.59	55.56
4	>1200	295.36	304.62	56.58	47.51
	<601	234.46	236.89	18.19	15.76
5	601-1200	245.82	263.12	46.73	29.43
	>1200	229.02	258.05	42.89	13.88

Note: 10.1 years correspond to the average inter-survey period between NFI 1 and NFI 2; see below.

Table 125 Growing stock, gross growth, cut and mortality for deciduous trees (related to deciduous forest area). In the Alps (production region 4) below 1200 m, data are separated for eastern and western Alps.

NFI region	Altitude [m]	Growing stock 1985 [m^3 ha^{-1}]	Growing stock 1995 [m^3 ha^{-1}]	Gross growth [m^3 ha^{-1}10.1yr^{-1}]	Cut and mortality [m^3 ha^{-1} 10.1yr^{-1}]
	<601	322.29	357.28	96.07	61.19
1	601-1200	318.04	354.25	91.93	55.75
	>1200	196.67	233.21	50.95	12.38
	<601	342.05	377.85	134.41	99.01
2	601-1200	370.66	424.4	142.1	88.57
	>1200	144.81	233.5	110.57	21.88
	<601	379.93	427.12	115.75	68.56
3	601-1200	374.75	427.88	113.4	60.82
	>1200	257.27	311.7	72.32	17.88
4 east	<601	382.98	373.57	107.96	117.37
4 west	<601	156.46	190.79	78.05	43.72
4 east	601-1200	249.86	299.12	83.94	34.68
4 west	601-1200	193.29	217.06	46.78	23.01
4	>1200	168.69	225.99	81.64	24.41
	<601	152.1	176.26	52.55	28.43
5	601-1200	134.02	163.17	49.93	20.96
	>1200	142.14	186.53	60.34	16.26

Note: 10.1 years correspond to the average inter-survey period between NFI 1 and NFI 2; see below.

Conversion of NFI data to annual estimates of gross growth and cut & mortality

The average inter-survey period between NFI 1 and NFI 2 is not exactly 10 years, but 10.1 years. With regard to the individual spatial strata, the variance is even larger (Table 126).

Table 126 Average inter-survey period [in years] between NFI 1 and NFI 2 for all spatial strata.

	Altitude [m]		
NFI region	< 601	601-1200	> 1200
1. Jura	10.0	10.3	10.6

2. Central Plateau	10.3	10.4	10.7
3. Pre-Alps	10.4	10.1	10.0
4. Alps	9.9	10.0	9.9
5. Southern Alps	10.0	9.9	9.8

To convert gross growth and cut & mortality measured between NFI 1 and II into average annual gross growth and average annual cut & mortality, those data had to be divided by the time periods shown in Table 126.

[annual gross growth] $_i$ = [gross growth between NFI 1 and NFI 2] $_i$ / time period $_i$

[annual cut & mortality] $_i$ = [cut & mortality between NFI 1 and NFI 2] $_i$ / time period $_i$

where i indicates the different spatial strata.

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[18] was applied. The application of Biome-BGC in Switzerland has been evaluated by Schmid et al. (2006).

Biome-BGC was run for typical climatic conditions representing the spatial strata differentiated for the NIR. The climate data were obtained from MeteoSchweiz[19] and cover a period of at least 27 years (cf. Thürig and Schmid 2008 for details). First, the model was run with these 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 called climate factor. It can be calculated for all the simulated years and represents the deviation of the growth of this specific year from the average growth in the simulated period.

In order to be able to calculate climate factors for future years without applying the complex model Biome-BGC but with simple climate data, multiple regression analyses were done. For each spatial stratum, the dependencies of the annual climate factors calculated by Biome-BGC as explained above were correlated with simple climate data of the corresponding years. The climate factors were the dependent variable and the corresponding monthly climate data were the explanatory variables. All explanatory variables had a significant influence on the dependent climate factor (P-Value ≤ 0.05) and the coefficient of determination R^2 of those multiple regression analysis was between 0.43 and 0.82 (cf. Thürig et al. 2005a for details). The calibrated functions could then be applied to calculate climate factors for current and future years as a function of simple climate data. The parameters of the function for each spatial stratum can be found in Thürig et al. (2005a).

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 37 shows the climate factors for all spatial strata averaged for the time period 1986-1995. The maximum deviance from the expected value is 7.4%, whereas the average deviance is 2.4%. 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).

---

[18] See for example http://www.ntsg.umt.edu/ecosystem_modeling/BiomeBGC/

[19] http://www.meteoschweiz.ch/

To calculate a time series of the annual gross growth from 1990 to 2005, the average gross growth derived from the NFI 1 and NFI 2 data was multiplied with the corresponding annual climate factor as calculated by the functions mentioned above.

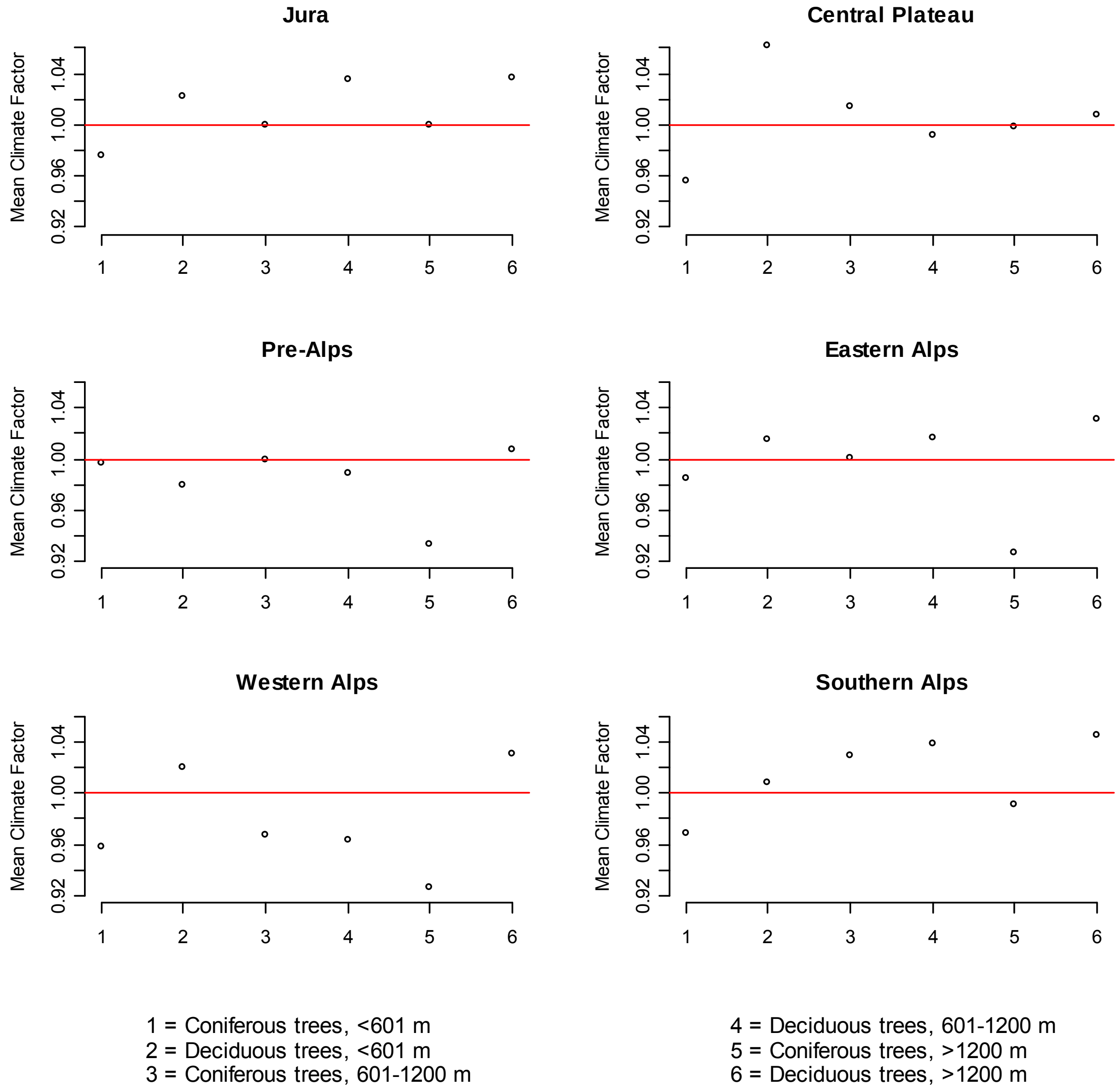


Figure 37 Climate factors calculated for the individual spatial strata, averaged for the years 1986-1995.

To avoid a systematic overestimation of the annual gross growth in the reporting, the climate factors were standardized to result in an average of 1 over the reference period (1986-1995) within all spatial strata. The same correction was then applied to climate factors going beyond the reference period. The resulting standardized climate factors for the time series 1986 to 2005 are displayed for each spatial stratum in Figure 38.

Except for the Southern Alps below 600 m above see level, 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 1995. The estimated climate correction factors for the lower Southern Alps (< 600 m) show an extreme growth reduction for hot years such as 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, the affected region makes up only 0.1% of the Swiss forest area and therefore, only 0.1% of the 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), growth in 2003 was reduced between 20 and 60%. The same results were found by Leuzinger et al. (2005) for a forest near Basel.

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 37). This identifies a missing sensibility of the model used to derive the climate correction factors. This missing sensibility could be caused by the fact that the method works with measured climate data from only 10 different climate stations. For the rest of the altitudinal levels, precipitation and temperature were extrapolated by a climate model (see Thürig et al. 2005a for more details). To increase the sensibility 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 altitudinal levels.

In Europe, the summer of 2003 was the hottest and driest summer in over 500 years (Luterbacher et al. 2004). However, several studies indicate an increasing frequency for 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 to take into account the effect of inter-annual climate variability on annual gross growth.

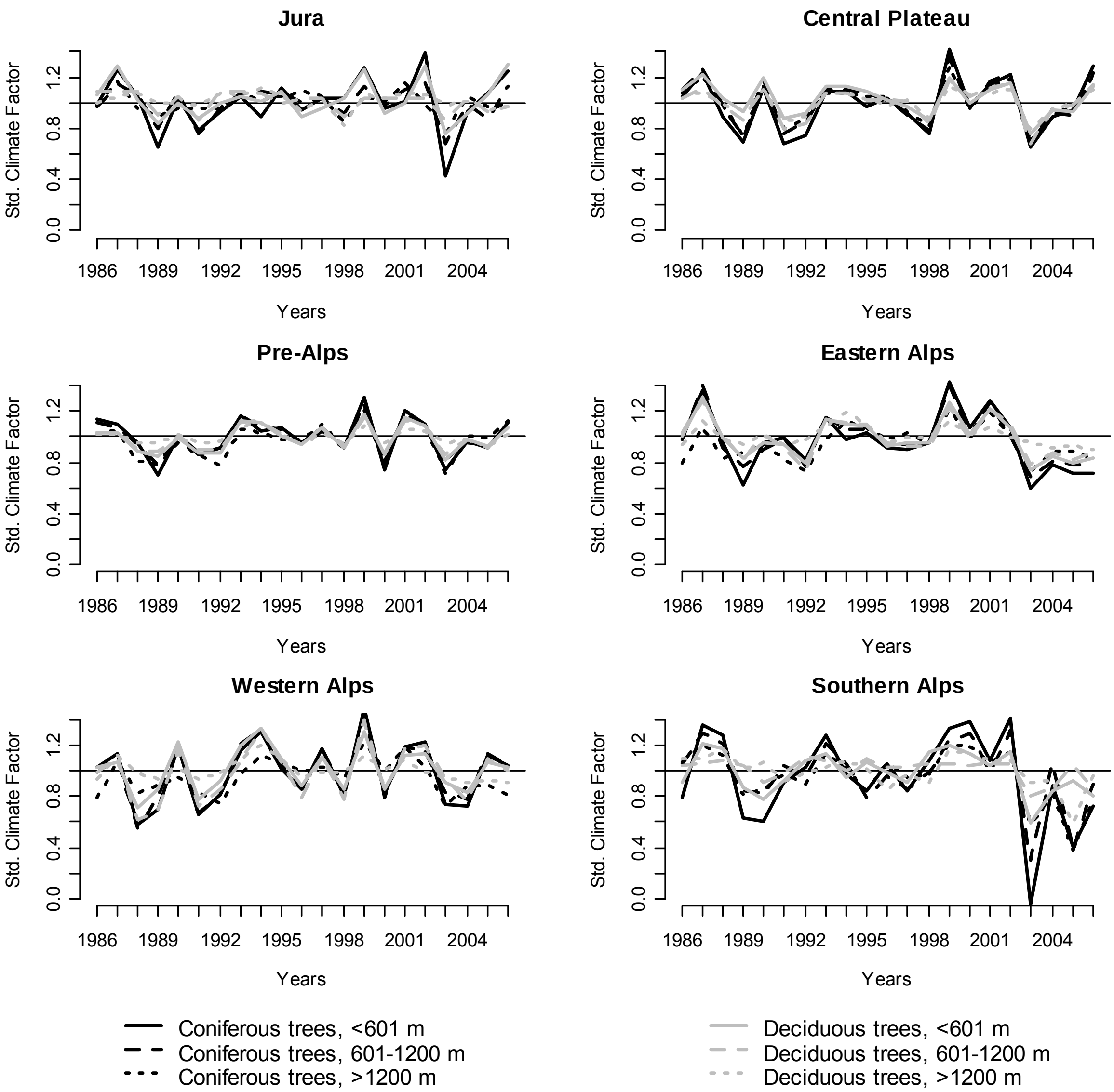


Figure 38 Standardized climate factors for the individual spatial strata from1986 to 2006.

Annual cut and mortality

Cut and mortality could only be quantified as sum of cut and mortality (CM) measured between NFI 1 and NFI 2. To calculate the annual cut and mortality (CMy) for the years 1986 to 1995, the total amount of cut & mortality was distributed among the ten years, weighted by the percentage of the annual harvesting amounts taken from the forest statistics (Table 127, SFSO 2006b, FOEN 2008b).

Table 127 Annual harvesting amount in m^3 merchantable timber per coniferous and deciduous tree species and production region derived from the forest statistics (SFSO 2006b, FOEN 2008b). All values were averaged over three years to compensate for extreme events such as the storms Vivian (1990) and Lothar (1999) (e.g. value for 2004 is the average value for the years 2002-2004).

	1. Jura		2. Central plateau		3. Pre-Alps		4. Alps		5. Southern Alps	
Year	Conif.	Dec.	Conif.	Dec.	Conif.	Dec.	Conif.	Dec.	Conif.	Dec.
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
1989	639'699	368'530	1'207'615	562'104	865'133	141'788	617'456	64'786	43'150	25'472
1988	630'454	368'483	1'246'394	558'806	868'603	145'121	609'846	65'259	43'327	28'118
1987	606'645	363'712	1'224'466	541'145	800'508	139'369	624'252	68'340	40'795	28'942
1986	652'936	363'906	1'287'969	523'611	697'280	130'709	643'790	65'567	40'315	29'169

For the years 1996 to 2006, no NFI data are available. Therefore, CM_y for that period were calculated on the basis of the annual harvesting amounts derived from the annual forest statistic and corrected for the amount of total losses as observed in the NFI (e.g. natural mortality, harvesting damage). The correction factor was derived for all the production regions and tree species by building the ratio between CM and the sum of the annual harvesting amount reported in the forest statistics from 1986 to 1995:

$$\text{Correction factor}_i = [\, \Sigma_a (CM_a / T_a)*10 \,]_i \,/\, [\, \Sigma_y \text{Harvesting amount forest statistics}_y \,]_i$$

i = 1-10 (five production regions and two tree species)

a = 1-3 (three zones of altitude: <601 m, 601-1200 m, >1200 m)

y = 1986-1995

where T is the exact inter-survey period between the two inventories (Table 126).

Table 128 shows the resulting correction factors for all NFI regions and tree species.

Harvesting amounts from the forest statistics were averaged over the actual year and the previous two years in order to level out extreme events such as heavy storms.

Table 128 Correction factors to convert annual harvesting amounts from the forest statistics (SFSO 2006b) into total amount of cut & mortality for the period 1996-2006.

NFI region	Tree species	Correction factors
1	coniferous	1.177
1	deciduous	1.315
2	coniferous	1.331
2	deciduous	1.535
3	coniferous	1.543
3	deciduous	1.920
4	coniferous	1.941
4	deciduous	2.380
5	coniferous	2.262
5	deciduous	5.737

Growing stock: Calculation of time series

The time series of the growing stocks (GS) were calculated based on the growing stock measured in the NFI 1 for the years 1986 to 1995 and NFI 2 for the years 1996 to 2006 plus the annual gross growth, minus the annual amounts of cut & mortality (CM_y).

The growing stock of the years 1986-1994 was calculated by extrapolating the growing stock of 1985.

$GS_{ay} = GS1985 + \Sigma_y$ [annual gross $growth_y$] - Σ_y [CM_y]

y = 1986 to ay

ay = actual year

The growing stock of the years 1995-2006 was calculated in the same way by extrapolating the growing stock of 1995.

These values given in round wood over bark [m^3 ha^{-1}] were converted to carbon in living biomass [t C ha^{-1}] as follows:

$[\text{C in living biomass}]_s =$

$\Sigma_t\,[\text{round wood over bark}]_{s,t} * \text{density}_t * \text{BEF}_{s,t} * \text{C-content} * [\text{percentage of tree species}]_{t,s}$

where s indicates the 15 different spatial strata and t the two different tree species (coniferous and deciduous trees).

As an example of the calculation, the 1986-1990 development of the growing stock [t C ha^{-1}] in the Central Plateau (NFI region 2) below 601 m for coniferous and deciduous trees is shown:

$GS1986_c = 417.17 = 414.90 + 15.79 - 13.52$

$GS1987_c = 422.97 = 417.17 + 18.66 - 12.86$

$GS1988_c = 423.33 = 422.97 + 13.45 - 13.09$

$GS1989_c = 421.06 = 423.33 + 10.41 - 12.68$

$GS1990_c = 423.20 = 421.06 + 16.84 - 14.70$

$GS1986_d = 346.70 = 342.05 + 14.02 - 9.37$

$GS1987_d = 352.42 = 346.70 + 15.40 - 9.68$

$GS1988_d = 355.49 = 352.42 + 13.07 - 10.0$

$GS1989_d = 357.13 = 355.49 + 11.70 - 10.06$

$GS1990_d = 361.80 = 357.13 + 15.09 - 10.42$

$[\text{C in living biomass 1990}]_{\text{Central Plateau, <601, c}} = 123.57 = 423.2 * 0.4 * 1.46 * 0.5$

[C in living biomass 1990]$_{\text{Central Plateau, <601, d}}$ = 153.22 = 361.8 * 0.55 * 1.54 * 0.5

[C in living biomass 1990]$_{\text{Central Plateau, <601}}$ = 136.68 = 123.57 * 0.558 + 153.22 * 0.442

Table 129 displays the calculated growing stock values for 1990 to 2006 specified for all spatial strata. Table 130 displays the calculated gross growth for the same time period and strata, and Table 131 displays the calculated cut & mortality for the same time period and strata.

Table 129 Growing stock of CC12 from 1990 to 2006 in t C ha^{-1}.

		C in Biomass [t C ha^{-1}]							
Altitude [m]	**NFI region**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
<601	**1**	129.10	129.78	130.96	132.42	133.50	134.94	135.70	136.75
	2	136.68	136.25	136.13	137.71	139.11	140.02	141.00	141.60
	3	156.80	157.70	158.70	161.08	163.31	165.14	166.40	168.16
	4	95.38	95.36	95.29	96.37	97.70	98.77	99.39	100.52
	5	73.88	74.88	76.18	77.45	78.17	79.08	79.77	80.16
601-1200	**1**	124.71	125.04	126.16	127.56	128.82	129.83	130.84	131.90
	2	149.71	149.58	149.89	151.76	153.44	154.81	156.10	157.08
	3	152.16	152.72	153.40	155.52	157.51	159.22	160.46	162.21
	4	100.95	101.06	100.91	102.04	103.44	129.62	105.53	106.77
	5	69.74	70.98	72.38	73.67	74.70	75.79	76.81	77.74
>1200	**1**	84.98	85.51	86.17	87.10	87.86	88.59	89.28	90.00
	2	93.50	93.79	94.19	95.00	95.76	96.42	97.06	97.61
	3	116.23	116.44	116.47	117.59	118.71	119.64	120.45	121.57
	4	94.53	94.23	93.73	94.08	94.94	95.78	96.41	97.22
	5	78.26	79.42	80.52	81.82	82.95	83.84	84.90	85.81

		C in Biomass [t C ha^{-1}]								
Altitude [m]	**NFI region**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
<601	**1**	137.99	139.99	140.65	141.75	144.16	144.50	145.71	147.33	149.20
	2	141.53	143.54	142.14	141.06	140.40	139.17	139.17	138.90	139.64
	3	169.19	171.38	170.94	171.73	172.24	172.24	173.11	173.62	174.52
	4	100.67	102.05	102.29	103.81	105.22	105.57	105.87	106.49	106.87
	5	80.97	81.92	82.81	83.57	84.64	84.39	84.74	85.28	85.37
601-1200	**1**	132.56	133.72	134.36	135.40	136.69	137.31	138.56	139.31	140.31
	2	157.37	159.67	158.66	157.97	157.58	156.44	156.71	156.68	157.67
	3	163.33	165.54	164.81	164.90	164.52	164.10	164.50	164.73	165.50
	4	107.59	109.50	110.41	112.25	113.79	114.46	115.20	116.19	117.09
	5	78.65	79.63	80.71	81.82	83.06	83.54	84.31	85.29	85.91
>1200	**1**	90.35	91.04	91.42	92.14	92.74	93.26	94.07	94.59	95.02
	2	98.01	98.91	98.91	98.97	99.07	99.02	99.34	99.56	100.07
	3	122.22	123.44	122.63	122.35	121.63	120.79	120.85	120.93	121.35
	4	97.83	98.88	99.62	100.79	101.71	102.02	102.61	103.21	103.69
	5	86.71	88.03	89.43	90.77	92.25	92.94	93.89	94.15	95.04

Table 130 Gross growth of living biomass of CC12 from 1990 to 2006 in t C ha^{-1}.

		C in Biomass [t C ha^{-1}]							
Altitude [m]	**NFI region**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
<601	**1**	3.56	3.02	3.46	3.71	3.44	3.89	3.22	3.49
	2	5.57	3.74	4.01	5.35	5.35	4.97	4.86	4.46
	3	4.49	3.92	3.98	5.09	4.90	4.63	4.00	4.55
	4	3.36	2.57	2.63	3.57	3.71	3.28	2.79	3.23
	5	1.73	2.06	2.44	2.56	2.12	2.39	2.24	2.05
601-1200	**1**	3.44	2.61	3.30	3.50	3.50	3.35	3.27	3.29
	2	5.67	3.79	4.17	5.35	5.35	5.15	4.85	4.51
	3	4.18	3.66	3.77	4.74	4.54	4.34	3.82	4.32
	4	2.63	2.19	2.00	2.92	2.98	3.48	2.26	2.54
	5	1.86	2.05	2.27	2.28	2.11	2.22	2.23	2.22
>1200	**1**	1.92	1.92	1.96	2.14	2.08	2.11	1.98	1.99
	2	1.66	1.21	1.31	1.60	1.60	1.54	1.43	1.33
	3	2.52	2.28	2.10	2.80	2.73	2.58	2.42	2.69
	4	1.90	1.65	1.51	1.94	2.23	2.12	1.83	1.92
	5	1.51	1.57	1.52	1.80	1.69	1.47	1.68	1.61

		C in Biomass [t C ha^{-1}]								
Altitude [m]	**NFI region**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
<601	**1**	3.69	4.51	3.32	3.56	4.71	2.36	3.28	3.80	4.26
	2	3.83	6.14	4.63	5.31	5.59	3.34	4.34	4.43	5.69
	3	3.88	5.20	3.47	4.97	4.64	3.38	4.13	3.91	4.62
	4	2.77	4.11	2.88	3.66	3.47	2.51	2.54	2.94	2.90
	5	2.58	2.72	2.58	2.36	2.61	1.31	1.90	2.07	1.80
601-1200	**1**	2.89	3.45	3.21	3.42	3.51	2.46	3.22	2.88	3.34
	2	3.84	6.08	4.71	5.42	5.65	3.21	4.41	4.44	5.67
	3	3.75	5.02	3.41	4.74	4.42	3.40	3.95	3.78	4.41
	4	2.27	3.43	2.34	3.09	2.74	1.96	2.04	2.30	2.25
	5	2.29	2.35	2.34	2.29	2.37	1.64	1.93	2.12	1.91
>1200	**1**	1.59	1.99	1.93	2.16	1.93	1.56	1.98	1.84	1.87
	2	1.18	1.72	1.38	1.56	1.61	1.00	1.32	1.32	1.63
	3	2.27	2.95	1.98	2.94	2.68	1.84	2.48	2.45	2.76
	4	1.77	2.27	1.86	2.19	1.91	1.39	1.66	1.65	1.54
	5	1.61	2.02	1.96	1.81	1.90	1.16	1.44	0.77	1.43

Table 131 Cut & mortality of living biomass of CC12 from 1990 to 2006 in t C ha^{-1}.

		C in Biomass [t C ha^{-1}]							
Altitude [m]	**NFI region**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
<601	1	-2.41	-2.33	-2.28	-2.25	-2.36	-2.45	-2.45	-2.45
	2	-4.35	-4.18	-4.14	-3.76	-3.96	-4.06	-3.87	-3.87
	3	-3.05	-3.01	-2.98	-2.70	-2.68	-2.80	-2.74	-2.78
	4	-2.43	-2.59	-2.69	-2.50	-2.38	-2.21	-2.16	-2.10
	5	-1.06	-1.06	-1.14	-1.29	-1.40	-1.47	-1.56	-1.66
601-1200	1	-2.40	-2.28	-2.19	-2.10	-2.24	-2.34	-2.26	-2.24
	2	-4.07	-3.91	-3.87	-3.47	-3.67	-3.79	-3.56	-3.54
	3	-3.11	-3.10	-3.09	-2.62	-2.56	-2.63	-2.58	-2.57
	4	-1.82	-2.08	-2.15	-1.78	-1.58	-1.90	-1.39	-1.30
	5	-0.83	-0.81	-0.86	-0.99	-1.08	-1.13	-1.21	-1.30
>1200	1	-1.50	-1.39	-1.30	-1.21	-1.32	-1.38	-1.29	-1.27
	2	-0.95	-0.92	-0.91	-0.79	-0.84	-0.88	-0.80	-0.78
	3	-2.06	-2.07	-2.07	-1.68	-1.62	-1.65	-1.61	-1.57
	4	-1.66	-1.95	-2.01	-1.59	-1.37	-1.28	-1.20	-1.11
	5	-0.48	-0.41	-0.42	-0.50	-0.56	-0.58	-0.63	-0.70

		C in Biomass [t C ha^{-1}]								
Altitude [m]	**NFI region**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
<601	1	-2.45	-2.51	-2.65	-2.47	-2.30	-2.02	-2.06	-2.19	-2.39
	2	-3.90	-4.13	-6.04	-6.38	-6.26	-4.56	-4.34	-4.70	-4.94
	3	-2.85	-3.02	-3.92	-4.17	-4.13	-3.39	-3.26	-3.40	-3.72
	4	-2.62	-2.73	-2.64	-2.13	-2.07	-2.15	-2.25	-2.31	-2.52
	5	-1.77	-1.77	-1.69	-1.60	-1.55	-1.56	-1.56	-1.53	-1.71
601-1200	1	-2.22	-2.29	-2.56	-2.38	-2.21	-1.84	-1.96	-2.14	-2.34
	2	-3.55	-3.77	-5.72	-6.11	-6.04	-4.35	-4.14	-4.48	-4.67
	3	-2.63	-2.81	-4.14	-4.65	-4.80	-3.82	-3.54	-3.56	-3.64
	4	-1.45	-1.52	-1.43	-1.25	-1.20	-1.29	-1.30	-1.31	-1.35
	5	-1.37	-1.37	-1.27	-1.18	-1.13	-1.16	-1.16	-1.15	-1.28
>1200	1	-1.25	-1.30	-1.55	-1.44	-1.33	-1.04	-1.17	-1.31	-1.44
	2	-0.77	-0.83	-1.37	-1.50	-1.51	-1.06	-1.00	-1.09	-1.12
	3	-1.61	-1.74	-2.78	-3.23	-3.41	-2.67	-2.42	-2.37	-2.33
	4	-1.16	-1.22	-1.13	-1.02	-0.98	-1.08	-1.07	-1.06	-1.05
	5	-0.71	-0.70	-0.57	-0.47	-0.42	-0.47	-0.49	-0.50	-0.55

All steps, data and excel-files needed to reproduce the calculation of the CC 12 emission factors of 2005 and to calculate the CC 12 emission factors for the year 2006 are summarized in FOEN (2007b).

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^3 ha^{-1} was estimated. Multiplied by the wood density for coniferous trees (0.4 t m^{-3}; Vorreiter 1949) an average growing stock of 16 t ha^{-1} results. Applying a default BEF of 1.45 (Burschel et al. 1993), an average biomass for brush forest of 23.2 t ha^{-1} that translates to 11.6 t C ha^{-1} (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^3 ha^{-1} and 219 m^3 ha^{-1}, 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^3 ha^{-1} was estimated. Multiplied by the wood density for coniferous trees (0.4 t m^{-3}; Vorreiter 1949) we end up with an average growing stock of 60 t ha^{-1}. Applying a default BEF of 1.45 (Burschel et al. 1993), an average biomass for forest on unproductive areas of 87 t ha^{-1} that translates to 43.5 t C ha^{-1} (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:

$[\text{weighted C content}]_i = RS_i * CS + (1- RS_i) * CI$

where RS_i is the rate of the brush forest per spatial stratum i,

CS is the carbon content of brush forest (11.6 t C ha^{-1}),

CI is the carbon content of forest on unproductive areas (43.5 t C ha^{-1}).

Table 132 shows the carbon content per spatial stratum in t C ha^{-1}.

Table 132 Rate of brush forest and forest on unproductive areas and the resulting weighted carbon content in t C ha^{-1} 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^{-1}]
1	<601	25	356	381	0.0656	41.41
	601-1200	1	1780	1781	0.000561	43.48
	>1200	1	178	179	0.00558	43.32
2	<601	25	534	559	0.0447	42.07
	601-1200	25	356	381	0.0656	41.41
	>1200	1	0	1	1	11.60
3	<601	25	356	381	0.0656	41.41
	601-1200	50	3204	3254	0.0154	43.01
	>1200	2100	1780	3880	0.541	26.23
4	<601	100	356	456	0.219	36.50
	601-1200	1925	4984	6909	0.279	34.61
	>1200	36925	7120	44045	0.838	16.76
5	<601	200	534	734	0.272	34.81
	601-1200	2550	3560	6110	0.417	30.19
	>1200	16875	5162	22037	0.766	19.07

* 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

In the second NFI, all dead trees (standing and lying) larger than 12 cm were measured. Thus, an estimate of the dead-wood pool in Swiss productive forests (CC 12) can be done. In Table 133, the amount of dead wood is differentiated for the production regions. So far, no data about the temporal change of the dead-wood pool are available (The dead-wood pool was not measured in the course of NFI 1, and NFI 3 data will be available in 2008 for the first time).

Table 133 Dead wood in Swiss productive forests (CC 12) specified for the NFI production regions (Brassel and Brändli 1999).

	1. Jura [m^3 ha^{-1}]	**2. Central plateau** [m^3 ha^{-1}]	**3. Pre-Alps** [m^3 ha^{-1}]	**4. Alps** [m^3 ha^{-1}]	**5. Southern Alps** [m^3 ha^{-1}]	**Mean value Switzerland** [m^3 ha^{-1}]
Lying trees	1.1	0.9	3.7	9.5	4.0	4.6
Standing trees	5.1	4.0	8.4	10.0	7.7	7.4
Total	6.3	4.9	12.2	19.5	11.6	11.9

Applying the same wood densities, BEFs and carbon content as for the living growing stock, dead wood per spatial stratum can be estimated (Table 134).

Table 134 Dead wood in Swiss productive forests (CC 12) per spatial stratum in t C ha^{-1}.

NFI region	**Altitude [m]**	**Carbon in dead biomass [t C ha^{-1}]**
1	<601	2.34
	601-1200	2.19
	>1200	2.18
2	<601	1.72
	601-1200	1.67
	>1200	1.66
3	<601	4.45
	601-1200	4.01
	>1200	3.98
4	<601	7.51
	601-1200	6.75
	>1200	6.22
5	<601	5.13
	601-1200	5.06
	>1200	4.06

Soil organic carbon of mineral forest soils

According to IPCC (2003; Table 3.1.2) soil carbon of the organic soil horizons should be accounted as dead organic matter, together with dead wood. Therefore, soil carbon of mineral forest soils in organic soil horizons is added to the dead wood for Swiss productive and unproductive forests (CC 12 and CC 13). The soil horizons L (litter), F (fermentation) and H (humus) were estimated in a study done by Moeri (2007) as follows.

Acquisition of data:
In a first phase of the study, field work was accomplished. A total of 30 additional sites were sampled from 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 the study sites, the investigations were made within an area of 50 x 50 m.

At each study site, 8 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 2 transects with 20 measurements.

Samples were dried at a temperature of 60°C to constant weight (at least 24 hours), weighted and the densities (g/cm^3) were calculated. The average densities (± sd) were: L = 0.09 ± 0.05, F = 0.14 ± 0.06, H = 0.22 ± 0.08. Finally, samples were milled and analysed for their C and N concentrations (NC 2500, Carlo Erba Instruments).

Database:
At WSL, approximately 1300 soil profiles had been investigated during the past 10-15 years. These existing data were arranged in a database. Approximately 870 sites with different information on the soil characteristics distributed among different forest types throughout Switzerland were chosen for the compilation presented here. This information included thickness of the organic layers and sometimes measured carbon content analysis. Some additional information had to be deduced by Moeri (2007) from pictures and field protocols.

The organic carbon stock at each site 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 by Moeri (2007) from the laboratory data contained in the WSL database. Approximately 400 sites were selected and used for the present study done by Moeri (2007). The C concentrations from the WSL database were stratified for coniferous, mixed and for deciduous forests and average C concentrations were calculated. Those average C concentration values per strata enabled the calculation of the amount of carbon in organic soil horizons on each site.

Carbon stock in dead organic matter is calculated as the sum of the dead wood and the soil organic carbon of mineral forest soils (CC 12, CC 13) in organic soil horizons (Table 135 and Table 136). So far, there are no data available about dead wood in unproductive forests (CC 13). Therefore, dead wood in unproductive forests is estimated as the soil organic carbon of mineral forest soils in organic soil horizons.

For afforestations (CC 11), the amount of dead wood and soil carbon in the soil organic horizons was assumed to be zero.

Table 135 Carbon stock in dead organic matter of productive forests (CC 12).

NFI Region	Altitude [m]	Carbon in dead biomass [t C ha^{-1}]	Carbon in L, F and H horizon [t C ha^{-1}]	Carbon stock in dead organic matter (stockCd,i) [t C ha^{-1}]
1	<601	2.34	9.7	12.04
1	601-1200	2.19	9.7	11.89
1	>1200	2.18	9.7	11.88
2	<601	1.72	9.5	11.22
2	601-1200	1.67	9.5	11.17
2	>1200	1.66	9.5	11.16
3	<601	4.45	17.4	21.85
3	601-1200	4.01	17.4	21.41
3	>1200	3.98	17.4	21.38
4	<601	7.51	33.4	40.91
4	601-1200	6.75	33.4	40.15
4	>1200	6.22	33.4	39.62
5	<601	5.13	22.3	27.43
5	601-1200	5.06	22.3	27.36
5	>1200	4.06	22.3	26.36

Table 136 Carbon stock in dead organic matter of unproductive forests (CC 13).

NFI Region	Altitude [m]	Carbon in dead biomass [t C ha^{-1}]	Carbon in L, F and H horizon [t C ha^{-1}]	Carbon stock in dead organic matter (stockCd,i) [t C ha^{-1}]
1	<601	0	9.7	9.7
1	601-1200	0	9.7	9.7
1	>1200	0	9.7	9.7
2	<601	0	9.5	9.5
2	601-1200	0	9.5	9.5
2	>1200	0	9.5	9.5
3	<601	0	17.4	17.4
3	601-1200	0	17.4	17.4
3	>1200	0	17.4	17.4
4	<601	0	33.4	33.4
4	601-1200	0	33.4	33.4
4	>1200	0	33.4	33.4
5	<601	0	22.3	22.3
5	601-1200	0	22.3	22.3
5	>1200	0	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 t C ha^{-1} in 0-30 cm topsoil is assumed. These soil samples were stratified for the five NFI production regions (Table 137).

Table 137 Soil organic carbon (SOC) of mineral forest soils (CC 11, CC 12, CC 13) in mineral soil horizons (0-30 cm) in t C ha^{-1} in the 5 NFI production regions (N = number of samples): The average values ± standard deviation are given.

NFI region (N)	SOC of mineral topsoil 0-30 cm
1. Jura (32)	75.0 (± 37.2)
2. Central Plateau (24)	62.6 (± 32.6)
3. Pre-Alps (25)	75.3 (± 21.4)
4. Alps (39)	72.1 (± 40.6)
5. Southern Alps (16)	109.0 (± 43.7)
Total Switzerland (136)	76.0 (± 37.6)

Due to following reasons it is assumed that in the years 1990 to 2006 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 common 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 results from the NFI 3 were not yet available, the average growing stock and growth of afforestations were empirically assessed with NFI 1 and NFI 2, 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 $m^3 ha^{-1}$. The growing stock on moderate sites was assumed to be one-third smaller than on good sites (60 $m^3 ha^{-1}$), and two-third smaller on bad sites (30 $m^3 ha^{-1}$). As trees below 12 cm DBH were not measured in the NFI, the growing stock of 10 year old stands on good sites was assumed to be 2 $m^3 ha^{-1}$. 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-third slower on poor sites. The annual growth was calculated as the difference between growing stocks of two following years. These assumptions are not valid for single stands, but can be applied as a rough simplification. Table 138 shows the simulated growing stock and growth for all three site qualities.

Table 138 Estimated average growing stock and annual growth of forest stands in round wood (defined in Table 139) up to 20 years (CC 11) specified for altitude zone.

Stand age [yr]	**< 601 m altitude**		**601 - 1200 m altitude**		**> 1200 m altitude**	
	Growing stock [m^3ha^{-1}]	**Growth** [$m^3 ha^{-1} year^{-1}$]	**Growing stock** [m^3ha^{-1}]	**Growth** [$m^3 ha^{-1} year^{-1}$]	**Growing stock** [m^3ha^{-1}]	**Growth** [$m^3 ha^{-1} year^{-1}$]
0-9	0	0	0	0	0	0
10	**2**	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	**90**	12	**60**	10	**30**	7

To convert the estimated growing stock and growth into carbon, the following equations were applied:

C stock in living biomass = Average growing stock * density * BEF * C-content

Growth of living biomass = Average growth * density * BEF * C-content

In Table 139, abbreviations and units are explained. Table 140 shows the parameters and the converted values.

Table 139 Conversion of growing stock and growth to total carbon in biomass.

Name	Description	Value	Unit
Average growing stock	Average growing stock of round wood over bark, without branches	See Table 140	m^3 ha^{-1}
Average growth	Average growth per ha and year	See Table 140	m^3 ha^{-1} $year^{-1}$
Density	Tree density averaged for coniferous and deciduous trees	0.47	t m^{-3}
BEF	Biomass expansion factor to convert round wood over bark into total tree biomass (Burschel et al. 1993); averaged value for coniferous and deciduous trees.	1.45	-
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 140	t C ha^{-1}
Growth of living biomass	Growth of carbon in t C per ha and year	See Table 140	t C ha^{-1} $year^{-1}$

Table 140 Carbon stock in living biomass and growth of living biomass in afforestations (CC 11) specified for altitude zone.

Altitude [m]	Average growing stock [m^3 ha^{-1}]	Average growth [m^3 $ha^{-1}$$year^{-1}$]	Density [t m^{-3}]	BEF	Carbon content	Carbon stock in living biomass [t C ha^{-1}]	Growth of living biomass [t C ha^{-1} $year^{-1}$]
0-600	36.25	7.5	0.47	1.45	0.5	12.35	2.56
601-1200	19.67	5	0.47	1.45	0.5	6.70	1.70
>1200	7.08	2.5	0.47	1.45	0.5	2.41	0.85

l) Specifications for Calculating Carbon Fluxes in Case of Land-use Change Comprising Forest Land

According to the land use statistics, 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 115) 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 of soil carbon was not considered and was set to zero.

Cut and mortality was inferred from NFI 1 and NFI 2, 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 by 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_2O 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 common 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 2008b). Table 141 shows the annual number of fires and the burnt area from 1990 to 2006.

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_4 is 0.354 Mg CH_4 ha^{-1} as proposed by EEA 2006.

For N_2O, the default emission factor of 0.11 g (kg combusted biomass)$^{-1}$ is applied (IPCC 2003, Table 3A.1.16).

The mass of available fuel is estimated to average 250’000 kg biomass ha^{-1}. 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^{-3} 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 141 are calculated.

CO_2 emissions caused by wildfires are included in CRF Table 5.A.

Table 141 Productive forest land affected by wildfires (Source: FOEN 2008b) and resulting GHG emissions 1990-2006.

Year	Number	Area burnt [ha]	CH_4 [Mg]	N_2O [Mg]
1990	216	1102	390.11	13.62
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	3.62
1995	56	438	155.05	5.42
1996	61	233	82.48	2.88
1997	77	1511	534.89	18.68
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	6.97
2004	46	20	7.08	0.25
2005	97	47	16.64	0.58
2006	70	101	35.75	1.25

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 & 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 case of gross growth, cut and mortality, the uncertainty is assessed as low. In case of BEFs, the uncertainty is assessed as medium. In case of soil carbon pool, the uncertainty is assessed as medium.

7.3.4. Source-Specific QA/QC and Verification

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 doubling of available AREA activity data (SFSO 2007a), the consideration of UNFCCC review reports, and one amendment have led to a significant recalculation in source category 5A.

In detail, following the recommendations of UNFCCC (2007, 2007a), the methodological approach has been revised with respect to:

- A land-use conversion period of 20 years (instead of one year) has been applied to

- carbon stock changes in living and dead biomass for “Land converted to forest land”;
- soil carbon stock changes in the case of “Land converted to forest land”.

- Soil organic carbon above mineral forest soils (litter) is reported for dead organic matter in accordance with IPCC (2003; Table 3.1.2).
- The EEA (2006) emission factor for CH_4 emissions from forest fire has been adopted. Moreover, the mass of available fuel (kg biomass per ha) has been reevaluated and the area burnt by forest fires for 2005 has been revised.

Furthermore, during the in-country review in March 2007 Switzerland revised the parameters chosen for the definition of forest (FOEN 2006h) to be compliant with the agreed values in decision 16/CMP.1. This provoked a minor reorganization of the combination category matrix that defines the main IPCC categories as well as the country specific sub-divisions (confer FOEN 2006d and FOEN 2007f).

As required by decision 14/CP.11 estimates for NMVOC emissions in forests are reported for the first time.

7.3.6. Source-Specific Planned Improvements

As soon as the results from the third NFI (2004-2006) are available, gross growth rates and losses by harvesting amounts and mortality, currently extrapolated from NFI 1 (1983-1985) and NFI 2 (1993-1995), will be recalculated for the years from 1995 onwards. The publication of first NFI 3 data is expected in 2008, and thus the incorporation of NFI 3 results is scheduled for the subsequent submission in April 2009.

With the results of the NFI 3, the growing stock and increment of afforestations will be analyzed more precisely.

In the third NFI, the amount of dead wood larger than 7 cm was measured by the line intersect method. Therefore, more accurate estimates about dead-wood will be performed, especially in unproductive forests. Additionally, by analysing the difference in dead-wood larger than 12 cm between the second and the third NFI, changes of the dead-wood pool will be performed for the 2009 submission.

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, including the effect of inter-annual climate variability on estimating gross growth becomes more and more important. Our approach is a first methodological possibility. However, first results show that the methodology should be improved. To increase the sensibility 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.

The estimation of soil carbon pools is planned to be improved. Moreover, arguments confirming the sink effect of Swiss forest soils are planned to be strengthened.

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 – Crop Land

7.4.1. Source Category Description

Key category 5B1
CO_2 from 5B1 "Crop Land remaining Crop Land" (level).

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 142).

Table 142 Standard values for arable crop yields (t C ha^{-1}; FAL/RAC 2001, assuming a carbon fraction of 0.5 (IPCC default).

Crop	Yield [t C ha^{-1}]
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:

$$\text{Biomass cropland} = \Sigma_f \, (A_f / A_t) * C_f$$

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^{-1}) according to Table 142. 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^{-1}.

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 (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 ± 5 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 ± 48 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 t C ha^{-1} according to measurements in Europe including Switzerland as compiled by Leifeld et al. (2003, 2005).

d) N_2O Emissions from Land Use Conversion to Cropland

N_2O 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):

$Emission(N_2O) = deltaC_s * 1 / (C : N) * EF1 * 44 / 28$ [Gg N_2O]

where:

$deltaC_s$: 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 kg N_2O-N $(kg N)^{-1}$

$DeltaC_s$ is calculated according to the methodology described in Chapter 7.2.1. If $DeltaC_s$ is positive (carbon gain) there is no N_2O emission. On organic soils the carbons stock difference is zero (see Chapter 7.2.6).

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.

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 $Ca(CO_3)$. The resulting carbon emissions associated with liming are 5.4 Gg C $year^{-1}$.

7.4.3. Uncertainties and Time-Series Consistency

Uncertainties for soil carbon stocks are given together with the mean value in the text. 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.

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 doubling of available AREA activity data (SFSO 2007a) has led to a significant recalculation in source category 5B.

Following the recommendations of UNFCCC (2007, 2007a), a land-use conversion period of 20 years (instead of one year) has been applied to soil carbon stock changes in the case of "Land converted to cropland".

Furthermore, to calculate N_2O emissions from land-use conversion to cropland the IPCC C:N default value has been replaced with a country specific ratio (Leifeld et al. 2007).

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 emission rates from cropland to grassland and vice versa in the future.

7.5. Source Category 5C – Grassland

7.5.1. Source Category Description

The categoryies 5C1 Grassland remaining Grassland and 5C2 Land converted to Grassland are **not key categories**.

5C2 was a key category in the previous submission (FOEN 2007). This is no longer the case due to the recalculations in the LULUCF sector (see chapter 9).

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 5.C.2, 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 111).

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 143), 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 143 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^{-1}]
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 144 shows the living biomass of permanent grassland for the three altitudinal zones as the cumulated annual yield including roots.

Table 144 Living biomass C_l of permanent grassland (CC 31).

Altitude [m]	C_l [t C ha^{-1}]
<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 described in Chapter 7.3.2.g. Brush forest is assumed to contain 11.6 t C ha^{-1}.

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 (2000) 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 (Cl) for CC 33 is therefore calculated as:

CI = [(CI vineyards * area vineyards) + (CI * area low-stem orchards)] / (area vineyards + area low-stem orchards)

CI of vineyards is 3.61 t C ha^{-1}, calculated based on the mean stand density (5556 vines ha^{-1}) 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. 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.

Stem wood volume = $r^2 * \pi *$ 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^{-3} (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:

C low-stem = stem wood volume * BEF * wood density * carbon content
= 7.75 dm^3 * 2.3 * 0.55 kg/dm^3 * 50% C-content = 4.9 kg C

The mean stand density of low-stem orchards is estimated at 2500 ha^{-1} (Widmer, 2006), resulting in a CI of 12.25 t C ha^{-1}.

The resulting CI for CC 33 is 3.74 t C ha^{-1}.

Orchards (CC 35)

Orchards are loosely planted larger fruit trees ('Hochstammobst') with grass understory. CI of orchards trees is calculated as:

CI biomass = (carbon per fruit tree [t]*number fruit trees [ha^{-1}] / area orchards [ha]) + carbon in grass [ha^{-1}]

The carbon content of a large fruit tree with a diameter at breast height (DBH) of 25 - 35 cm was calculated as follows:

C(Hochstamm) = Stem wood volume * KE-Factor = 225 kg C

where:

Stem wood volume of an apple tree with DBH between 25 and 35 cm: 0.5 m^3 (expert knowledge);

KE-Factor [tC m^{-3}]= BEF * Density * C-content = 0.45, (Wirth et al. 2004, p. 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^{-1}. The resulting woody biomass of CC 35 is thus 17.78 t C ha^{-1}. 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^{-1};Table 144) was taken to obtain a total biomass stock of 24.63 t C ha^{-1} for CC 35.

Stony Grassland (CC 36)

Approximately 35% of the surface of category 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 (11.60 t C ha^{-1}) was multiplied by 0.35 to account for the 35% vegetation coverage. This results in a carbon content of 4.06 t C ha^{-1}.

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 144, 6.05 t C ha^{-1}, 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^{-1}) 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 Cs values calculated for grasslands CC 31 are given in Table 145.

Table 145 Mean carbon stocks under permanent grassland on mineral soils.

Altitude [m]	C_S [t C ha^{-1}, 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 ± 48 t C ha^{-1}.

Shrub Vegetation (CC 32)

Due to lack of data, the mean value of Table 145, 68.23 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 t C ha^{-1} (mineral soils) and 240 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 145, 68.23 t ha^{-1} was used as the soil carbon default for this category.

Orchards (CC 35)

Cs 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 t C ha^{-1}) was taken as Cs orchards, and the value of 240 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 > 1200m a.s.l. Thus, the carbon stock Cs of CC 36 is calculated as:

Cs of CC 36 = 0.35 * Cs permanent grassland > 1200 m = 26.31 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 145) in accordance to the procedure followed for biomass. Cs CC 37 is thus 68.23 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 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 CO_2 emissions caused by agricultural lime application are included under '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. 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.

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 doubling of available AREA activity data (SFSO 2007a), the consideration of UNFCCC review reports, and one amendment have led to a significant recalculation in the source category 5C:

Following the recommendations of UNFCCC (2007, 2007a), a land-use conversion period of 20 years (instead of one year) has been applied to soil carbon stock changes in the case of “Land converted to grassland”.

Furthermore, during the in-country review in March 2007 Switzerland revised the parameters chosen for the definition of forest (FOEN 2006h) to be compliant with the agreed values in decision 16/CMP.1. This provoked a minor reorganization (involving CC 34 Copse) of the combination category matrix that defines the main IPCC categories as well as the country specific sub-divisions (confer FOEN 2006d and FOEN 2007f).

As required by decision 14/CP.11 estimates for biogenic NMVOC emissions in natural grasslands are reported for the first time.

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 111)

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 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 146 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 147).

Table 146 Assigned carbon content of CC 42 according to different tags.

Tag	Assigned category	CC	Carbon stock in living biomass, [t C ha^{-1}]
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.

Table 147 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^{-1}]
	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
Total	**2840**	**2749**	**2775**	**8364**	**100%**	**8.2***

*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 and 1994) as well as reed. For these peatlands, the same value (240 t C ha^{-1}) 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 grassland on mineral soils (68.23) and organic soils (240), thus 154 t C ha^{-1}.

c) Changes in Carbon Stocks

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.

d) N_2O 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 and 1994). Therefore, no N_2O emissions are reported in CRF Table 5 (II).

7.6.3. Uncertainties and Time-Series Consistency

In case of activity data, the uncertainty is assessed as low. In case of carbon stocks, the uncertainty is assessed as high.

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 doubling of available AREA activity data (SFSO 2007a) has led to a significant recalculation in source category 5D.

The error leading to an underestimation of C stocks in CC 42 as reported in FOEN (2007; Chapter 7.7.6) has been corrected.

7.6.6. Source-Specific Planned Improvements

For improvements with respect to the assigned carbon contents of CC 42 in Table 146 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_2 from Land converted to Settlements (level and trend)

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 111.

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 (CRW) in settlements remaining settlements (IPCC 2003; p. 3.297).This value ranges from 1.8 to 3.4 t C ha^{-1} yr^{-1}, the arithmetic mean is 2.9 t C ha^{-1} yr^{-1}. 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 (CRW, t C ha^{-1} yr^{-1}).

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[20] data was 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 system. The resulting digital terrain (DTM) and surface model (DSM) had a spatial resolution of 1 m and both were bilinearly resampled to 2.5 m. The difference between LIDAR-based digital surface model (DSM) and digital terrain model (DTM) 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

[20] LIDAR is an acronym for LIght Detection And Ranging.

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 39 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_i [t C ha^{-1}] = $coverage_i$ /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^{-1} $year^{-1}$] 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^{-1} yr^{-1}), CC 52 is estimated to contain an average C stock of 11.4 t C ha^{-1}, CC 53 8.9 t C ha^{-1}, and CC 54 18.6 t C ha^{-1} (Figure 39).

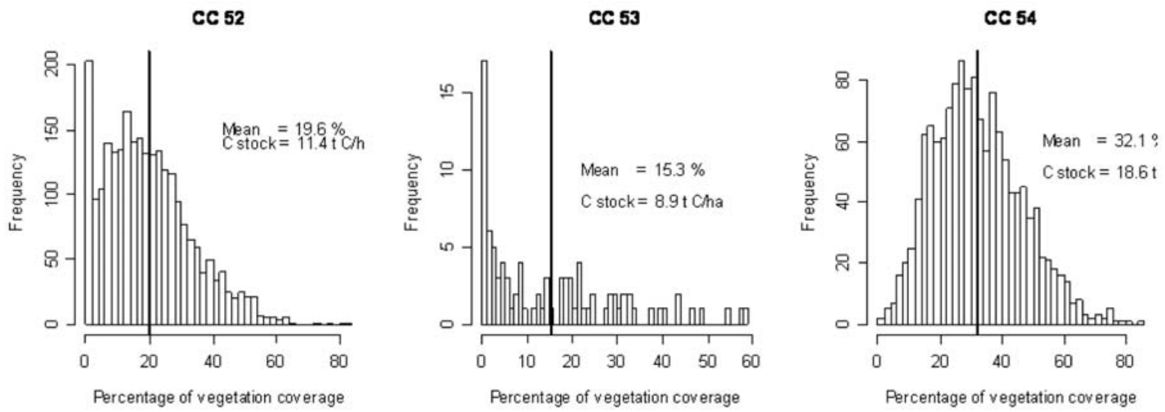


Figure 39 Vegetation cover and carbon stock of grassland vegetation with wood biomass larger than 3 m. CC 52: Herbaceous biomass in settlements, CC 53 Shrubs in settlements, CC 54 Trees in settlement.

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^{-1} (0-30 cm, same value as for cropland).

c) Changes in Carbon Stocks

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.

7.7.3. Uncertainties and Time-Series Consistency

In case of activity data, the uncertainty is assessed as low. In case of carbon stocks, the uncertainty is assessed as high.

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 doubling of available AREA activity data (SFSO 2007a) has led to a significant recalculation in source category 5E.

The error leading to an underestimation of C stocks in CC 52, CC 53, and CC 54 as reported in FOEN (2007; Chapter 7.7.6) has been corrected.

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 standard. 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 matrix, those categories show an increasing tendency. 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 category 5F Other Land is not a key category.

As shown in Table 111 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. In the case of land-use change, the net C changes in biomass and soil are calculated as described in chapter 7.2.1.

7.8.3. Uncertainties and Time-Series Consistency

In the case of other land, the uncertainty of activity data and carbon stock data is assessed as low.

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 doubling of available AREA activity data (SFSO 2007a) has led to a significant recalculation in 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”.

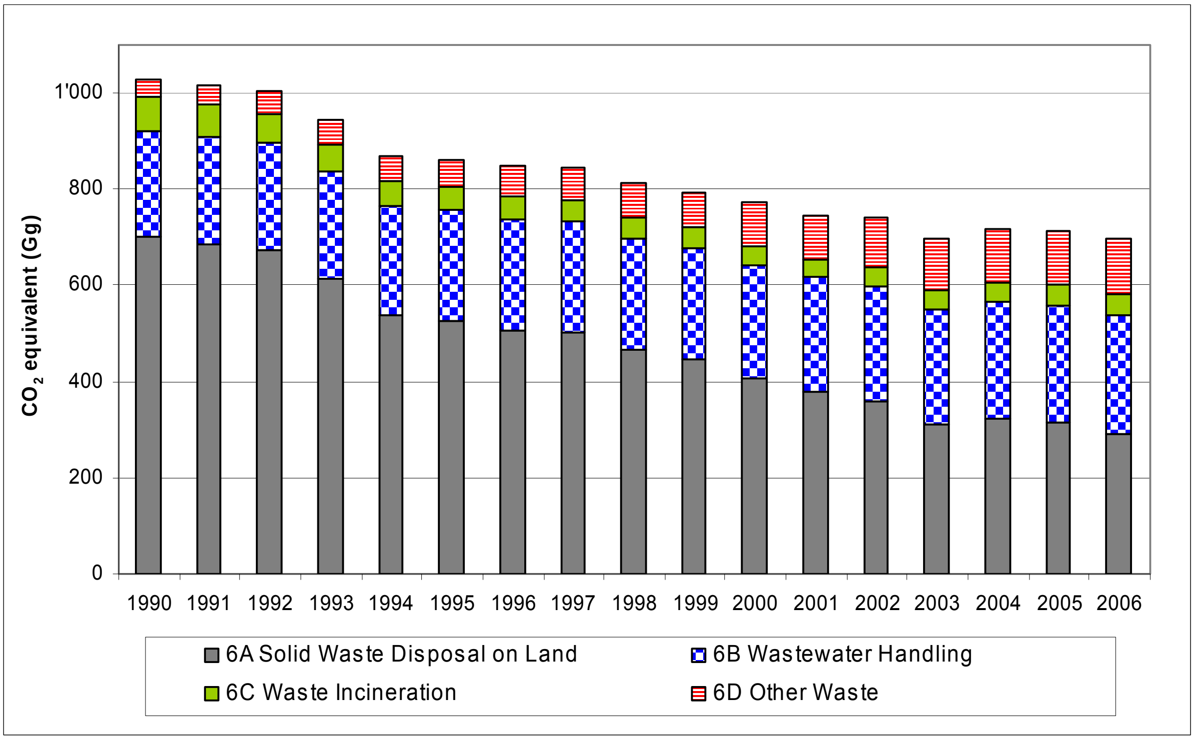


Figure 40 Switzerland’s greenhouse gas emissions in the waste sector 1990–2006.

Table 148 Trend of total GHG emissions from waste management in Switzerland 1990-2006

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	CO_2 equivalent (Gg)									
CO_2	62	59	60	54	42	37	34	31	29	25
CH_4	756	745	728	672	608	603	590	588	557	537
N_2O	212	214	216	217	218	221	224	226	228	229
Sum	1'030	1'018	1'004	943	867	861	848	845	814	791

Gas	2000	2001	2002	2003	2004	2005	2006
	CO_2 equivalent (Gg)						
CO_2	22	19	16	16	15	15	15
CH_4	516	491	481	436	452	444	425
N_2O	234	237	242	246	250	255	257
Sum	772	747	740	698	717	714	697

In source category 6 "Waste" a total of 697 Gg CO_2 equivalents were emitted in the year 2006. 41.7% of the emissions stem from the sub-category 6A “Solid Waste Disposal on Land”, 35.2% from 6B “Wastewater Treatment”, 16.8% from 6D “Others” and 6.3% from 6C “Waste Incineration”.

The total greenhouse gas emissions in source category 6 "Waste" show a decrease from 1990 until 2006. They are dominated by the greenhouse gas emissions from source category 6A “Solid Waste Disposal on Land”. In this source category the CH_4 emissions decreased from 1990 until 2006. N_2O and CO_2 are of minor importance in the waste sector. The relative trends of the gases can be seen in Figure 41.

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.

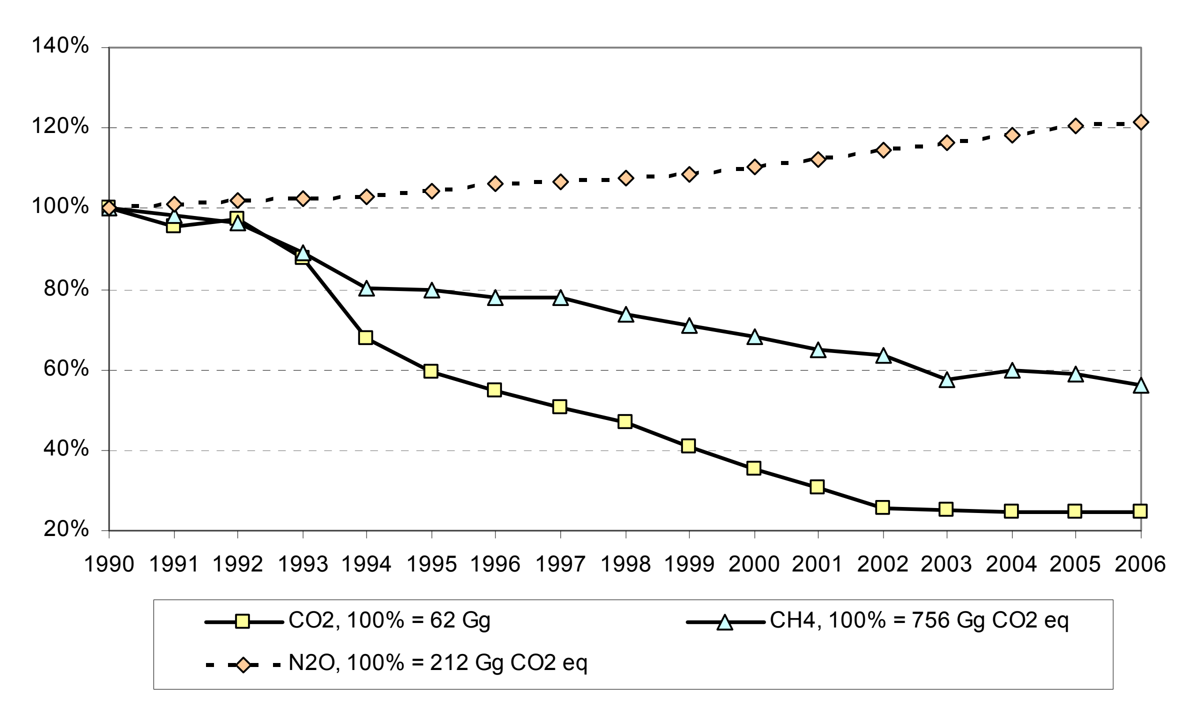


Figure 41 Trend of total GHG emissions from waste management in Switzerland 1990-2006.

Box: Waste related GHG emissions in Switzerland

There are different activities for the 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.

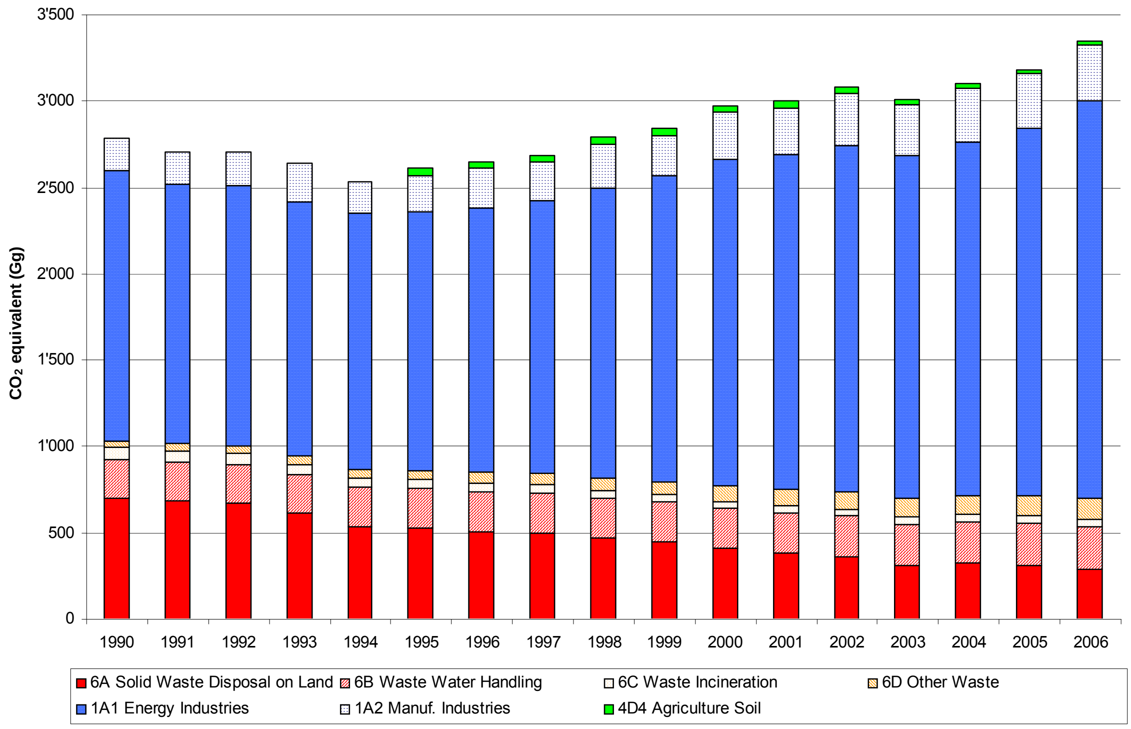


Figure 42 Waste related GHG emissions from 1990-2006

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 149 gives an overview on the waste quantities generated in Switzerland in 2006, and indicates the main treatment options as well as the waste treatment facilities. Note that these quantities in Table 149 do not include imported waste. (For the calculation of greenhouse gas emissions for the present Inventory, other quantities are used that include imports and exclude exports, therefore Table 149 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 [21].

[21] 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/01517/01519/03284/index.html?lang=en).

Table 149 Overview on waste generation and waste disposal in 2006.

Waste category Disposal Option and Waste Type	Quantity Gg	 %
Municipal solid waste	**5'308**	100
Recyling	**2'670**	50
paper	1'279	
used glas	308	
organic waste	885	
aluminium, aluminium cans	5	
PET (bottles)	32	
tinplate	13	
textiles	47	
batteries	2	
electrical equipment	99	
Treatment	**2'628**	50
MSW incineration	2'628	
Final Disposal	**9**	0.17
landfilled	9	
Construction waste	**11'900**	100
Recyling	**9'700**	82
direct use at construction site	5100	
separation and recyling	4600	
Treatment	**477**	4
incineration (used wood etc.)	477	
Final Disposal	**1'723**	14
landfilled	1'723	
Hazardous waste	**1'167**	100
Recyling	**125**	11
	125	
Treatment	**769**	66
incineration and chem.-physical treatment	769	
Final Disposal	**273**	23
landfilled	273	
Sewage sludge	**206**	100
Recyling	**23**	11
used in agriculture	23	
Treatment	**181**	88
incineration	181	
Final Disposal	**2**	1
landfilled	2	

Table 149 shows that of the 5'308 Gg of municipal solid waste (MSW) generated in 2006, 2'670 Gg or 50.3% were recycled. The main recycled waste types were paper/cardboard (1’279 Gg), organic waste (885 Gg treated in centralized composting and digestion plants, without backyard composting), and used glass (308 Gg) (FOEN 2006e). The part of MSW that was not recycled was mainly incinerated (2'628 Gg or 49.5%) or disposed of in landfills (9 Gg or 0.2%).

About 11'900 Gg construction waste was generated in Switzerland in 2006 (FOEN 2006e). From this quantity about 9’700 Gg (82%) was recycled.[22] 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 2006.[23] 769 Gg hazardous waste was treated (715 Gg domestically and 54 Gg abroad). About 125 Gg hazardous waste was recycled (65 Gg domestically and 60 Gg abroad). 273 Gg of the hazardous waste was disposed of on landfills.

About 206 Gg (dry matter) sewage sludge was generated in 2006. 11% of sewage sludge was recycled, i.e. this sewage sludge was used as fertilizer in agriculture. 88% or 181 Gg sewage sludge was incinerated (in MSW incineration plants or mono incineration plants), and 1% disposed of in landfills.

The greenhouse gas emissions from domestic waste treatment activities are estimated in the appropriate chapters, i.e. energy, agriculture or waste.

8.2. Source Category 6A – Solid Waste Disposal on Land

8.2.1. Source Category Description

Key category 6A
CH_4 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, eleven managed biogenic active landfills are equipped to recover landfill gas (SFOE 2007a). 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.

[22] 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 2006 are assumed to be the same as in the year 2000.

[23] The latest available data for hazardous waste on this general level refer to the year 2005.

Table 150 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 2005/6A1
6A2	Unmanaged Waste Disposal Sites	Emissions from all other waste disposal sites that don’t fall into 6A1. (included in 6A1)	EMIS 2005/6A1
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_4 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_4 generation in the year t:

$$CH_4 \text{ generated in the year t [Gg/year]} = \sum_x [A \cdot k \cdot M(x) \cdot L_0(x) \cdot e^{-k(t-x)}] \cdot (1-OX)$$

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
$L_0(x)$ = methane generation potential (MCF(x) • DOC(x) • DOC_F • F • 16/12) [Gg CH_4 / Gg waste]
MCF(x) = methane correction factor (fraction)
DOC(x) = degradable organic carbon [Gg C/ Gg waste]
DOC_F = portion of DOC, that is converted to landfill gas (fraction)
F = portion of CH_4 in landfill gas (fraction)
16/12 = factor to convert C to CH_4.
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_F = 0.6 (default value according to IPCC 1997a-c)

F = 0.5 (default value according to IPCC 1997a-c)

The degradable organic carbon is also calculated based on the default values from IPCC 1997a-c.

For the calculation of CH_4 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_4 generated.

Table 151 Parameters used for FOD model

	k [1/yr]	**L_0** [Gg CH_4 / Gg waste]	**DOC** [-]
municipal solid waste	0.139	0.050	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_4 that is recovered and used as fuel for co-generation units as well as for flaring is subtracted from the CH_4 generated in landfills (resulting from step1).

CH_4 emissions $_{\text{step ii)}}$ = CH_4 emissions $_{\text{step i)}}$ – (CH_4 emissions $_{\text{step i)}}$ * Fl(t)) – Qco-gen(t)

where
Fl(t) = portion of generated methane that is flared in the present year (fraction)
Qco-gen(t) = CH_4 which is recovered in co-generation units in the present (Gg)

iii) In the third step CH_4 emissions from on-site open burning are added. This results in the overall CH_4 emissions from landfill sites.

CH_4 emissions $_{\text{step iii)}}$ = CH_4 emissions step ii) + Qopen(t)

where
Qopen(t) = CH_4 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_4 burnt (co-generation and flaring), or to the waste quantity burnt (open burning), respectively.

Emission Factors

Emission factors for CO_2, CH_4, CO, NMVOC and SO_2 are country specific based on measurements and expert estimates, documented in EMIS. CO_2 emissions from non-biogenic wastes are included, while the CO_2 emissions from biogenic wastes are excluded from total emissions.

The following table presents the emission factors used in 6A1:

Table 152 Emission Factors for 6A1 "Managed Waste Disposal Sites on Land" in 2006.

Source	**CO_2 biogenic**	**CO_2 fossil**	**CH_4**	**NO_x**	**CO**	**NMVOC**	**SO_2**
6A1 Managed Waste Disposal on Land	**t / t CH_4 produced**						
Direct emissions from landfill	3.00	0	1				
	kg / t CH_4 flared						
Flaring	2'750	0		1	17		0
	kg / t waste burned						
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 2005/6A1.

Table 153 Activity data in 6A1: Waste disposed of on Managed Landfill Sites from 1990 to 2006 (source EMIS 2005/6A1).

Source / Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6A1 Managed Waste Disposal on Land											
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	168.8	122.2	76.8	59.1	41.4	47.3	53.2	53.5
Sewage sludge	Gg (dry)	58.8	58.8	58.2	34.9	41.4	29.6	18.7	15.8	12.8	8.9
Open burned waste	Gg	17.0	20.0	30.0	27.0	11.4	10.0	8.7	8.6	8.6	5.7
Total waste quantity	**Gg**	**859.8**	**886.3**	**894.0**	**821.1**	**710.8**	**630.6**	**551.4**	**544.4**	**537.6**	**533.4**

Source / Parameter	Unit	2000	2001	2002	2003	2004	2005	2006
6A1 Managed Waste Disposal on Land								
Municipal solid waste (MSW)	Gg	287.1	184.1	81.2	42.5	29.9	22.9	18.3
Construction waste	Gg	53.5	29.1	4.9	4.8	4.8	4.8	4.8
Sewage sludge	Gg (dry)	4.8	4.6	4.5	4.0	2.0	2.0	1.6
Open burned waste	Gg	3.9	2.4	1.0	0.6	0.2	0.2	0.2
Total waste quantity	**Gg**	**349.2**	**220.2**	**91.5**	**51.8**	**36.8**	**29.9**	**24.8**

Table 153 documents the reduction by about 35 times of municipal solid waste, construction waste, sewage sludge and open burned waste disposed of over the period 1990–2006. 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_4 flared. The landfill gas recovered and used as fuel for co-generation units has been moved and is reported under 1A1 energy.

Table 154 Activity data in 6A1: Share of CH_4 used as fuel in co-generation units and flared from 1990 to 2006. (source EMIS 2005/6A1).

Source / Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
6A1 Managed Waste Disposal on Land											
CH_4 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
6A1 Managed Waste Disposal on Land								
CH_4 flared	Gg	3.4	3.1	2.8	2.5	2.3	2.1	1.9

The CH_4 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_4 recovery from 1990 until 2006 this is the reason for CH_4 emissions from the source category 6A being a key source regarding trend.

8.2.3. Uncertainties and Time-Series Consistency

Uncertainty in CH_4 emissions from Solid Waste disposal on land in 6A

Uncertainty of direct CH_4 emissions from sanitary landfills is estimated at about 60%[24].

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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

8.2.5. Source-Specific Recalculations

Emissions from landfill gas recovery in co-generation units have been moved and are reported under the energy sector (1A1).

8.2.6. Source-Specific Planned Improvements

It is planned to use country specific parameters for the CH_4 model.

8.3. Source Category 6B – Wastewater Handling

8.3.1. Source Category Description

Key category 6B N_2O from domestic and commercial waste water handling (level)

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).

---

[24] Source: EMIS 2005/6A1. 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).

Table 155 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 2005/6B1/6B2 and SFOE 2007 EF: EMIS 2005/6B1/6B2
6B3	Others	Not occurring in Switzerland	

The emissions related to wastewater treatment fall under various categories as laid out in Figure 43 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.

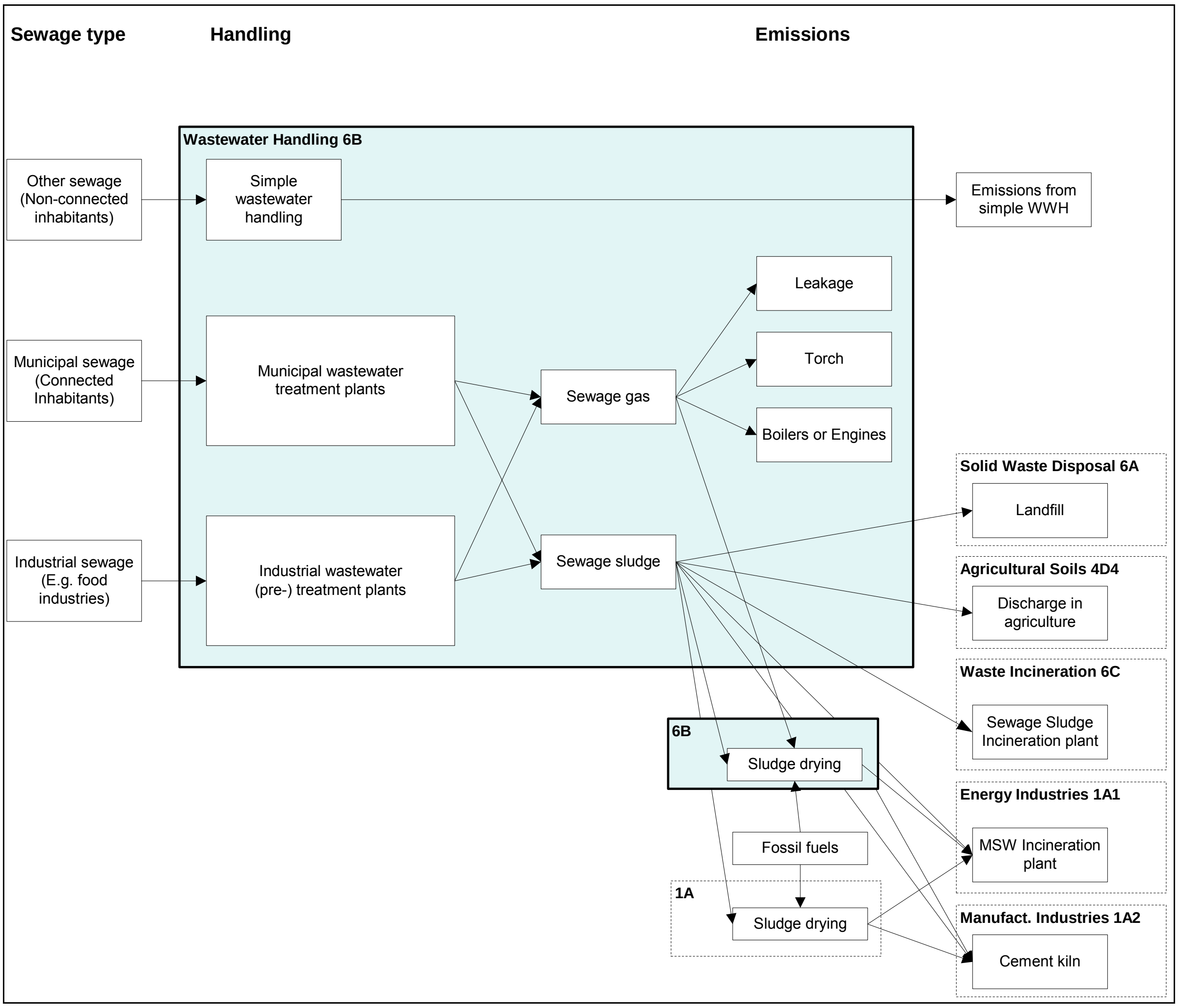


Figure 43 System boundaries of emissions related to wastewater treatment.

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_2O.

Emission Factors

Emission factors for CO_2, CH_4, N_2O, CO, NMVOC and SO_2 are country specific based on measurements and expert estimates, documented in the EMIS database. N_2O is derived from the IPCC-default method.

The following table presents the emission factors used in 6B2:

Table 156 Emission Factors for 6B2 Domestic and Commercial Waste Water in 2006.

Source	CO_2 biog.	N_2O	CH_4	NO_x	CO	NMVOC	SO_2
	kg/connected inhabitant	g/inhabitant	g/connected inhabitant				
6B2 Domestic and Commercial Waste Water	41.5	90.5	220	37	57	1	180

Please note that the activity data for N_2O 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 2005/6B1/6B2 and from SFOE 2007.

Table 157 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
6B2 Domestic and Commercial Waste Water											
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	%	91.1	91.5	92	92.4	92.8	93.2	93.7	94.1	94.5	95
Connected inhabitants	inhabitants in 1000	6'191	6'295	6'388	6'458	6'530	6'599	6'657	6'693	6'740	6'809

Source/Parameter	Unit	2000	2001	2002	2003	2004	2005	2006
6B2 Domestic and Commercial Waste Water								
Population	inhabitants in 1000	7'209	7'285	7'343	7'405	7'454	7'501	7'557
Fraction connected to waste water treatment plants	%	95.4	95.4	95.4	95.4	95.4	95.4	95.4
Connected inhabitants	inhabitants in 1000	6'877	6'950	7'005	7'064	7'111	7'156	7'209

8.3.3. Uncertainties and Time-Series Consistency

Uncertainty in N_2O 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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

8.3.5. Source-Specific Recalculations

The number of inhabitants was slightly modified; numbers are now consistently based on data from the Swiss overall energy statistics (SFOE 2007). Since the number of inhabitants is used as activity data for the modelling of the emissions of 6B Waste Water Handling, they had to be recalculated accordingly.

8.3.6. Source-Specific Planned Improvements

It is planned to include emissions from pre-treatment of industrial effluents.

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 158 Overview on waste incineration sources reported under 6C.

Waste incineration	**Specification**	**Data Source**
Hospital waste incineration	Emissions from incinerating hospital waste in hospital incinerators	AD, EF: EMIS 2005/6C
Illegal waste incineration	Emissions from illegal incineration of municipal solid wastes at home Emissions from waste incineration at construction sites (open burning)	AD, EF: EMIS 2005/6C
Insulation material from cables	Emissions from incinerating cable insulation materials	AD, EF: EMIS 2005/6C
Sewage sludge	Emissions from sewage sludge incineration plants	AD, EF: EMIS 2005/6C
Crematoria	Emissions from the burning of dead bodies	AD, EF: EMIS 2005/6C

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 159 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 incineration 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_2, CH_4, N_2O, CO, NMVOC and SO_2 are country specific based on measurements and expert estimates, documented in the EMIS 2005/6C 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 160 Emission Factors for 6C “Waste Incineration” in 2006 (source EMIS 2005/6C).

6C Waste Incineration							
Source	**CO_2** t/t	**CH_4** kg/t	**N_2O** g/t	**NO_x** kg/t	**CO** kg/t	**NMVOC** kg/t	**SO_2** 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	0.09	800	0.7	0.170	0.0045	0.39
	CO_2 t/crem.	**CH_4** kg/crem.	**N_2O** g/crem.	**NO_x** kg/crem.	**CO** kg/crem.	**NMVOC** kg/crem.	**SO_2** kg/crem.
Crematoria	0	0	0	0.270	0.228	0.019	0

Additional information on the emission factor CO_2:

For all waste incineration options the CO_2 emissions only from non-biodegradable waste is taken into account.

- Hospital waste incineration plants: Mainly waste of fossil origin. Default value for the CO_2 emission factor taken from CORINAIR (1992).
- Illegal waste incineration: The main source of non-biodegradable CO_2 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_2 emission factor is based on measurements of the flue gas quantity and the assumption, that the ratio CO_2/O_2 is the same as in municipal solid waste incineration plants.

- Sewage sludge plants: Sewage sludge is biodegradable waste. Emission factor for CO_2 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 161 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
Total	**Gg**	**124.5**	**117.4**	**110.2**	**103.1**	**95.9**	**97.7**	**101.0**	**102.1**	**103.2**	**101.3**
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
Hospital Waste Incineration	Gg	5.0	2.5	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
Insulation material cables	Gg	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sewage sludge	Gg dry	64.3	70.2	76.0	82.1	88.2	100.0	100.7
Total	**Gg**	**99.3**	**102.7**	**106.0**	**112.1**	**118.2**	**130.0**	**130.7**
Cremations	Numb.	43'604	45'681	46'419	48'080	48'100	48'710	48'872

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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

8.4.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

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_4 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 162 Specification of source category 6D "Other".

6D		Specification	Data Source
	Car shredding plants	Emissions from car shredding plants	AD, EF: EMIS 2005/2A7
	Composting and digesting	Process related emissions from composting and digesting organic waste	AD, EF: EMIS 2005/6D

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 2005/2A7 and EMIS 2005/6D database. Data used included Edelmann and Schleiss 1999, and AQMD 2002.

The following table presents the emission factors used in 6D:

Table 163 Emission Factors for 6D Others in 2006.

Source	CH_4	N_20	NO_X	CO	NMVOC	SO_2
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 2005/2A7 and EMIS 2005/6D.

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 164 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
Shredder	Gg	300	300	300	300	300	300	300
Compost	Gg	640	650	730	745	760	775	790
Fermentation	Gg	69.8	71.5	81.0	92.5	104.0	115.5	127.0

8.5.3. Uncertainties and Time-Series Consistency

Uncertainty in CH_4 emissions from composting and digestion 6D

The uncertainty of the CH_4 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 check between EMIS and Internal GHG Files (Section 1.4.3) and the general QA/QC measures described in Section 1.6 have been carried out.

8.5.5. Source-Specific Recalculations

Emissions from biogas recovery in co-generation units of digesting organic waste have been moved and are reported under the energy sector (1A1).

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 2008a) had been updated, mainly based on the "Report of the individual review of the greenhouse gas inventory of Switzerland submitted in 2006" (UNFCCC 2007). 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 1990-2005.

The recalculation refers to the data of CRF submission on 13 April 2007 (FOEN 2007).

1 Energy

a) Fuel consumption of coal and heavy fuel oil has been corrected, to include data from the Swiss overall energy statistics instead of the model from Basics (2007) for absolute emissions of coal and heavy fuel oil in source category 1A2f. For 2005, the Swiss overall energy statistics showed an increase in coal consumption while the data from Basics did not, and the Swiss overall energy statistics was considered to be more reliable than the data from Basics. Emissions of the category 1A2f are corrected from 1990 to 2005. The time series decreased on average per year by 16 Gg CO_2 emissions, the maximum increase occurs for 2005 with an increase of 57 Gg CO_2, the highest decrease occurs for 1997 with a decrease of 67 Gg CO_2. Base year emissions in 1990 increased by 4.1 Gg CO_2. For years in which estimates for heavy fuel oil and coal consumption for the bottom-up part in 1A2f exceeded the amount allocated top-down for 1A2f, it was interpreted that this was due tostock changes, and corresponding corrections were made. Furthermore, 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 2007, CEPE 2007). The results cause a small shift between 1A2 and 1A4a.

b) During the in-country review in 2007, an error was identified that arose from an assumption that fugitive losses during the transmission and distribution of natural gas should be subtracted from the amount of gas that is combusted, generating CO_2 emissions.The error has been corrected. Leakages affect several categories but for reasons of simplicity, the entire amount of leaking natural gas had been subtracted from 1A4b, as it is the category with the largest leakages.

c) The consumption of lignite is exclusively used in the cement industry. The whole amount of lignite has therefore been shifted from several categories into 1A2f. The emission factors for solid fuels were adapted correspondingly in all the sectors concerned.

d) Emissions from landfill gas recovery in co-generation (6A) and emissions from fermentation engines (6D) have been moved into the energy sector (1A1a). Note that emissions of CH_4, N_2O and NMVOC associated with fermentation and generation of methane on landfills are still attributed to processes remaining in category 6D or 6A1.

e) The method for subtracting Liechtenstein's fuel consumption was slightly modified, leading to shifts among some categories. The net change in CO_2 is not affected by the reallocation, but some marginal changes occur for CH_4 and N_2O.

f) Activity data for the amount of municipal solid waste used as a fuel in energy production in 1A1a has been corrected. Recalculations have been made for the years 1997-2005. The recalculation led to changes in anthropogenic emissions between –2.7 Gg CO_2 eq (2004) to +8.6 Gg CO_2 eq (2001) from 1997 to 2005.

g) Activity data for the amount of waste derived fuel in cement industry in 1A2f has been based on a new data source and recalculations were made for the years 2004 and 2005.

h) Off-road emissions have been recalculated to an update of the off-road database. 1A3c Railways, 1A3d Navigation, 1A4c agriculture/forestry machinery and 1A5 Other/Off-road are concerned.

2 Industrial Processes

i) 2C1 Iron and Steel production have been updated for the years 2003-2005. Previously, an extrapolation had been made for these years. Now new data is available for 2006, and the years 2003-2005 have been interpolated. CO_2 emissions in 2C1 increased by 6.7 Gg in 2003, 13.4 Gg in 2004 and 20.1 Gg in 2005.

j) 2F Consumption of Halocarbons and SF_6: Some improvements in the emission modelling have been carried out for Commercial Refrigeration, Air Conditionning etc. Details are described in Table 82.

3 Solvent and Other Product Use

k) 3D Other: The number of inhabitants was slightly modified; numbers are now consistently based on data from the Swiss overall energy statistics (SFOE 2007). Since the number of inhabitants is used as activity data for the modelling of the emissions of some activities of 3D Other, they had to be recalculated accordingly.

4 Agriculture

l) 4A Enteric fermentation, 4B Manure Management and 4D Agricultral Soils: 2005 and 2006 data have been recalculated due to the availability of updated activity data.

m) 4D Agricultural Soils: The emissions had to be recalculated from 1995 onwards due to a mistake in the activity data of sewage sludge and compost.

5 Land Use, Land-Use change and Forestry

The doubling of available AREA activity data (SFSO 2007a), the consideration of UNFCCC review reports, and some minor improvements and amendments have led to a significant recalculation in the LULUCF sector.

In detail, following the recommendations of UNFCCC (2007, 2007a), the methodological approach has been revised with respect to:

n) A land-use conversion period of 20 years (instead of one year) has been applied to
    - carbon stock changes in living and dead biomass for “Land converted to forest land”;
    - soil carbon stock changes in the case of “Land converted to forest land”, “Land converted to cropland”, and “Land converted to grassland”.

o) Soil organic carbon of mineral forest soils (litter) is reported for dead organic matter in accordance with IPCC (2003; Table 3.1.2).

p) The EEA (2006) emission factor for CH_4 emissions from forest fire has been adopted. Moreover, the mass of available fuel (kg biomass per ha) has been reevaluated and the area burnt by forest fires for 2005 has been revised.

Furthermore, as a consequence of the in-country review in March 2007 Switzerland revised the parameters chosen for the definition of forest (FOEN 2006h) to be compliant with the agreed values in decision 16/CMP.1. This provoked a minor reorganization of the combination category matrix that defines the main IPCC categories as well as the country specific sub-divisions (confer FOEN 2006d and FOEN 2007f).

Further improvements comprise:

q) To calculate N_2O emissions from land-use conversion to cropland the IPCC C:N default value has been replaced with a country specific ratio (Leifeld et al. 2007).

r) The error leading to an underestimation of C stocks in combination categories CC 42, 52, 53, and 54 as reported in FOEN (2007; Chapter 7.7.6) has been corrected.

s) As required by decision 14/CP.11 estimates for biogenic NMVOC emissions in Switzerland are reported for the first time.

6 Waste

t) 6B Waste Water Handling: The number of inhabitants was slightly modified in the Swiss overall energy statistics (SFOE 2007). Since it is used as activity data for the modelling of the emissions of 6B Waste Water Handling, they had to be recalculated accordingly.

u) Emissions from landfillgas recovery in co-generation units from managed landfills (6A) as well as emissions from gas recovery in co-generation units from digesting organic waste (6D) have been moved into the energy sector (1A1).

9.2. Implications for Emission Levels 1990 and 2005

Table 165 shows the recalculation results for the base year 1990. It results in an increase of the total emissions in CO_2 equivalents (without CO_2 emissions from LULUCF) of 50.77 Gg CO_2 eq. This corresponds to an increase of the latest submission compared to the previous submission of 0.10% of the national total. If the LULUCF sector is included, there is a decrease of -819.1 Gg CO_2 due to extended recalculations of the LULUCF sector.

Table 165 Overview of implications of recalculations on 1990 data. Emissions are shown before the recalculation according to the previous submission in 2007 "Prev." (FOEN 2007) and after the recalculation according to the present submission "Latest". The differences "Differ." are defined as latest minus previous submission.

Recalculation	CO_2			CH_4			N_2O			Sum (CO_2, CH_4 and N_2O)		
Emissions for 1990	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
1 Energy	41'261.3	41'307.1	45.86	563.1	566.5	3.40	267.6	268.2	0.63	42'092.0	42'141.9	49.88
2 Ind. Processes (without syn. gases)	2'831.3	2'831.3	0.00	9.1	9.1	0.00	173.8	173.8	0.00	3'014.2	3'014.2	0.00
3 Solvent and Other Product Use	357.0	357.2	0.17	0.0	0.0	0.00	109.4	110.1	0.73	466.4	467.3	0.90
4 Agriculture				3'042.3	3'042.3	0.00	2'861.1	2'861.1	0.00	5'903.4	5'903.4	0.00
5 LULUCF	-1'710.7	-2'594.3	-883.58	1.5	8.2	6.69	5.0	12.0	7.01	-1'704.2	-2'574.1	-869.89
6 Waste	62.0	62.0	0.00	755.9	755.9	0.00	211.6	211.6	-0.01	1'029.5	1'029.5	-0.01
Sum (without synthetic gases)	42'800.9	41'963.3	-837.56	4'371.9	4'382.0	10.09	3'628.5	3'636.8	8.35	50'801.3	49'982.2	-819.12

Recalculation	**HFC**			**PFC**			**SF6**			**Sum (synthetic gases)**		
Emissions for 1990	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 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	243.9	243.9	0.00

Recalculation		**Sum (all gases)**		
Emissions for 1990		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LULUCF		**51'045.1**	**50'226.0**	**-819.12**
		100.00%	98.40%	-1.60%
Total CO_2 eq Em. without LULUCF		**52'749.4**	**52'800.1**	**50.77**
		100.00%	100.10%	0.10%

For 2005, the recalculation results in an increase of the total emissions in CO_2 equivalents (without emissions/removals from LULUCF) of 154.45 Gg CO_2 eq. This corresponds to an increase of the latest submission compared to the previous submission of 0.29% of the national total. If the LULUCF sector is included, a decrease of -450.64 Gg CO_2 (-0.84%) is found due to modifications of the LULUCF sector.

Table 166 Overview of implications of recalculations on 2005 data. Emissions are shown before the recalculation according to the previous submission in 2007 "Prev." (FOEN 2007) and after the recalculation according to the present submission "Latest". The differences "Differ." are defined as latest minus previous submission.

Recalculation	**CO_2**			**CH_4**			**N_2O**			**Sum (CO_2, CH_4 and N_2O)**		
Emissions for 2005	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
1 Energy	43'668.5	43'749.3	80.71	288.5	293.5	4.95	355.0	355.4	0.40	44'312.1	44'398.1	86.06
2 Ind. Processes (without syn. gases)	2'096.2	2'116.3	20.10	7.1	7.1	0.00	145.0	145.0	0.00	2'248.3	2'268.4	20.10
3 Solvent and Other Product Use	185.9	186.3	0.41	0.0	0.0	0.00	50.9	51.7	0.80	236.8	238.0	1.21
4 Agriculture	0.0	0.0	0.00	2'778.4	2'796.4	17.99	2'454.4	2'484.4	30.04	5'232.8	5'280.8	48.03
5 LULUCF	-259.2	-859.5	-600.30	0.5	0.3	-0.12	10.1	5.5	-4.67	-248.6	-853.7	-605.09
6 Waste	15.4	15.4	0.00	444.2	444.2	0.00	254.6	254.6	-0.03	714.1	714.1	-0.03
Sum (without synthetic gases)	45'706.8	45'207.7	-499.09	3'518.7	3'541.5	22.82	3'270.1	3'296.6	26.54	52'495.6	52'045.8	-449.72

Recalculation	**HFC**			**PFC**			**SF6**			**Sum (synthetic gases)**		
Emissions for 2005	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.	Prev.	Latest	Differ.
Source and Sink Categories	CO_2 equivalent (Gg)									CO_2 equivalent (Gg)		
2 Ind. Processes (only syn. gases)	638.9	637.9	-0.95	56.3	56.3	0.00	196.4	196.4	0.03	891.6	890.7	-0.92

Recalculation		**Sum (all gases)**		
Emissions for 2005		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LULUCF		**53'387.2**	**52'936.6**	**-450.64**
		100.00%	99.16%	-0.84%
Total CO_2 eq Em. without LULUCF		**53'635.8**	**53'790.2**	**154.45**
		100.00%	100.29%	0.29%

9.3. Implications for Emissions Trends, including Time Series Consistency

Due to recalculation, the emission trend 1990–2005 reported in the 2007 submission has slightly changed. Compared to 1990, 2005 emissions (national total without emissions/-removals from LULUCF) showed an increase of 1.68% before recalculation (previous submission). After recalculation, the increase turns out to be somewhat larger: 1.88% (latest submission).

Table 167 Change of the emission trend 1990–2005 due to recalculation. "Previous" refers to data reported in FOEN 2007, whereas "latest" refers to the present submission.

Recalculation	**1990**		**2005**		**change 2005/1990**	
Submission	previous	latest	previous	latest	previous	latest
Unit	CO_2 eq (Gg)				%	
Total excl. LULUCF	52'749.4	52'800.1	53'635.8	53'790.2	1.68%	1.88%

All time series in the present submission are consistent.

References

Altherr, E., Unfried, P., Hradetzky, J., Hradetzky, V. 1978: Statistische Rindenbeziehungen als Hilfsmittel zur Ausformung und Aufmessung unentrindeten Stammholzes, Teil IV: Fichte, Tanne, Douglasie und Sitkafichte. Mitteilungen der Forstlichen Versuchs- und Forschungsanstalt Baden-Württemberg 90.

Ammann, C., Flechard, C.R., Leifeld, J., Neftel, A., Fuhrer, J. 2007: The carbon budget of newly established temperate grassland depends on management intensity. Agriculture, Ecosystems & Environment 121: 5-20. http://dx.doi.org/10.1016/j.agee.2006.12.002 [10.04.2008]

Andreani-Aksoyoglu, S., Keller, J. 1995: Estimates of monoterpene and isoprene emissions from the forests in Switzerland. Journal of Atmospheric Chemistry 20: 71-87. http://dx.doi.org/10.1007/BF01099919 [10.04.2008]

ARE 2002: Fahrleistungen der Schweizer Fahrzeuge. Ergebnisse der periodischen Erhebung Fahrleistungen (PEFA) 2000. Federal Office for Spatial Development, Bern. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

ARE/SAEFL 2001: Le paysage sous pression, suite 2. [Landschaft unter Druck, 2. Fortschreibung]. Federal Office for Spatial Development, Bern and Swiss Agency for the Environment, Forests and Landscape, Bern. http://www.are.admin.ch/themen/raumplanung/00246/00451/02327/index.html?lang=fr [27.03.2008]

ARE/SFSO 2000: Mobilität in der Schweiz. Ergebnisse des Mikrozensus 2000 zum Verkehrsverhalten. [La mobilité en Suisse. Résultats du microrecensement 2000 sur le comportement de la population en matière de transports]. Federal Office for Spatial Development, Bern and Swiss Federal Statistical Office, Neuchâtel. http://www.bfs.admin.ch/bfs/portal/de/index/themen/11/07/01/02/02.html [German] [08.02.2008] http://www.bfs.admin.ch/bfs/portal/fr/index/themen/11/07/01/02/02.html [French] [08.02.2008]

ART 2007: Bretscher D., Leifeld J. Uncertainty in agricultural CH_4 and N_2O emissions of Switzerland 2007. Internal documentation, Agroscope Reckenholz-Tänikon Research Station, Zürich 2007.

AQMD 2002: Technology assessment for proposed Rule 1133 “Emission reductions from composting and related operations”. South Coast Air Quality Management District, California, USA, March 2002. http://www.aqmd.gov/rules/doc/r1133/r1133_techassessment.pdf [09.04.2008]

Basics 2007: CO_2-Emissionen 1990-2006 von Industrie und Dienstleistungen. Teil Industrie. Short documentation, February 2005. Updated 17.12.2007, including Excel-files for update of year 2006. Basics AG, Zürich http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Battelle 1994: Methanfreisetzung bei der Erdgasnutzung in der Schweiz und Vergleich mit anderen Emittenten. Studie im Auftrag des Schweizerischen Vereins des Gas- und Wasserfaches SVGW. Battelle Ingenieurtechnik, Zürich.

Berthoud, F. 2004: Dokumentation der Methan- & Lachgastabelle. Eine Hilfeleistung zum Verstehen der Berechnungen und Berechnungsgrundlagen der landwirtschaftlichen Treibhausgasemissionen hin zu den Resultatwerten des Common Reporting Format des IPCC. Internal documentation. Agroscope FAL, Swiss Federal Research Station for Agroecology and Agriculture. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Brassel, P., Brändli, U.-B. 1999: Schweizerisches Landesforstinventar. Ergebnisse der Zweitaufnahme 1993-1995. [Results of the second Swiss national forest inventory 1993-1995]. Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft, Birmensdorf. Bundesamt für Umwelt, Wald und Landschaft, Bern. Haupt, Bern, Stuttgart, Wien. [available in German, French and Italian]

Braun, M., Hurni, P., Spiess, E. 1994: Phosphor- und Stickstoffüberschüsse in der Landwirtschaft und Para-Landwirtschaft : Abschätzung für die Schweiz und das Rheineinzugsgebiet der Schweiz unterhalb der Seen. [Surplus de phosphore et d'azote dans l'agriculture et la para-agriculture: estimation pour la Suisse et pour le bassin versant hydrographique suisse du Rhin en aval des lacs]. Schriftenreihe der FAC Liebefeld 18. [in German, with English and French summary]

Burschel, P., Kürsten, E., Larson, B.C. 1993: Die Rolle von Wald und Forstwirtschaft im Kohlenstoffhaushalt. Eine Betrachtung für Deutschland. Forstliche Forschungsberichte München 126.

BUS 1986: Leitbild für die Schweizerische Abfallwirtschaft. [Lignes directrices pour la gestion des déchets en Suisse]. Schriftenreihe Umweltschutz Nr. 51. Bundesamt für Umweltschutz BUS [Les cahiers de l'environnement No 51. Office fédéral de la protection de l' environnement], (= former name of SAEFL and FOEN, respectively, until 1988). Bern.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Carbotech 2008: Swiss Greenhouse Gas Inventory 2006: PFCs, HFCs and SF_6 Emissions. Confidential report no. 251.09 for internal use on behalf of the Federal Office for the Environment, Bern. Basel.

Cemsuisse 2005: Jahresbericht cemsuisse 2005. [Rapport annuel 2005]. Association of the Swiss Cement Industry, Bern.
http://www.cemsuisse.ch/file/Jahresbericht_2005_09.05.06.pdf [German and French] [09.04.2008]

Cemsuisse 2007: Jahresbericht cemsuisse 2006. [Rapport annuel 2006]. Association of the Swiss Cement Industry, Bern.
www.cemsuisse.ch/file/Jahresbericht_2006.pdf [German and French] [19.02.2008]

CEPE 2007: Energieverbrauch und CO_2-Emissionen des Dienstleistungssektors in der Schweiz: Aufdatierung für das Jahr 2006. Short documentation for FOEN (17.12.2007). Centre for Energy Policy and Economics (CEPE), Zürich
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Ciais, P., Reichstein, M., Viovy, N., Granier, A., Ogée, J., Allard, V., Aubinet, M., Buchmann, N., Bernhofer, C., Carrara, A., Chevallier, F., De Noblet, N., Friend, A.D., Friedlingstein, P., Grünwald, T., Heinesch, B., Keronen, P., Knohl, A., Krinner, G., Loustau, D., Manca, G., Matteucci, G., Miglietta, F., Ourcival, J.M., Papale, D., Pilegaard, K., Rambal, S., Seufert, G., Soussana, J.F., Sanz, M.J., Schulze, E.D., Vesala, T., Valentini, R. 2005: Europe-wide reduction in primary productivity caused by the heat and drought in 2003. Nature 437: 529-533.
http://dx.doi.org/10.1038/nature03972 [09.04.2008]

de Keizer, C., Ramirez, A., van der Sluijs, J. 2007: Uncertainty Ranges and Correlations Assumed in Tier 2 Studies of Several European Countries, Proceedings of the 2nd International Workshop on Uncertainties in Greenhouse Gas Inventories, 27-28 Sep 2007, Laxenburg, Austria.
http://www.ibspan.waw.pl/ghg2007/GHG-total.pdf [03.12.2007]

Dobbertin, M., Giuggiola, A. 2006: Baumwachstum und erhöhte Temperaturen. In: Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) (ed.), Forum für Wissen: 35-46.
http://www.wsl.ch/publikationen/reihen/forum/pdf/Forum_06_35_45.pdf

EAFV/BFL (eds.) 1988: Schweizerisches Landesforstinventar. Ergebnisse der Erstaufnahme 1982-1986. [Results of the first Swiss national forest inventory 1982-1986]. Eidgenössische Anstalt für das forstliche Versuchswesen, Berichte Nr. 305.

EEA 2002: EMEP/CORINAIR Emission Inventory Guidebook. European Environment Agency. 3rd edition.
http://reports.eea.europa.eu/EMEPCORINAIR3/en/page002.html [21.02.2008]

EEA 2005: EMEP/CORINAIR Emission Inventory Guidebook - Third edition, October 2003. Update 2005. European Environment Agency. Technical Report No. 30.

EEA 2006: EMEP/CORINAIR 2006 Emission Inventory Guidebook (December 2006, B1103-5). European Environment Agency. Technical Report No. 11/2006.
http://reports.eea.europa.eu/EMEPCORINAIR4/en/page002.html [21.02.2008]

EC 2004: Commission decision 2004/156/EC of 29 January 2004, Establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (notified under document number C(2004) 130). Official Journal of the European Union L59, 26.2.2004.
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2004/l_059/l_05920040226en00010074.pdf [21.02.2008]

Edelmann, W., Schleiss, K. 1999: Ökologischer, energetischer und ökonomischer Vergleich von Vergärung, Kompostierung und Verbrennung fester biogener Abfallstoffe. On behalf of the Swiss Federal Office of Energy, Bern and the Swiss Agency for the Environment, Forests and Landscape, Bern.

EKV 1991: Energieverbrauch in der schweizerischen Industrie im Jahre 1990. [Energy consumption in the Swiss Industry in the year 1990]. Erhebung, durchgeführt im Auftrage des Eidgenössischen Verkehrs- und Energiewirschaftsdepartementes. Schweizerischer Energie-Konsumenten-Verband von Industrie und Wirtschaft, Basel.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

EMIS 2005/(NFR-Code): Comments to EMIS database. Internal documents. Federal Office for the Environment, Bern.
To find the EMIS comment that belongs to the specified NFR Code, see Table 168 on page 265 [available in German only].

EMPA 1999: Written communication from Dr. H.W. Jäckle (EMPA, Dübendorf) to Andreas Liechti (FOEN, Bern), 09.03.1999.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

EnAW 2007: Database with details from companies who commit themselves to CO_2 reduction targets within the framework of CO_2 target agreements with the Energy Agency for Industry (EnAW) in accordance with the CO_2 Act in order to get an exemption from the CO_2 tax. Swiss Federal Office of Energy, Bern. Internal document.

EV 2007: Jahresbericht 2006. Erdöl-Vereinigung [Rapports annuel 2006. L'Union Pétrolière]. Zürich.
http://www.erdoel.ch/doc/300319850511072007.pdf [German] [14.02.2008]
http://www.erdoel.ch/doc/314815700111072007.pdf [French] [14.02.2008]

FAL/RAC 2001: Grundlagen für die Düngung im Acker- und Futterbau 2001. Eidgenössische Forschungsanstalt für Agrarökologie und Landbau / Eidgenössische Forschungsanstalt für Pflanzenbau, Agrarforschung, June 2001, Zürich-Reckenholz, Nyon. [available in German and French]
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FAO 2007: Personal communication from Mrs Neuhaus (FAO secretariat; c/o FOAG) to D. Bretscher (ART), 09.07. 2007.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FCCC 2003: Guidelines for the Preparation of National Communications by Parties Included in Annex I to the Convention, Part I: UNFCCC Reporting Guidelines on Annual Inventories. FCCC/CP/2002/8. http://unfccc.int/resource/docs/cop8/08.pdf [14.02.2008]

FDEA 2003: Kurzfassung. Bericht 2003 über die Pflichtlagerpolitik 2004 bis 2007. Federal Department of Economic Affairs, Bern 2004.

FEDRO 2004: Automatic traffic counts (ATC). Swiss Federal Roads Authority, Bern. http://www.astra.admin.ch/verkehrsdaten/00299/00301/00359/00589/index.html?lang=de [14.02.2008]

FOCA 1991: Crossair confidential data 1991. Federal Office of Civil Aviation, Bern.

FOCA 1991a: L'aviation civile Suisse en 1990. Federal Office of Civil Aviation, Bern. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FOCA 2004: Unternehmensstatistik der Schweizerischen Helikopterunternehmungen. Federal Office of Civil Aviation, Bern. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FOCA 2006: GHG emissions of Swiss civil aircraft in 1990 and 2004: data, proceeding and description of the calculations. Written communication from Theo Rindlisbacher and Paul Stulz (FOCA, Bern) to Andreas Liechti (FOEN, Bern), 20./22.02.2006. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FOCA 2006a: GHG emissions of Swiss civil aircraft in 1990, 1995, 2000, 2002, 2004 and 2005: data, proceeding and description of the calculations. Written communication from Theo Rindlisbacher (FOCA, Bern) to Paul Filliger (FOEN, Bern), 17.11.2006. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FOCA 2007 GHG emissions of Swiss civil aircraft in 2006. Written communication from Theo Rindlisbacher (FOCA, Bern) to Beat Müller (FOEN, Bern), 03.12.2007. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FOCA 2007a: Aircraft Piston Engine Emissions. Summary Report. Federal Office of Civil Aviation. Report Ref. 0 / 3/33/33-05-003 ECERT. Bern. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en Related reports are available on http://www.bazl.admin.ch/fachleute/01169/01174/01176/index.html?lang=en [02.02.2008]

FOEN 2006: Switzerland's Greenhouse Gas Inventory 1990–2004, National Inventory Report and CRF tables 2006. Submission of 10 November 2006 to the United Nations Framework Convention on Climate Change. Federal Office for the Environment, Bern. http://www.environment-switzerland.ch/climatereporting/03211/index.html?lang=en

FOEN 2006a: Switzerland's Greenhouse Gas Inventory 1990–2004, National Inventory Report and CRF tables 2006. Submission of 12 April 2006 to the United Nations Framework Convention on Climate Change. Federal Office for the Environment, Bern.

FOEN 2006b: Switzerland's Greenhouse Gas Inventory 1990–2004, National Inventory Report and CRF tables 2006. Submission of 31 May 2006 to the United Nations Framework Convention on Climate Change. Federal Office for the Environment, Bern. http://www.environment-switzerland.ch/climatereporting/00545/00546/index.html?lang=en

FOEN 2006c: Prozess EMIS (Luftschadstoff-Emissions-Inventar der Schweiz). Beschrieb des Prozesses (= Handbuch zur EMIS-Datenbank (Entwurf)). Internes Dokument. [Manual to EMIS database (draft). Internal document]. Federal Office for the Environment, Bern.

FOEN 2006d: Definition der Kombinationskategorien (CC) für die LULUCF-Berichterstattung auf der Basis der AREA-Landnutzungs- und Landbedeckungskategorien. Internes Dokument, Version vom 02.03.2006. [Definition of combination categories (CC) for

LULUCF reporting based on AREA land-use/land-cover categories. Internal document, 02.03.2006.] Federal Office for the Environment, Bern. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FOEN 2006h: Switzerland's Initial Report under Article 7, paragraph 4 of the Kyoto Protocol. Federal Office for the Environment, Bern. Including the Update following the UNFCCC review. http://www.environment-switzerland.ch/climatereporting/03211/index.html?lang=en

FOEN 2007: Switzerland's Greenhouse Gas Inventory 1990–2005, National Inventory Report and CRF tables 2007. Submission of 13 April 2007 to the United Nations Framework Convention on Climate Change. Federal Office for the Environment, Bern. To be published on http://www.climatereporting.ch

FOEN 2007b: Handbuch: Berechnung der Wald-Emissionsfaktoren. [Manual: Calculation of EFs for Forest Land]. Inklusive 5 Excel-Dateien. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FOEN 2007d: Anlieferungen in KVA 2006, Federal Office for the Environment, Bern, http://www.bafu.admin.ch/abfall/01517/01519/05042/index.html?lang=de [18.02.2008]

FOEN 2007e: Abfallmengen und Recycling 2006 im Überblick. Federal Office for the Environment, Bern. http://www.bafu.admin.ch/abfall/01517/01519/05042/index.html?lang=de [18.02.2008]

FOEN 2007f: Definition der Kombinationskategorien (CC) für die LULUCF-Berichterstattung auf der Basis der AREA-Landnutzungs- und Landbedeckungskategorien. Internes Dokument, Version 2 vom 30.05.2007. [Definition of combination categories (CC) for LULUCF reporting based on AREA land-use/land-cover categories. Internal document, version 2 as of 30.05.2007.] Federal Office for the Environment, Bern. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

FOEN 2007g: Anthropogene VOC-Emissionen. Schweiz 1998, 2001 und 2004. Swiss Agency for the Environment, Forests and Landscape, Bern. http://www.bafu.admin.ch/voc/01265/index.html?lang=de

FOEN 2008: Switzerland's Greenhouse Gas Inventory 1990–2006, National Inventory Report and CRF tables 2008. Submission of 15 April 2008 under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol. Federal Office for the Environment, Bern. To be published on http://www.climatereporting.ch

FOEN 2008a: Description of the Quality Management System. Supplement to Switzerland's Greenhouse Gas Inventory 1990-2006. Submission of 15 April 2008 under the United Nations Framework Convention on Climate Change and under the Kyoto Protocol. Federal Office for the Environment, Bern. To be published on http://www.climatereporting.ch

FOEN 2008b: Jahrbuch Wald und Holz 2007. Umwelt-Wissen Nr. 0807. [Annuaire La forêt et le bois 2007. Connaissance de l'environnement no 0807]. Federal Office for the Environment, Bern. [German and French] To be published on http://www.environment-switzerland.ch/publikationen

Fuhrer, J., Beniston, M., Fischlin, A., Frei, C., Goyette, S., Jasper, K., Pfister, C. 2006: Climate risks and their impact on agriculture and forests in Switzerland. Climatic Change 79: 79–102. http://www.springerlink.com/content/y42148qn061r8182/ [09.04.2008]

Gense, N.L.J., Vermeulen, R.J. 2002: N_2O formation in vehicle catalysts. Netherlands Organisation for Applied Scientific Research (TNO), TNO Report 02.OR.VM.017.1/NG.

Gense, N.L.J., Vermeulen, R.J. 2002a: N_2O emission from passenger cars. Netherlands Organisation for Applied Scientific Research (TNO), TNO Report, 02.OR.VM.016.1/NG.

Hackl, A., Mauschitz, G. 2003: Emissionen aus Anlagen der Österreichischen Zementindustrie IV. Jahresreihe 2000-2002. Weitra/Wien. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Hadorn, R., Wenk, C. 1996: Effect of different sources of dietary fibre on nutrient and energy utilization in broilers. 2. Energy and N-balance as well as whole body composition. Archiv für Geflügelkunde 60: 22-29.

Hausberger, S., Engler, D., Ivanisin, M., Rexeis, M. 2002: Update of the Emission Functions for Heavy Duty Vehicles in the Handbook Emission Factors for Road Traffic. Institute for Internal Combustion Engines and Thermodynamics, Graz University of Technology. Elaborated in order of Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft; Bundesministerium für Verkehr, Innovation und Technologie; Umweltbundesamt Österreich. Final Report. http://www.hbefa.net/documents/DACH_SNF_Endbericht.zip [08.02.2008]

IAI 2005: Aluminium for future Generations. Sustainability Update 2004. International Aluminium Institute, London. http://www.world-aluminium.org/iai/publications/documents/update_2004.pdf [08.08.2006]

INFRAS 2004: Emission Factors for Passenger Cars and Light-Duty Vehicles. Handbook Emission Factors for Road Transport (HBEFA), Version 2.1. Swiss Agency for the Environment, Forests and Landscape, Bern, Umweltbundesamt, Berlin, Umweltbundesamt, Wien. http://www.hbefa.net/documents/AU_EFA_LMW.pdf [08.02.2008]

INFRAS 2004a: Handbuch Emissionsfaktoren des Strassenverkehrs 2.1. Dokumentation. In Zusammenarbeit mit IFEU, TU Graz, RWTÜV. Umweltbundesamt, Berlin; Swiss Agency for the Environment, Forests and Landscape, Bern; Umweltbundesamt, Wien. http://www.hbefa.net/documents/HBEFA21_Dokumentation.pdf [08.02.2008]

INFRAS 2007: Schadstoffemissionen und Treibstoffverbrauch des Offroad-Sektors. Unpublished draft version to FOEN. Bern, November 2007.

INFRAS 2007a: Off-road emissions in Switzerland in 1990, 1995, 2000, 2005, and 2010. Written communication from Ulrich Schäffeler (INFRAS, Bern) to Beat Müller (FOEN, Bern), 01.11.2007. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

IPCC 1997a: Greenhouse Gas Inventory Reference Manual, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Reporting Instructions (Volume 1). Intergovernmental Panel on Climate Change. http://www.ipcc-nggip.iges.or.jp/public/gl/invs4.htm [27.03.2008]

IPCC 1997b: Greenhouse Gas Inventory Reference Manual, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Workbook (Volume 2). Intergovernmental Panel on Climate Change. http://www.ipcc-nggip.iges.or.jp/public/gl/invs5.htm [27.03.2008]

IPCC 1997c: Greenhouse Gas Inventory Reference Manual, Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Reference Manual (Volume 3). Intergovernmental Panel on Climate Change. http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm [27.03.2008]

IPCC 2000: Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC GPG). Intergovernmental Panel on Climate Change. http://www.ipcc-nggip.iges.or.jp/public/gp/english/ [27.03.2008]

IPCC 2003: Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC GPG LULUCF). http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.htm [27.03.2008]

IPCC 2006: 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Intergovernmental Panel on Climate Change.
http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.htm [28.03.2008]

Jolly, W.M., Dobbertin, M., Zimmermann, N.E., Reichstein, M. 2005: Divergent vegetation growth responses to the 2003 heat wave in the Swiss Alps. Geophysical Research Letters 32: L18409.
http://dx.doi.org/10.1029/2005GL023252 [09.04.2008]

Karl, T., Guenther, A., Lindinger, C., Jordan, A., Fall, R., Lindinger, W. 2001: Eddy covariance measurements of oxygenated volatile organic compound fluxes from crop harvesting using a redesigned proton-transfer-reaction mass spectrometer. Journal of Geophysical Research 106 D20: 24157-24167.
http://www.agu.org/journals/jd/jd0120/jd106_20.html [09.04.2008]

Kaufmann, E. 2001: Estimation of standing timber, growth and cut. In: Brassel, P., Lischke, H. (eds.): Swiss National Forest Inventory: Methods and Models of the Second Assessment. Swiss Federal Research Institute WSL, Birmensdorf: 162-196.

Kaufmann, E. 2005: Personal communication from Edgar Kaufmann (WSL, Zürich) to Esther Thürig (FOEN, Bern), 12.12.2005.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Kaufmann, U. 2006: Energieverbrauch stationäre Motoren und Gasturbinen ab 1990. Excel data file for internal use to FOEN. 07.07.2006.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Keller, J., Andreani-Aksoyoglu, S., Joss, U. 1995: Inventory of natural emissions in Switzerland. In: Power, H., Moussiopoulos, N., Brebbia C.A. (eds.): Air Pollution III, Volume 2, Air Pollution Engineering and Management: 339-346. Computational Mechanics Publications.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

König, G., Brunda, M., Puxbaum, H., Hewitt, C.N., Duckham, S.C., Rudolph, J. 1995: Relative contribution of oxygenated hydrocarbons to the total biogenic VOC emissions of selected mid-European agricultural and natural plant species. Atmospheric Environment 29: 864–874.
http://dx.doi.org/10.1016/1352-2310(95)00026-U [09.04.2008]

Kühlwein, J. 2004: Unsicherheiten bei der rechnerischen Ermittlung von Schadstoffemissionen des Straßenverkehrs und Anforderungen an zukünftige Modelle. [Uncertainties in the arithmetical determination of pollutant emissions from road traffic and demands on future models]. Dissertation am Institut für Energiewirtschaft und Rationelle Energieanwendung (IER) der Universität Stuttgart, 20. September 2004.
http://elib.uni-stuttgart.de/opus/volltexte/2004/2079/pdf/Dissertation_Joerg_Kuehlwein.pdf [14.02.2008]

Leifeld, J., Bassin, S., Fuhrer, J. 2003: Carbon stocks and carbon sequestration potentials in agricultural soils in Switzerland. Schriftenreihe der FAL 44. Zürich-Reckenholz.
http://www.services.art.admin.ch/pdf/FAL_SR_44_E_i.pdf [19.03.2007]

Leifeld, J., Bassin, S., Fuhrer, J. 2005: Carbon stocks in Swiss agricultural soils predicted by land-use, soil characteristics, and altitude. Agriculture, Ecosystems & Environment 105 (1/2): 255-266.
http://dx.doi.org/10.1016/j.agee.2004.03.006 [09.04.2008]

Leifeld, J., Fuhrer, J. 2005: Greenhouse gas emissions from Swiss agriculture since 1990: Implications for environmental policies to mitigate global warming. Environmental Science & Policy 8: 410-417.
http://dx.doi.org/10.1016/j.envsci.2005.04.001 [09.04.2008]

Leifeld, J., Zimmermann, M., Fuhrer, J. 2007: Characterization of soil carbon stocks and site-specific sequestration potentials of agricultural soils. Extended Summary. Final Report, Contract Number: 810.03.0716 / 2003.C.04. Agroscope Reckenholz-Tänikon Research Station ART. http://www.bafu.admin.ch/climatereporting/00545/01913/index.html?lang=en

Leuzinger, S., Zotz, G., Asshoff, R., Körner, C. 2005: Responses of deciduous forest trees to severe drought in Central Europe. Tree Physiology 25: 641-650. http://heronpublishing.com/tree/summaries/volume25/a25-641.html [09.04.2008]

Lüscher, P., Rigling, A., Walthert, L., Zimmermann, S. 1994: Waldzustandsinventur 1993 - Bodenkundliche Erhebungen. Bodenkundliche Gesellschaft der Schweiz 18: 69-76.

Luterbacher, J., Dietrich, D., Xoplaki, E., Grosjean, M., Wanner, H. 2004: European seasonal and annual temperature variability, trends, and extremes since 1500. Science 303: 1499-1503. http://dx.doi.org/10.1126/science.1093877 [09.04.2008]

Mathys, L. 2005: Erfassung von Waldlücken mittels Laserscanning. [Mapping of Woodland Gaps through Laserscanning]. Schweizerische Zeitschrift für Forstwesen 156(10): 372-377.

Menzi, H., Frick, R., Kaufmann, R. 1997: Ammoniak-Emissionen in der Schweiz: Ausmass und technische Beurteilung des Reduktionspotenzials. [Emissions d'ammoniac en Suisse: amplitude et évaluation technique du potential de réduction]. Schriftenreihe der FAL 26. Zürich-Reckenholz. [in German, with English and French summary]

Moeri, A.C. 2007: Kohlenstoffvorräte in Schweizer Waldböden mit besonderer Berücksichtigung der organischen Auflage. Diplomarbeit bei der Eidgenössischen Forschungsanstalt für Wald, Schnee und Landschaft (WSL). Geographisches Institut der Universität Zürich. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

OEP 2008: Liechtenstein's Greenhouse Gas Inventory 1990-2006, National Inventory Report 2006, Submission of 29 February 2008 to the United Nations Framework Convention on Climate Change. Office of Environmental Protection (OEP). Principality of Liechtenstein. Vaduz, 29 February 2008. http://unfccc.int/files/national_reports/annex_i_ghg_inventories/national_inventories_submissions/application/x-zip-compressed/lie_2007_nir_29feb.zip [27.03.2008]

Perruchoud, D., Kienast, F., Kaufmann, E., Bräker, O.U 1999: 20th Century Carbon Budget of Forest Soils in the Alps. Ecosystems 2: 320-337. http://dx.doi.org/10.1007/s100219900083 [09.04.2008]

Perruchoud, D., Walthert, L., Zimmermann, S., Lüscher, P. 2000: Contemporary carbon stocks of mineral forest soils in the Swiss Alps. Biogeochemistry 50: 111-136. http://dx.doi.org/10.1023/A:1006320129112 [09.04.2008]

Prasuhn, V., Braun, M. 1994: Abschätzung der Phosphor- und Stickstoffverluste aus diffusen Quellen in die Gewässer des Kantons Bern. [Estimation des pertes en phosphore et en azote dans les eaux du canton de Berne à partir de sources diffuses]. Schriftenreihe der FAC Liebefeld 17. [in German, with English and French summary]

Prasuhn, V., Mohni, R. 2003: GIS-gestützte Abschätzung der Phosphor- und Stickstoffeinträge aus diffusen Quellen in die Gewässer des Kantons Bern. FAL, interner Bericht z.H. Amt für Gewässerschutz und Abfallwirtschaft, Kanton Bern. Zürich-Reckenholz.

Pulles 2005: Written communication from T. Pulles (TNO Built Environment and Geosciences, Netherlands) to N. Kljun (INFRAS, Bern), 11.12.2005. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

RAP 1999: Fütterungsempfehlungen und Nährwerttabellen für Wiederkäuer [Apports alimentaires recommandés et tables de la valeur nutritive des aliments pour les ruminants]. Landwirtschaftliche Lehrmittelzentrale, Zollikofen. Vierte Auflage. http://www.alp.admin.ch/dokumentation/00611/00631/index.html?lang=de [09.04.2008]

Riemersma, I., Jordaan, K., Oonk, J. 2003: N_2O emissions of HD vehicles. Netherlands Organisation for Applied Scientific Research (TNO), TNO Report 03.OR.VM.006.1/IJR.

Ruffner, H.P. 2005: Written communication from Hans Peter Ruffner (Forschungsanstalt Wädenswil) to Jens Leifeld (ART, Reckenholz), 19.12.2005. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

RIVM 2005: Greenhouse Gas Emissions in the Netherlands 1990-2003. National Inventory Report 2005. RIVM report 773201009 / 2005. National Institute for Public Health and the Environment (RIVM); Netherlands Environmental Assessment Agency (MNP); Global Sustainability and Climate (KMD), Bilthoven. http://www.rivm.nl/bibliotheek/rapporten/773201009.pdf [21.02.2008]

RWTÜV 2003: Update der Emissionsfaktoren für Motorräder. RWTÜV Fahrzeug GmbH, Würselen. http://www.hbefa.net/documents/EFaktoren_Motorraeder_2004.pdf [27.03.2008]

SAEFL 1992: Abfallkonzept für die Schweiz, Schriftenreihe Umwelt Nr. 73. Swiss Agency for the Environment, Forests and Landscape, Bern.

SAEFL 1995: Emissionen des Strassenverkehrs 1950-2010. [Emissions polluantes du trafic routier de 1950 à 2010]. Schriftenreihe Umwelt Nr. 255. [Cahier de l'environnement No 255]. Swiss Agency for the Environment, Forests and Landscape, Bern. [available in German and French] http://www.bafu.admin.ch/publikationen/index.html?action=show_publ&lang=D&id_thema=18&series=SRU&nr_publ=255 [27.03.2008]

SAEFL 1996: Schadstoffemissionen und Treibstoffverbrauch des Offroad Sektors, Umwelt-Materialien Nr. 49. Elektrowatt Ingenieurunternehmung AG, Zürich; Technik Thermische Maschinen, Niederrohrdorf; Swiss Agency for the Environment, Forests and Landscape, Bern.

SAEFL 2000: Handbuch Emissionsfaktoren für stationäre Quellen. Ausgabe 2000, Reihe Vollzug Umwelt. Swiss Agency for the Environment, Forests and Landscape, Bern. http://www.bafu.admin.ch/publikationen/index.html?action=show_publ&lang=de&id_thema=18&series=VU&nr_publ=5006 [25.03.2008]

SAEFL 2001: Bauabfälle Schweiz - Mengen, Perspektiven und Entsorgungswege. Umwelt-Materialien Nr. 131. Band 1: Kennwerte. Swiss Agency for the Environment, Forests and Landscape, Bern. http://www.bafu.admin.ch/publikationen/index.html?action=show_publ&lang=D&id_thema=4&series=UM&nr_publ=131 [27.03.2008]

SAEFL 2004: Luftschadstoff-Emissionen des Strassenverkehrs 1980-2030. [Émissions polluantes du trafic routier de 1980 à 2030]. [Pollutant emissions from road transport 1980-2030]. Schriftenreihe Umwelt Nr. 355. Swiss Agency for the Environment, Forests and Landscape, Bern. http://www.hbefa.net/documents/sru_355_d.pdf [German] [08.02.2008] http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en [English]

SAEFL 2004a: Handbook Emission Factors for Road Transport. Swiss Agency for the Environment, Forests and Landscape / INFRAS, CD ROM, Bern. http://www.bafu.admin.ch/publikationen/index.html?lang=en&action=show_publ&id_thema=18&series=VU&nr_publ=5014 [08.02.2008]

SAEFL 2005e: Arbeitsblatt Emissionsfaktoren Feuerungen, Bundesamt für Umwelt, Wald und Landschaft (BUWAL), Stand Oktober 2005. [Worksheet Emission Factors Fuel Combustion. Swiss Agency for the Environment, Forests and Landscape]. Bern. http://www.bafu.admin.ch/luft/00596/00598/index.html?lang=de [03.04.2008]

SAEFL 2005g: CO_2-Emissionen aus der Abfallverbrennung – Antwort. Interne Notiz. [CO_2 emissions from waste incineration - reply. Internal note]. Swiss Agency for the Environment, Forests and Landscape, Bern. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

SAEFL/ARE 2004: Fahrleistungen des Strassenverkehrs in der Schweiz. Verkehrsgrundlagen 1980-2030 zur Berechnung der Luftschadstoff-Emissionen des Strassenverkehrs. Arbeitsunterlage 34. Swiss Agency for the Environment, Forests and Landscape, Bern; Federal Office for Spatial Development, Bern. http://www.hbefa.net/documents/AU_Verkehr_V7e.pdf [14.02.2008]

SBV 1998: Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 1997. Swiss Farmers Union, Brugg. [available in German and French]

SBV 2004: Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2003. Swiss Farmers Union, Brugg. [available in German and French]

SBV 2007: Statistische Erhebungen und Schätzungen über Landwirtschaft und Ernährung 2006. Swiss Farmers Union, Brugg. [available in German and French] http://www.sbv-usp.ch/de/shop/statistische-erhebungen [24.01.2008]

Schmid, M., Neftel, A., Fuhrer, J. 2000: Lachgasemissionen aus der Schweizer Landwirtschaft. [Emissions de protoxyde d'azote de l'agriculture Suisse]. Schriftenreihe der FAL 33. Zürich-Reckenholz. http://www.services.art.admin.ch/pdf/FAL_SR_33_D_i.pdf [09.04.2008]

Schmid, S., Zierl, B., Bugmann, H. 2006: Analyzing the carbon dynamics of central European forests: comparison of Biome-BGC simulations with measurements. Regional Environmental Change 6(4):167-180. http://dx.doi.org/10.1007/s10113-006-0017-x

Schwager, S. 2005: Personal communication from Stefan Schwager (FOEN, Bern) to Andreas Liechti (FOEN, Bern), 23.12.2005. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Schwarz, W. 2001: Emissionen des Kältemittels R-134a aus mobilen Klimaanlagen. Jährliche Emissionsraten von bis zu sieben Jahre alten Pkw-Klimaanlagen. [Emission of Refrigerant R-134a from Mobile Air-Conditioning Systems Annual Rate of Emission from Passenger-Car Air-Conditioning Systems up to Seven Years Old]. Gutachten durch die Oeko-Recherche GmbH für das Umweltbundesamt (FKZ 360 09 006), Frankfurt. http://www.oekorecherche.de/deutsch/berichte/volltext/vollR134a.pdf [German] [31.01.2008] http://www.oekorecherche.de/english/berichte/volltext/MAC-LOSS-2001.pdf [English] [31.01.2008]

SFOE 1990: Schweizerische Gesamtenergiestatistik 1990. Statistique globale suisse de l'énergie 1990. Swiss Federal Office of Energy, Bern.

SFOE 2001: Schweizerische Gesamtenergiestatistik 2000. Statistique globale suisse de l'énergie 2000. Swiss Federal Office of Energy, Bern. http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=fr&name=fr_166628788.pdf [German and French] [27.03.2008]

SFOE 2007: Schweizerische Gesamtenergiestatistik 2006. Statistique globale suisse de l'énergie 2006. Swiss Federal Office of Energy, Bern. http://www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_237460077.pdf [German and French] [02.02.2008]

SFOE 2007a: Schweizerische Statistik der erneuerbaren Energien. Ausgabe 2006. Swiss Federal Office of Energy, Bern. http://www.bfe.admin.ch/themen/00526/00541/00543/index.html?lang=de&dossier_id=00772 [German, with French Summary] [22.02.2008]

SFSO 1997: Digital terrain model („Geländedaten", 100m-Raster). Swiss Federal Statistical Office, GEOSTAT, Neuchâtel. http://www.bfs.admin.ch/bfs/portal/fr/index/dienstleistungen/geostat/datenbeschreibung/gelaendedaten.html [06.03.2008]

SFSO 2000: Einblicke in die schweizerische Landwirtschaft. Swiss Federal Statistical Office, Neuchâtel.

SFSO 2000a: Digital soil map 1:200'000 („Bodeneignungskarte", BEK). Swiss Federal Statistical Office, GEOSTAT, Neuchâtel. http://www.bfs.admin.ch/bfs/portal/fr/index/dienstleistungen/geostat/datenbeschreibung/digitale_bodeneignungskarte.html [06.03.2008]

SFSO 2002: Einblicke in die schweizerische Landwirtschaft. Swiss Federal Statistical Office, Neuchâtel. [available in German and French]

SFSO 2003: Statistisches Jahrbuch der Schweiz 2003 [Statistical Yearbook of Switzerland 2003]. Swiss Federal Statistical Office, Neuchâtel [in German and French] http://www.bfs.admin.ch/bfs/portal/en/index/dienstleistungen/publikationen_statistik/statistische_jahrbuecher/stat__jahrbuch_der.html [27.03.2008]

SFSO 2005: Swiss Land Use Statistics (Arealstatistik Schweiz). Supply of hectare-based data of the first survey (Arealstatistik 1979/85, ASCH1) and second survey (Arealstatistik 1992/97, ASCH2). Swiss Federal Statistical Office, Neuchâtel. http://www.bfs.admin.ch/bfs/portal/fr/index/infothek/erhebungen__quellen/blank/blank/arealstatistik/01.html [06.03.2008] and http://www.bfs.admin.ch/bfs/portal/fr/index/infothek/nomenklaturen/blank/blank/arealstatistik/01.html [06.03.2008]

SFSO 2006a: Arealstatistik 2004/09 - Kategorienkatalog. Bodenbedeckung, Bodennutzung. Sektion Geoinformatik. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en See also: http://www.bfs.admin.ch/bfs/portal/fr/index/themen/02/03.html [06.03.2008]

SFSO 2006b: Wood production in Switzerland 1975-2005. Swiss Federal Statistical Office, Neuchâtel. http://www.agr-bfs.ch [official text in German, English, French and Italian] [19.03.2008]

SFSO 2007: Volkswirtschaftliche Gesamtrechnung 1990–2005 (National Accounting 1990–2005). Swiss Federal Statistical Office. Neuchatel 2007. http://www.bfs.admin.ch/bfs/portal/de/index/news/medienmitteilungen.Document.100037.pdf [20.02.2008]

SFSO 2007a: Supply of provisional data of the AREA Land Use Statistics. Written communication from Felix Weibel and Jürg Burkhalter (SFSO, Neuchâtel) to Helmut Recher (Sigmaplan, Bern), 29.06.2007. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

SGIA 2007: Jahresbericht 2006. Swiss Gas Industry Association, http://www.erdgas.ch/fileadmin/authors/Broschueren/jahresbericht_2006_d.pdf [03.03.2008]

SGWA 2005: Technische Gasstatistik 2004. Swiss Gas and Water Industry Association. http://www.svgw.ch/deutsch/filesPR/Gasstat_2004_d.pdf [21.02.2008]

SGWA 2007: Technische Gasstatistik 2006. Swiss Gas and Water Industry Association. www.svgw.ch/deutsch/files/Gasstat_2006_d.pdf [29.02.2008]

SGWA 2007a: Eigenschaften des in der Schweiz verteilten Erdgases, Merkblatt G 2007 / 1 d Ausgabe September 2007. Swiss Gas and Water Industry Association. http://www.svgw.ch/deutsch/filesPR/v803d.pdf [03.03.2008]

Soliva, C.R. 2006: Report to the attention of IPCC about the data set and calculation method used to estimate methane formation from enteric fermentation of agricultural livestock population and manure management in Swiss agriculture. On behalf of the Federal Office for the Environment, Bern. ETH Zurich, Institute of Animal Science. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Soliva, C.R. 2006a: Dokumentation der Berechnungsgrundlage von Methan aus der Verdauung und dem Hofdünger landwirtschaftlicher Nutztiere. Im Auftrag des Bundesamtes für Umwelt, Bern. ETH Zürich, Institut für Nutztierwissenschaften. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Spicer C.W., Holdren M. W., Riggin R. M., Lyon T. F. 1994: Chemical composition and photochemical reactivity of exhaust from aircraft turbine engines. Annales Geophysicae 12 (10-11): 944-955. http://www.springerlink.com/content/v1g443p1h216765l/ [07.04.2008]

Spirig, C., Neftel, A. 2002: Biogene VOC und Aerosole. Bedeutung der biogenen flüchtigen organischen Verbindungen für die Aerosolbildung. Schriftenreihe der FAL 42. Zürich-Reckenholz. http://www.services.art.admin.ch/pdf/FAL_SR_42_D_i.pdf [06.02.2008]

SQS 2008: IQNet and SQS ISO 9001:2000 Certificate. Certified area: National Inventory System. Field of activity: Greenhouse Gas Inventory and CO_2 Statistics. Registration Number: CH-34433. Issued on 04.01.2008 http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Swiss Confederation 1983: Loi fédérale du 7 octobre 1983 sur la protection de l'environnement (Loi sur la protection de l'environnement, LPE). As at 1 January 2008. http://www.admin.ch/ch/f/rs/c814_01.html [official text in German, French and Italian] [06.02.2008]

Swiss Confederation 1985: Ordonnance du 16 décembre 1985 sur la protection de l'air (OPair). [Swiss Federal Ordinance on Air Pollution Control]. As at 1 January 2008: Annex 5
http://www.admin.ch/ch/f/rs/c814_318_142_1.html [official text in German, French and Italian] [06.02.2008]
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en [English; as at 28 March 2000]

Swiss Confederation 1991: Loi fédérale du 4 octobre 1991 sur les forêts (Loi sur les forêts, LFo). As at 6 April 2004. http://www.admin.ch/ch/f/rs/c921_0.html [official text in German, French and Italian] [27.03.2008]

Swiss Confederation 1991a: Ordonnance du 21 janvier 1991 sur la protection des hauts-marais et des marais de transition d'importance nationale (Ordonnance sur les hauts-marais). As at 12 July 2005. http://www.admin.ch/ch/f/rs/c451_32.html [official text in German, French and Italian] [27.03.2008]

Swiss Confederation 1992: Ordonnance du 30 novembre 1992 sur les forêts (OFo). As at 26 September 2006. http://www.admin.ch/ch/f/rs/c921_01.html [official text in German, French and Italian] [27.03.2008]

Swiss Confederation 1994: Ordonnance du 7 septembre 1994 sur la protection des bas-marais d'importance nationale (Ordonnance sur les bas-marais). As at 12 July 2005.

http://www.admin.ch/ch/f/rs/c451_33.html [official text in German, French and Italian] [27.03.2008]

Swiss Confederation 1997: Ordonnance du 12 novembre 1997 sur la taxe d'incitation sur les composés organiques volatils (OCOV). As at 1 May 2007. http://www.admin.ch/ch/f/rs/c814_018.html [official text in German/French/Italian] [06.02.2008]

Theloke, J., Obermeier, A., Friedrich, R. 2000: Ermittlung der Lösemittelemissionen 1994 in Deutschland und Methoden zur Fortschreibung. Institut für Energiewirtschaft und Rationelle Energieanwendung (IER) der Universität Stuttgart.Forschungsbericht 295 42 628. Im Auftrag des Umweltbundesamtes. http://www.umweltdaten.de/publikationen/fpdf-l/2484.pdf [09.04.2008]

Thürig, E., Palosuo, T., Bucher, J., Kaufmann, E. 2005: The impact of windthrow on carbon sequestration in Switzerland: a model-based assessment. Forest Ecology and Management 210: 337-350. http://dx.doi.org/10.1016/j.foreco.2005.02.030 [09.04.2008]

Thürig, E., Kaufmann, E., Schmid, S., Bugmann, H. 2005a: Treibhausgas Inventar: Waldkennzahlen und jährlicher Klimaeinfluss. Internal report to FOEN. Inclusive: Excel-Datei Klimafaktoren.berechnen.xls zur Berechnung des jährlichen klimakorrigierten Zuwachses. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Thürig, E., Schmid, S. 2008: Jährliche CO_2-Flüsse im Wald: Berechnungsmethode für das Treibhausgasinventar. [Annual CO_2 fluxes in forests: calculation method for the Greenhouse Gas Inventory]. Schweizerische Zeitschrift für Forstwesen 159 (2); 31-38. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

UNECE 2003: Guidelines for Estimating and Reporting Emission Data under the Convention on Long-range Transboundary Air Pollution. Air Pollution Studies No. 15. New York and Geneva. http://www.unece.org/env/documents/2003/eb/air/ece.eb.air.80.E.pdf [14.02.2008]

UNFCCC 2006: Report of the individual review of the greenhouse gas inventory of Switzerland submitted in 2005. FCCC/ARR/2005/CHE, 11 April 2006. http://unfccc.int/resource/docs/2006/arr/che.pdf [14.02.2008]

UNFCCC 2007: Report of the individual review of the greenhouse gas inventory of Switzerland submitted in 2006. FCCC/ARR/2006/CHE, 31 July 2007. http://unfccc.int/resource/docs/2007/arr/che.pdf [07.02.2008]

UNFCCC 2007a: Report of the review of the initial report of Switzerland. FCCC/IRR/2007/CHE, 17 August 2007. http://unfccc.int/resource/docs/2007/irr/che.pdf [27.02.2008]

Vorreiter, L. 1949: Holztechnisches Handbuch; Band I: Allgemeines, Holzkunde, Holzschutz und Holzvergütung. Verlag Georg Fromme & Co., Wien.

VTG 2006: Consumption of aviation fuel and jet kerosene of military aircraft in Switzerland 1970-2004 (Excel-File). Written communication from Urs Baserga (VTG) to Andreas Liechti (FOEN, Bern), 09.01.2006. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

VTG 2006a: Consumption of aviation fuel and jet kerosene of military aircraft in Switzerland 2005. Written communication from Urs Baserga (VTG) to Paul Filliger (FOEN, Bern), 27.11.2006. http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

VTG 2007: Consumption of aviation fuel and jet kerosene of Swiss military aircraft in 2006. Written communication from Urs Baserga (VTG, Dübendorf) to Paul Filliger (FOEN,

Bern), 19.11.2007.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Walther U., Menzi, H., Ryser, J.-P., Flisch, R., Jeangros, B., Maillard, A., Siegenthaler, A., Vuilloud, P.A. 1994: Grundlagen für die Düngung im Acker- und Futterbau. Agrarforschung 1(7): 1-40.
http://www.agrarforschung.ch/de/inh_det.php?id=724 [09.04.2008]

Warneke C., Luxembourg, S.L., de Gouw, J.A., Rinne, H.J.I., Guenther, A.B., Fall, R. 2002: Disjunct eddy covariance measurements of oxygenated VOC fluxes from an Alfalfa field before and after cutting. Journal of Geophysical Research 107 D8: 4067.
http://dx.doi.org/10.1029/2001JD000594 [09.04.2008]

WBCSD 2001: The Cement CO_2 Protocol: CO_2 emissions Monitoring and Reporting Protocol for the Cement Industry. Guide to the Protocol, Version 1.6. WBCSD Working Group Cement, World Business Council for Sustainable Development.
http://www.wbcsdcement.org/pdf/co2-protocol.pdf [09.04.2008]

Widmer, A. 2006: Written communication from Albert Widmer (Forschungsanstalt Wädenswil) to Jens Leifeld (ART, Reckenholz), 20.06.2006.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Wiesen, P., Kleffmann, J., Kurtenbach, R., Becker, K.H. 1994: Nitrous Oxide and Methane Emissions from Aero Engines. Geophysical Research Letters 21: 2027-2030.
http://www.agu.org/pubs/crossref/1994/94GL01709.shtml [07.04.2008]

Wirth, C., Schulze, E. D., Schwalbe, G., Tomczyk, I., Weber, G.-E., Weller, E. 2004: Dynamik der Kohlenstoffvorräte in den Wäldern Thüringens: Abschlussbericht zur 1. Phase des BMBF-Projektes "Modelluntersuchung zur Umsetzung des Kyoto-Protokolls". Mitteilungen der Thüringer Landesanstalt für Wald, Jagd und Fischerei 23.

Würsch, H. 2004: Written communication from Herbert Würsch (Ricoter Erdaufbereitung AG, Aarberg) to Jens Leifeld (ART, Reckenholz), 19.11.2004.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Xinmin, J. 2004: Die Methanemissionen der Schweizer Gasindustrie. Abschätzung der Gasemissionen [Methane emissions from Swiss gas industry. Estimation of methane emissions]. Gas, Wasser, Abwasser 5/2004: 337-345.
http://www.environment-switzerland.ch/climatereporting/00545/01913/index.html?lang=en

Zimmermann, M., Leifeld, J., Schmidt, M.W.I., Smith, P., Fuhrer, J. 2007: Measured soil organic matter fractions can be related to pools in the RothC model. European Journal of Soil Science 58: 658–667.
http://dx.doi.org/10.1111/j.1365-2389.2006.00855.x [09.04.2008]

References to EMIS database comments

Table 168 Assignements 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 (*.doc)
1 A 1 a	Kehrichtdeponien
1 A 1 a	Vergärung
1 A 1 a i	*SAEFL (2005e)*
1 A 1 a ii	Fernwärme *.doc
1 A 1 a ii	*SAEFL (2005e)*
1 A 1 a ii	Kehrichtverbrennungsanlagen
1 A 1 a ii	Sondermüllverbrennungsanlagen
1 A 1 b	Raffineriefeuerungen *.doc
1 A 2 a	Eisengiessereien, Kupolöfen
1 A 2 a	*SAEFL (2005e)*
1 A 2 a	Stahlwerke Wärmeöfen
1 A 2 b	Aluminium-Produktion
1 A 2 b	Buntmetall-Giessereien, übriger Betrieb
1 A 2 b	*SAEFL (2005e)*
1 A 2 c	*SAEFL (2005e)*
1 A 2 d	*SAEFL (2005e)*
1 A 2 d	Zellulose-Produktion *.doc
1 A 2 e	*SAEFL (2005e)*
1 A 2 f	Feinkeramik-Produktion
1 A 2 f	Glas, übrige Produktion
1 A 2 f	Glaswolle-Produktion, Rohprodukt
1 A 2 f	*SAEFL (2005e)*
1 A 2 f	Hohlglas-Produktion
1 A 2 f	Kalk-Produktion, Feuerung
1 A 2 f	Mischgut-Produktion
1 A 2 f	Steinwolle-Produktion, Rohprodukt
1 A 2 f	Zement-Produktion, Feuerung
1 A 2 f	Ziegeleien
1 A 4 a	*SAEFL (2005e)*
1 A 4 a	*SAEFL (2005e)*
1 A 4 a	*SAEFL (2005e)*
1 A 4 b	*SAEFL (2005e)*
1 A 4 b	*SAEFL (2005e)*
1 A 4 b	*SAEFL (2005e)*
1 A 4 c i	Grastrocknung
1 B 2 a iv	Raffinerie, Leckverluste
1 B 2 a v	Benzinumschlag, Tanklager
1 B 2 a v	Benzinumschlag, Tankstellen
1 B 2 b	Gasverteilung Netzverluste
1 B 2 b ii	Gasverteilung Kompressorstationen
1 B 2 c 2 1	Raffinerie, Abfackelung
2 A 1	Zementwerke Rohmaterial
2 A 1	Zementwerke übriger Betrieb
2 A 2	Kalkproduktion, Rohmaterial
2 A 2	Kalkproduktion, übriger Betrieb
2 A 5	Dachpappe Produktion
2 A 6	Strassenbelagsarbeiten; Voranstrich
2 A 7	Gips-Produktion übriger Betrieb
2 A 7	Shredder Anlagen
2 B 1	Ammoniak-Produktion
2 B 2	Salpetersäure Produktion
2 B 4	Graphit- und Siliziumkarbid-Produktion
2 B 5	Essigsäure-Produktion
2 B 5	PVC-Produktion
2 B 5	Ethen-Produktion
2 B 5	Formaldehyd-Produktion
2 C 1	Stahwerke Elektroschmelzöfen
2 C 1	Eisengiessereien, übriger Betrieb
2 C 3	Aluminium Produktion
2 C 5	Batterie-recycling
2 C 5	Silizium-Produktion
2 D 1	Zellulose-Produktion; übriger Betrieb
2 D 2	Bierbrauereien
2 D 2	Branntwein Produktion
2 D 2	Brot Produktion
2 D 2	Wein Produktion
2 G	Holzkohle Produktion
2 G	Sprengen und Schiessen
2 G	Spanplatten-Produktion
3 A	Farben-Anwendung andere industrielle
3 A	Farben-Anwendung andere nichtindustrielle
3 A	Farben-Anwendung Autoreparatur
3 A	Farben-Anwendung Bau
3 A	Farben-Anwendung Haushalte
3 A	Farben-Anwendung Holz
3 A	*RIVM (2005)*
3 A	*see chpt 2 in Carbotech (2008)*
3 B	Chemische Reinigung
3 B	Elektronik-Reinigung
3 B	Metallreinigung
3 B	Reinigung Industrie; übrige
3 B	*RIVM (2005)*
3 B	*see chpt 2 in Carbotech (2008)*
3 C	Druckfarben-Produktion
3 C	Farben-Produktion
3 C	Feinchemikalien-Produktion
3 C	Gummi-Verarbeitung
3 C	Klebband-Produktion
3 C	Klebstoff-Produktion
3 C	Lösungsmittel-Umschlag und -Lager
3 C	Pharmazeutische Produktion
3 C	Polyester-Verarbeitung
3 C	Polystyrol-Verarbeitung
3 C	Polyurethan-Verarbeitung
3 C	PVC-Verarbeitung
3 C	*RIVM (2005)*
3 C	*see chpt 2 in Carbotech (2008)*
3 D	Betonzusatzmittel-Anwendung
3 D	Coiffeursalons
3 D	Druckereien
3 D	Entfernung von Farben und Lacken
3 D	Entwachsung von Fahrzeugen
3 D	Fahrzeug-Unterbodenschutz
3 D	Feuerwerke
3 D	Flugzeug-Enteisung und sonstige Enteisung
3 D	Gas-Anwendung
3 D	Gerben von Ledermaterialien
3 D	Gesundheitswesen; übrige
3 D	Glaswolle-Imprägnierung
3 D	Holzschutzmittel-Anwendung
3 D	Klebstoff-Anwendung
3 D	Korrosionsschutz im Freien
3 D	Kosmetika-Produktion
3 D	Kosmetik-Institute
3 D	Kühlschmiermittel-Verwendung
3 D	Lachgasanwendung Haushalt
3 D	Lachgasanwendung Spitäler
3 D	Lösungsmittel-Emissionen IG nicht zugeordnet
3 D	Medizinische Praxen
3 D	Öl- und Fettgewinnung
3 D	Papier- und Karton-Produktion
3 D	Parfum- und Aromen-Produktion
3 D	Pflanzenschutzmittel-Verwendung
3 D	Pharma-Produkte im Haushalt
3 D	Reinigung Gebäude IGD
3 D	Reinigungs- und Lösemittel; Haushalte
3 D	*RIVM (2005)*
3 D	Schmierstoff-Verwendung
3 D	*see chpt 2 in Carbotech (2008)*
3 D	Spraydosen; Haushalte
3 D	Spraydosen; Industrie/Gewerbe
3 D	Steinwolle-Imprägnierung
3 D	Steinwolle-Imprägnierung
3 D	Tabakwaren Konsum
3 D	Tabakwaren-Produktion
3 D	Textilien-Produktion
3 D	Wissenschaftliche Laboratorien
4 F	Abfallverbrennung Land- Forstwirtschaft
6 A 1	Kehrichtdeponien
6 A 1	Kehrichtdeponien
6 A 1	Kehrichtdeponien
6 B 1 / 6 B 2	Kläranlagen
6 C	Abfallverbrennung illegal
6 C	Kabelabbrand
6 C	Klärschlammverbrennung
6 C	Krematorien
6 C	Spitalabfallverbrennung
6 D	Kehrichtdeponien
6 D	Klärschlamm-Austrag
6 D	Kompostierung
6 D	Vergärung

Annexes

Annex 1: Key Category Analysis and Uncertainty Evaluation

A1.1 Key Category Analysis

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%. All main source categories have been disaggregated into sources (e.g. 2A, 2B, 2C etc.) and gases (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6).

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_6 (2F), HFC from Refrigeration and AC Equipment (2F1-HFC) and SF_6 from Electrical Equipment (2F8-SF6) are separated from the rest (2F_o). In Agricultural Soils (4D), N_2O from Direct and Indirect Soil Emissions (4D1-N2O, 4D3-N2O), respectively, are separated from the rest (4D_o).

Results of Key Category Analysis – Level

Table 169 Key category analysis 2006 (without LULUCF) regarding level (year t refers to 2006)

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	52'800.14	53'209.07	100.00%	0.00%	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'362.70	10'686.76	20.08%	20.08%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	9'144.79	17.19%	37.27%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'624.02	4'741.09	8.91%	46.18%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'392.19	3'741.09	7.03%	53.21%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	3'387.45	2'864.13	5.38%	58.60%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	2'303.39	4.33%	62.92%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2'235.68	4.20%	67.13%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2'181.29	4.10%	71.23%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	1'063.19	2'094.91	3.94%	75.16%	KC level
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'812.58	3.41%	78.57%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	942.41	1'429.27	2.69%	81.25%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	1'205.54	2.27%	83.52%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	912.20	1.71%	85.23%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	1'387.85	708.24	1.33%	86.57%	KC level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.84	1.28%	87.85%	KC level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CO2	457.96	603.16	1.13%	88.98%	KC level
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	548.89	1.03%	90.01%	KC level
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	552.93	528.00	0.99%	91.01%	KC level
4B	4. Agriculture	B. Manure Management			CH4	557.43	501.59	0.94%	91.95%	KC level
4B	4. Agriculture	B. Manure Management			N2O	448.20	403.29	0.76%	92.71%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	321.38	0.60%	93.31%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	156.87	306.62	0.58%	93.89%	KC level
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	290.66	0.55%	94.43%	KC level
6B	6. Waste	B. Wastewater Handling			N2O	190.66	212.01	0.40%	94.83%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.90	187.53	0.35%	95.18%	KC level
3	3. Solvent and Other Product Use				CO2	357.17	185.64	0.35%	95.53%	-
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	177.86	0.33%	95.87%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	177.39	0.33%	96.20%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	380.46	174.45	0.33%	96.53%	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	173.76	143.90	0.27%	96.80%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	122.40	0.23%	97.03%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	121.47	0.23%	97.26%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	121.34	0.23%	97.49%	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	110.90	114.62	0.22%	97.70%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CO2	139.24	110.48	0.21%	97.91%	-
6D	6. Waste	D. Other			CH4	30.34	97.09	0.18%	98.09%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	88.00	91.42	0.17%	98.26%	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	83.89	0.16%	98.42%	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	64.49	80.58	0.15%	98.57%	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	68.54	0.13%	98.70%	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	53.34	0.10%	98.80%	-
3	3. Solvent and Other Product Use				N2O	110.14	52.71	0.10%	98.90%	-
2A_o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.21	46.46	0.09%	98.99%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	52.32	46.44	0.09%	99.08%	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6			SF6	79.58	41.89	0.08%	99.15%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	36.45	0.07%	99.22%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	57.10	35.14	0.07%	99.29%	-
6B	6. Waste	B. Wastewater Handling			CH4	28.60	33.35	0.06%	99.35%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	8.33	28.14	0.05%	99.40%	-
6C	6. Waste	C. Waste Incineration			N2O	14.69	24.97	0.05%	99.45%	-

(cont’d next page)

(cont'd)

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]			
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	23.14	0.04%	99.49%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	34.26	22.39	0.04%	99.54%	-
6D	6. Waste	D. Other			N2O	6.23	19.90	0.04%	99.57%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	19.20	0.04%	99.61%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.54	19.01	0.04%	99.65%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	8.14	17.59	0.03%	99.68%	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	15.26	0.03%	99.71%	-
6C	6. Waste	C. Waste Incineration			CO2	52.87	15.25	0.03%	99.74%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.29	14.92	0.03%	99.76%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	0.02%	99.78%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.11	9.47	0.02%	99.80%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.30	9.14	0.02%	99.82%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	9.57	7.55	0.01%	99.83%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	N2O	5.11	6.63	0.01%	99.84%	-
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8.16	6.51	0.01%	99.86%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	5.06	5.35	0.01%	99.87%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.28	0.01%	99.88%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.39	4.80	0.01%	99.89%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	2.95	4.17	0.01%	99.89%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.35	4.03	0.01%	99.90%	-
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.96	0.01%	99.91%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	0.01%	99.92%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	7.31	3.65	0.01%	99.92%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	1.60	3.46	0.01%	99.93%	-
2G	2. Industrial Proc.	G. Other			CO2	1.04	3.44	0.01%	99.94%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	2.26	3.39	0.01%	99.94%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.82	0.01%	99.95%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	2.82	0.01%	99.95%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.62	0.00%	99.96%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	0.00%	99.96%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CH4	2.43	2.24	0.00%	99.97%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.79	1.86	0.00%	99.97%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.85	1.58	0.00%	99.97%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.26	0.00%	99.98%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.21	0.00%	99.98%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.18	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	0.60	1.18	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.98	1.15	0.00%	99.98%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.51	1.10	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.99	0.00%	99.99%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.47	0.95	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.81	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.74	0.00%	99.99%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.55	0.64	0.00%	99.99%	-
2A_o	2. Industrial Proc.	A. Mineral Products			CH4	0.94	0.63	0.00%	99.99%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.65	0.58	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.42	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.36	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.34	0.00%	100.00%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.19	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	0.18	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.03	0.14	0.00%	100.00%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.13	0.00%	100.00%	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.13	0.08	0.00%	100.00%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.03	0.00%	100.00%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		N2O	0.03	0.03	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%	-
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%	-

Results of Key Category Analysis – Trend

Table 170 Key category analysis 2006 (without LULUCF) regarding trend (year t refers to 2006).

Key Category Analysis 2006 (without LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate (2006)	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
						[Gg CO2eq]	[Gg CO2eq]					
TOTAL					*All*	***52'800.14***	***53'209.07***	*100.00%*	*0.255573*	*100.0%*		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'624.02	4'741.09	8.91%	0.039103	15.3%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	9'144.79	17.19%	0.021445	8.4%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'063.19	2'094.91	3.94%	0.019087	7.5%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2'235.68	4.20%	0.015259	6.0%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'362.70	10'686.76	20.08%	0.014247	5.6%	KC level	KC trend
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'812.58	3.41%	0.013647	5.3%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'387.85	708.24	1.33%	0.012875	5.0%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'392.19	3'741.09	7.03%	0.012777	5.0%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2'181.29	4.10%	0.012118	4.7%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'387.45	2'864.13	5.38%	0.010249	4.0%	KC level	KC trend
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	548.89	1.03%	0.010236	4.0%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	942.41	1'429.27	2.69%	0.008943	3.5%	KC level	KC trend
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	290.66	0.55%	0.007604	3.0%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	912.20	1.71%	0.004021	1.6%	KC level	KC trend
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CH4	380.46	174.45	0.33%	0.003897	1.5%	-	KC trend
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	1'205.54	2.27%	0.003640	1.4%	KC level	KC trend
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	2'303.39	4.33%	0.003555	1.4%	KC level	KC trend
3	3. Solvent and Other Product Use				CO2	357.17	185.64	0.35%	0.003251	1.3%	-	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	156.87	306.62	0.58%	0.002770	1.1%	KC level	KC trend
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.84	1.28%	0.002656	1.0%	KC level	KC trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous	CO2	457.96	603.16	1.13%	0.002642	1.0%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.90	187.53	0.35%	0.002616	1.0%	KC level	KC trend
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	121.34	0.23%	0.002484	1.0%	-	KC trend
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	19.20	0.04%	0.002259	0.9%	-	KC trend
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	2.82	0.01%	0.001830	0.7%	-	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	321.38	0.60%	0.001578	0.6%	KC level	KC trend
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	122.40	0.23%	0.001477	0.6%	-	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.54	19.01	0.04%	0.001366	0.5%	-	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	121.47	0.23%	0.001355	0.5%	-	KC trend
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	68.54	0.13%	0.001278	0.5%	-	KC trend
6D	6. Waste	D. Other			CH4	30.34	97.09	0.18%	0.001240	0.5%	-	KC trend
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	177.39	0.33%	0.001195	0.5%	-	KC trend
4B	4. Agriculture	B. Manure Management			CH4	557.43	501.59	0.94%	0.001122	0.4%	KC level	KC trend
3	3. Solvent and Other Product Use				N2O	110.14	52.71	0.10%	0.001087	0.4%	-	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	53.34	0.10%	0.000994	0.4%	-	-
4B	4. Agriculture	B. Manure Management			N2O	448.20	403.29	0.76%	0.000902	0.4%	KC level	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6			SF6	79.58	41.89	0.08%	0.000714	0.3%	-	-
6C	6. Waste	C. Waste Incineration			CO2	52.87	15.25	0.03%	0.000709	0.3%	-	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	36.45	0.07%	0.000680	0.3%	-	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	173.76	143.90	0.27%	0.000582	0.2%	-	-
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CO2	139.24	110.48	0.21%	0.000556	0.2%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	552.93	528.00	0.99%	0.000545	0.2%	KC level	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.29	14.92	0.03%	0.000479	0.2%	-	-
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	177.86	0.33%	0.000445	0.2%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	57.10	35.14	0.07%	0.000418	0.2%	-	-
6B	6. Waste	B. Wastewater Handling			N2O	190.66	212.01	0.40%	0.000371	0.1%	KC level	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	8.33	28.14	0.05%	0.000368	0.1%	-	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	83.89	0.16%	0.000361	0.1%	-	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	64.49	80.58	0.15%	0.000291	0.1%	-	-
6D	6. Waste	D. Other			N2O	6.23	19.90	0.04%	0.000254	0.1%	-	-

(cont'd next page)

(cont'd)

Key Category Analysis 2006 (without LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate (2006)	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	N2O	34.26	22.39	0.04%	0.000226	0.1%	-	-
6C	6. Waste	C. Waste Incineration			N2O	14.69	24.97	0.05%	0.000189	0.1%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	8.14	17.59	0.03%	0.000175	0.1%	-	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.13	0.08	0.00%	0.000170	0.1%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	52.32	46.44	0.09%	0.000117	0.0%	-	-
2A_o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.21	46.46	0.09%	0.000111	0.0%	-	-
6B	6. Waste	B. Wastewater Handling			CH4	28.60	33.35	0.06%	0.000085	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	N2O	7.31	3.65	0.01%	0.000069	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.62	0.00%	0.000061	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	23.14	0.04%	0.000054	0.0%	-	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	110.90	114.62	0.22%	0.000054	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	88.00	91.42	0.17%	0.000051	0.0%	-	-
2G	2. Industrial Proc.	G. Other			CO2	1.04	3.44	0.01%	0.000045	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CH4	2.39	4.80	0.01%	0.000045	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	N2O	9.57	7.55	0.01%	0.000039	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.28	0.01%	0.000037	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	1.60	3.46	0.01%	0.000034	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.11	9.47	0.02%	0.000032	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8.16	6.51	0.01%	0.000032	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.35	4.03	0.01%	0.000031	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	15.26	0.03%	0.000029	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	0.00%	0.000028	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous	N2O	5.11	6.63	0.01%	0.000028	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.51	1.10	0.00%	0.000027	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.18	0.00%	0.000024	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.30	9.14	0.02%	0.000023	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	CH4	2.95	4.17	0.01%	0.000022	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	N2O	2.26	3.39	0.01%	0.000021	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CH4	1.98	1.15	0.00%	0.000016	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.21	0.00%	0.000015	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.99	0.00%	0.000014	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.82	0.01%	0.000012	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	N2O	0.60	1.18	0.00%	0.000011	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.47	0.95	0.00%	0.000010	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.26	0.00%	0.000009	0.0%	-	-
2A_o	2. Industrial Proc.	A. Mineral Products			CH4	0.94	0.63	0.00%	0.000006	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.42	0.00%	0.000006	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.85	1.58	0.00%	0.000005	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.81	0.00%	0.000005	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	5.06	5.35	0.01%	0.000005	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous	CH4	2.43	2.24	0.00%	0.000004	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.74	0.00%	0.000004	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.36	0.00%	0.000003	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	N2O	0.03	0.14	0.00%	0.000002	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CH4	0.55	0.64	0.00%	0.000002	0.0%	-	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.65	0.58	0.00%	0.000001	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	0.02%	0.000001	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.03	0.00%	0.000001	0.0%	-	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.79	1.86	0.00%	0.000001	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.19	0.00%	0.000001	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.18	0.00%	0.000001	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.13	0.00%	0.000001	0.0%	-	-
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.96	0.01%	0.000001	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	0.01%	0.000001	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.34	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%	-	-
1B2	1. Energy	B. Fugitive Emissions from Fuels	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 Construction	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%	-	-
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%	-	-

Table 171 Key category analysis 2006 (with LULUCF) regarding level (year t refers to 2006)

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	57'799.39	57'687.63	100.00%	0.00%	
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'362.70	10'686.76	18.53%	18.53%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	9'144.79	15.85%	34.38%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'624.02	4'741.09	8.22%	42.60%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'392.19	3'741.09	6.49%	49.08%	KC level
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	3'686.87	3'287.42	5.70%	54.78%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	3'387.45	2'864.13	4.96%	59.74%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	2'303.39	3.99%	63.74%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2'235.68	3.88%	67.61%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2'181.29	3.78%	71.39%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	1'063.19	2'094.91	3.63%	75.03%	KC level
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'812.58	3.14%	78.17%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	942.41	1'429.27	2.48%	80.65%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	1'205.54	2.09%	82.74%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	912.20	1.58%	84.32%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	1'387.85	708.24	1.23%	85.54%	KC level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.84	1.18%	86.73%	KC level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CO2	457.96	603.16	1.05%	87.77%	KC level
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	584.63	572.40	0.99%	88.77%	KC level
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	548.89	0.95%	89.72%	KC level
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	552.93	528.00	0.92%	90.63%	KC level
4B	4. Agriculture	B. Manure Management			CH4	557.43	501.59	0.87%	91.50%	KC level
4B	4. Agriculture	B. Manure Management			N2O	448.20	403.29	0.70%	92.20%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	321.38	0.56%	92.76%	KC level
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	405.66	315.35	0.55%	93.30%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	156.87	306.62	0.53%	93.84%	KC level
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	290.66	0.50%	94.34%	KC level
6B	6. Waste	B. Wastewater Handling			N2O	190.66	212.01	0.37%	94.71%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.90	187.53	0.33%	95.03%	KC level
3	3. Solvent and Other Product Use				CO2	357.17	185.64	0.32%	95.35%	-
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	177.86	0.31%	95.66%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	177.39	0.31%	95.97%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	380.46	174.45	0.30%	96.27%	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	173.76	143.90	0.25%	96.52%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	122.40	0.21%	96.73%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	121.47	0.21%	96.94%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	121.34	0.21%	97.16%	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	110.90	114.62	0.20%	97.35%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CO2	139.24	110.48	0.19%	97.55%	-
6D	6. Waste	D. Other			CH4	30.34	97.09	0.17%	97.71%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	88.00	91.42	0.16%	97.87%	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	83.89	0.15%	98.02%	-
5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	114.57	80.80	0.14%	98.16%	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	64.49	80.58	0.14%	98.30%	-
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	31.01	71.59	0.12%	98.42%	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	68.54	0.12%	98.54%	-
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	81.61	64.11	0.11%	98.65%	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	53.34	0.09%	98.74%	-
3	3. Solvent and Other Product Use				N2O	110.14	52.71	0.09%	98.84%	-
2A_o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.21	46.46	0.08%	98.92%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	52.32	46.44	0.08%	99.00%	-

(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]			
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6			SF6	79.58	41.89	0.07%	99.07%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	36.45	0.06%	99.13%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	57.10	35.14	0.06%	99.19%	-
6B	6. Waste	B. Wastewater Handling			CH4	28.60	33.35	0.06%	99.25%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	8.33	28.14	0.05%	99.30%	-
6C	6. Waste	C. Waste Incineration			N2O	14.69	24.97	0.04%	99.34%	-
5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	2.67	24.56	0.04%	99.39%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	23.14	0.04%	99.43%	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	44.32	22.63	0.04%	99.46%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	34.26	22.39	0.04%	99.50%	-
6D	6. Waste	D. Other			N2O	6.23	19.90	0.03%	99.54%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	19.20	0.03%	99.57%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.54	19.01	0.03%	99.60%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	8.14	17.59	0.03%	99.63%	-
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	1.59	16.64	0.03%	99.66%	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	15.26	0.03%	99.69%	-
6C	6. Waste	C. Waste Incineration			CO2	52.87	15.25	0.03%	99.72%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.29	14.92	0.03%	99.74%	-
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	7.93	13.65	0.02%	99.77%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	0.02%	99.78%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.11	9.47	0.02%	99.80%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.30	9.14	0.02%	99.82%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	9.57	7.55	0.01%	99.83%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	N2O	5.11	6.63	0.01%	99.84%	-
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8.16	6.51	0.01%	99.85%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	5.06	5.35	0.01%	99.86%	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	7.77	5.30	0.01%	99.87%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.28	0.01%	99.88%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.39	4.80	0.01%	99.89%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	2.95	4.17	0.01%	99.89%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.35	4.03	0.01%	99.90%	-
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.96	0.01%	99.91%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	0.01%	99.92%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	7.31	3.65	0.01%	99.92%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	1.60	3.46	0.01%	99.93%	-
2G	2. Industrial Proc.	G. Other			CO2	1.04	3.44	0.01%	99.93%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	2.26	3.39	0.01%	99.94%	-
5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	18.20	2.99	0.01%	99.94%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.82	0.00%	99.95%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	2.82	0.00%	99.95%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.62	0.00%	99.96%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	0.00%	99.96%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gase	CH4	2.43	2.24	0.00%	99.97%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.79	1.86	0.00%	99.97%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.85	1.58	0.00%	99.97%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.26	0.00%	99.98%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.21	0.00%	99.98%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.18	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	0.60	1.18	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.98	1.15	0.00%	99.98%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.51	1.10	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.99	0.00%	99.99%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.47	0.95	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.81	0.00%	99.99%	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	8.19	0.75	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.74	0.00%	99.99%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.55	0.64	0.00%	99.99%	-
2A_o	2. Industrial Proc.	A. Mineral Products			CH4	0.94	0.63	0.00%	99.99%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.65	0.58	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.42	0.00%	100.00%	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	4.22	0.37	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.36	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.34	0.00%	100.00%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.19	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	0.18	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.03	0.14	0.00%	100.00%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.13	0.00%	100.00%	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.13	0.08	0.00%	100.00%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.03	0.00%	100.00%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		N2O	0.03	0.03	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%	-
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)

Table 172 Key category analysis 2006 (with LULUCF) regarding trend (year t refers to 2006).

Key Category Analysis 2006 (without LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate (2006)	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
						[Gg CO2eq]	[Gg CO2eq]					
TOTAL					*All*	***57'799.39***	***57'687.63***	*100.00%*	*0.244277*	*100.0%*		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'624.02	4'741.09	8.22%	0.036858	15.1%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.56	9'144.79	15.85%	0.018254	7.5%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'063.19	2'094.91	3.63%	0.017955	7.4%	KC level	KC trend
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'406.59	2'235.68	3.88%	0.014447	5.9%	KC level	KC trend
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'812.58	3.14%	0.012285	5.0%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'387.85	708.24	1.23%	0.011757	4.8%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.73	2'181.29	3.78%	0.011541	4.7%	KC level	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'362.70	10'686.76	18.53%	0.011358	4.6%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'392.19	3'741.09	6.49%	0.011161	4.6%	KC level	KC trend
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	548.89	0.95%	0.009533	3.9%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'387.45	2'864.13	4.96%	0.008975	3.7%	KC level	KC trend
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	942.41	1'429.27	2.48%	0.008488	3.5%	KC level	KC trend
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	290.66	0.50%	0.006965	2.9%	KC level	KC trend
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CO2	3'686.87	3'287.42	5.70%	0.006814	2.8%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	912.20	1.58%	0.003861	1.6%	KC level	KC trend
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.94	1'205.54	2.09%	0.003156	1.3%	KC level	KC trend
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'474.84	2'303.39	3.99%	0.002895	1.2%	KC level	KC trend
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	156.87	306.62	0.53%	0.002606	1.1%	KC level	KC trend
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous	CO2	457.96	603.16	1.05%	0.002537	1.0%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.90	187.53	0.33%	0.002444	1.0%	KC level	KC trend
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	682.84	1.18%	0.002336	1.0%	KC level	KC trend
5E2	5. LULUCF	E. Settlements	2. Land converted to Settlements		CO2	405.66	315.35	0.55%	0.001555	0.6%	KC level	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.93	321.38	0.56%	0.001509	0.6%	KC level	KC trend
4B	4. Agriculture	B. Manure Management			CH4	557.43	501.59	0.87%	0.000951	0.4%	KC level	KC trend
4B	4. Agriculture	B. Manure Management			N2O	448.20	403.29	0.70%	0.000765	0.3%	KC level	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	552.93	528.00	0.92%	0.000415	0.2%	KC level	-
6B	6. Waste	B. Wastewater Handling			N2O	190.66	212.01	0.37%	0.000377	0.2%	KC level	-
5B1	5. LULUCF	B. Cropland	1. Cropland remaining Cropland		CO2	584.63	572.40	0.99%	0.000193	0.1%	KC level	-
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CH4	380.46	174.45	0.30%	0.003565	1.5%	-	KC trend
3	3. Solvent and Other Product Use				CO2	357.17	185.64	0.32%	0.002967	1.2%	-	KC trend
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	121.34	0.21%	0.002270	0.9%	-	KC trend
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	19.20	0.03%	0.002081	0.9%	-	KC trend
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	2.82	0.00%	0.001687	0.7%	-	KC trend
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	122.40	0.21%	0.001342	0.5%	-	KC trend
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	121.47	0.21%	0.001270	0.5%	-	KC trend
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.54	19.01	0.03%	0.001257	0.5%	-	KC trend
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	68.54	0.12%	0.001190	0.5%	-	KC trend
6D	6. Waste	D. Other			CH4	30.34	97.09	0.17%	0.001160	0.5%	-	KC trend
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	177.39	0.31%	0.001132	0.5%	-	KC trend
3	3. Solvent and Other Product Use				N2O	110.14	52.71	0.09%	0.000994	0.4%	-	KC trend
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	53.34	0.09%	0.000926	0.4%	-	KC trend
5C2	5. LULUCF	C. Grassland	2. Land converted to Grassland		CO2	31.01	71.59	0.12%	0.000706	0.3%	-	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6			SF6	79.58	41.89	0.07%	0.000652	0.3%	-	-
6C	6. Waste	C. Waste Incineration			CO2	52.87	15.25	0.03%	0.000652	0.3%	-	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	36.45	0.06%	0.000633	0.3%	-	-
5F2	5. LULUCF	F. Other Land	2. Land converted to Other Land		CO2	114.57	80.80	0.14%	0.000583	0.2%	-	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	173.76	143.90	0.25%	0.000513	0.2%	-	-
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CO2	139.24	110.48	0.19%	0.000495	0.2%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.29	14.92	0.03%	0.000439	0.2%	-	-
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	177.86	0.31%	0.000381	0.2%	-	-

(cont'd next page)

Key Category Analysis 2006 (without LULUCF) IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate (2006)	Level Assessment	Trend Assessment	% Contribution in Trend	Result level assessment	Result trend assessment
5E1	5. LULUCF	E. Settlements	1. Settlements remaining Settlements		CO2	2.67	24.56	0.04%	0.000380	0.2%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	57.10	35.14	0.06%	0.000380	0.2%	-	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		CO2	44.32	22.63	0.04%	0.000375	0.2%	-	-
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	83.89	0.15%	0.000347	0.1%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	8.33	28.14	0.05%	0.000344	0.1%	-	-
5A2	5. LULUCF	A. Forest Land	2. Land converted to Forest Land		CO2	81.61	64.11	0.11%	0.000301	0.1%	-	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	64.49	80.58	0.14%	0.000282	0.1%	-	-
5D1	5. LULUCF	D. Wetlands	1. Wetlands remaining Wetlands		CO2	18.20	2.99	0.01%	0.000264	0.1%	-	-
5C1	5. LULUCF	C. Grassland	1. Grassland remaining Grassland		CO2	1.59	16.64	0.03%	0.000261	0.1%	-	-
6D	6. Waste	D. Other			N2O	6.23	19.90	0.03%	0.000238	0.1%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	N2O	34.26	22.39	0.04%	0.000205	0.1%	-	-
6C	6. Waste	C. Waste Incineration			N2O	14.69	24.97	0.04%	0.000179	0.1%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	8.14	17.59	0.03%	0.000164	0.1%	-	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.13	0.08	0.00%	0.000157	0.1%	-	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		CH4	8.19	0.75	0.00%	0.000129	0.1%	-	-
2A_o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.21	46.46	0.08%	0.000110	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	52.32	46.44	0.08%	0.000100	0.0%	-	-
5D2	5. LULUCF	D. Wetlands	2. Land converted to Wetlands		CO2	7.93	13.65	0.02%	0.000100	0.0%	-	-
6B	6. Waste	B. Wastewater Handling			CH4	28.60	33.35	0.06%	0.000084	0.0%	-	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	110.90	114.62	0.20%	0.000068	0.0%	-	-
5A1	5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land		N2O	4.22	0.37	0.00%	0.000067	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	N2O	7.31	3.65	0.01%	0.000063	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	88.00	91.42	0.16%	0.000062	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.62	0.00%	0.000056	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	23.14	0.04%	0.000046	0.0%	-	-
5B2	5. LULUCF	B. Cropland	2. Land converted to Cropland		N2O	7.77	5.30	0.01%	0.000043	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CH4	2.39	4.80	0.01%	0.000042	0.0%	-	-
2G	2. Industrial Proc.	G. Other			CO2	1.04	3.44	0.01%	0.000042	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.28	0.01%	0.000035	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	N2O	9.57	7.55	0.01%	0.000035	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	1.60	3.46	0.01%	0.000032	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	15.26	0.03%	0.000029	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.35	4.03	0.01%	0.000029	0.0%	-	-
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8.16	6.51	0.01%	0.000028	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.11	9.47	0.02%	0.000028	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous	N2O	5.11	6.63	0.01%	0.000027	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%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.51	1.10	0.00%	0.000025	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.18	0.00%	0.000022	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	CH4	2.95	4.17	0.01%	0.000021	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	N2O	2.26	3.39	0.01%	0.000020	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.30	9.14	0.02%	0.000020	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CH4	1.98	1.15	0.00%	0.000014	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.21	0.00%	0.000013	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.99	0.00%	0.000013	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.82	0.00%	0.000012	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	N2O	0.60	1.18	0.00%	0.000010	0.0%	-	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.47	0.95	0.00%	0.000009	0.0%	-	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.26	0.00%	0.000008	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.42	0.00%	0.000005	0.0%	-	-
2A_o	2. Industrial Proc.	A. Mineral Products			CH4	0.94	0.63	0.00%	0.000005	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	N2O	5.06	5.35	0.01%	0.000005	0.0%	-	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.81	0.00%	0.000005	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.85	1.58	0.00%	0.000005	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.74	0.00%	0.000003	0.0%	-	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid and Gaseous	CH4	2.43	2.24	0.00%	0.000003	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.36	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	N2O	0.03	0.14	0.00%	0.000002	0.0%	-	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CH4	0.55	0.64	0.00%	0.000002	0.0%	-	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.65	0.58	0.00%	0.000001	0.0%	-	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.79	1.86	0.00%	0.000001	0.0%	-	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.09	0.03	0.00%	0.000001	0.0%	-	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.19	0.00%	0.000001	0.0%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.18	0.00%	0.000001	0.0%	-	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.13	0.00%	0.000001	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	0.02%	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%	-	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.34	0.00%	0.000000	0.0%	-	-
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.96	0.01%	0.000000	0.0%	-	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	0.01%	0.000000	0.0%	-	-
1B2	1. Energy	B. Fugitive Emissions from Fuels	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 Construction	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%	-	-
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)

A1.2 Uncertainty Evaluation

A1.2.1 Uncertainty Evaluation Tier 1

The uncertainty analysis presented in this paragraph is based on the data of the present GHG inventory (FOEN 2008). Here, the Tier 1 estimated uncertainties are presented for emissions which are not CO_2 emissions from Fuel Combustion and which are not key categories.

Table 173 Estimated uncertainties for emissions which are not CO_2 emissions from Fuel Combustion and which are not key categories

IPCC Source Categories (and fuels if applicable)					Gas	Base year emissions 1990	Year 2006 emissions	estimated emission uncertainty for year 2006
						Gg CO2 eq	Gg CO2 eq	%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.74	30%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.49	0.36	30%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.42	30%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.36	0.34	30%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and (	Gaseous Fuels	CH4	2.39	4.80	30%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and (	Liquid Fuels	CH4	1.98	1.15	30%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and (	Solid Fuels	CH4	0.55	0.64	30%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and (	Biomass	CH4	2.95	4.17	30%
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.65	0.58	60%
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.19	60%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Diesel	CH4	1.47	0.95	60%
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.13	60%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Gaseous Fuels	CH4	2.35	4.03	30%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Liquid Fuels	CH4	2.51	1.10	30%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Biomass	CH4	8.14	17.59	30%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.26	5.28	30%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.62	30%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	30%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	52.32	46.44	30%
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fore	Gaseous Fuels	CH4	0.09	0.03	30%
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fore	Liquid Fuels	CH4	1.85	1.58	30%
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	2.43	2.24	30%
2A_o	2. Industrial Proc.	A. Mineral Products			CH4	0.94	0.63	30%
2B	2. Industrial Proc.	B. Chemical Industry			CH4	8.16	6.51	30%
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	60%
6B	6. Waste	B. Wastewater Handling			CH4	28.60	33.35	30%
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.96	30%
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CO2	139.24	110.48	10%
2A_o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.21	46.46	2%
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	15.26	10%
2G	2. Industrial Proc.	G. Other			CO2	1.04	3.44	10%
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	9.13	0.08	10%
6C	6. Waste	C. Waste Incineration			CO2	52.87	15.25	10%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.18	80%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.15	2.82	80%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.99	80%
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.03	0.14	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and (	Gaseous Fuels	N2O	0.60	1.18	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and (	Liquid Fuels	N2O	9.57	7.55	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and (	Solid Fuels	N2O	7.31	3.65	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and (	Biomass	N2O	2.26	3.39	80%
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and (	Other Fuels	N2O	34.26	22.39	80%
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.79	1.86	150%
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.18	150%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Diesel	N2O	8.33	28.14	150%
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportatio	Gasoline	N2O	88.00	91.42	150%
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.21	150%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Gaseous Fuels	N2O	0.53	0.81	80%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Liquid Fuels	N2O	11.11	9.47	80%
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Ins	Biomass	N2O	1.60	3.46	80%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.79	1.26	80%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	23.14	80%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	N2O	0.30	0.19	80%
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	10.30	9.14	80%
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fore	Gaseous Fuels	N2O	0.02	0.01	80%
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Fore	Liquid Fuels	N2O	5.06	5.35	80%
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	5.11	6.63	80%
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		N2O	0.03	0.03	80%
2B	2. Industrial Proc.	B. Chemical Industry			N2O	173.76	143.90	41%
3	3. Solvent and Other Product Use				N2O	110.14	52.71	80%
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	177.86	75%
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	150%
6C	6. Waste	C. Waste Incineration			N2O	14.69	24.97	80%
6D	6. Waste	D. Other			N2O	6.23	19.90	80%
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	53.34	20%
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	36.45	20%
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6			SF6	79.58	41.89	20%
2F8	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	64.04	83.89	20%
TOTAL						**1'274.63**	**1'207.53**	**18%**

A1.2.2 Uncertainty Evaluation Tier 2 (Monte Carlo Simulation)

The uncertainty analysis presented in this paragraph is based on the data of the present GHG inventory for 1990 and 2006.

In contrast to the Tier 2 Uncertainty Analysis carried out for the 2004 GHG inventory (see FOEN 2006a), the present 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 the remaining categories, only the uncertainty of the emissions is taken into consideration. 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 are five non-key categories which contribute largely to the total level uncertainty of the inventory (see Table 179).

- 1A3b Road Transportation, diesel oil N_2O;
- 1A3b Road Transportation, gasoline N_2O;
- 2B Chemical Industry N_2O;
- 3 Solvent and Other Product Use N_2O;
- 4D2 Agricultural Soils: Pasture, Range and Paddock Manure), N_2O.

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 174 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	Gas	Probability Distribution		
Key Categories:				AD	EF	Emission
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		N2O	normal	triangle	---
4B	B. Manure Management		N2O	normal	triangle	---
4D1	D. Agricultural Soils; Direct Soil Emissions		N2O	normal	normal	---
4D1	D. Agricultural Soils; Direct Soil Emissions		N2O	normal	lognormal	---
4D3	D. Agricultural Soils; Indirect Emissions		N2O	normal	lognormal	---
4D3	D. Agricultural Soils; Indirect Emissions		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 175 Correlation coefficients of activity data (for a better readability, categories without any correlations have been hidden).

Activity Data

IPCC Source Category					Gas		11	12	13	19	20	25	26	32	33	34	35	36	37		41	42	43
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	11	1																
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	12		1															
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	13		1	1														
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	19	-0.5			1													
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	20	-0.5	-0.1	-0.1		1												
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	25						1											
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	26						1	1										
4B	4. Agriculture	B. Manure Management		liquid	N2O	32								1									
4B	4. Agriculture	B. Manure Management		solid	N2O	33								-1	1								
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		fertilizer	N2O	34								0.3	0.3	1							
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		organic soil	N2O	35											1						
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		deposition	N2O	36								0.2	0.2	0.7		1					
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		leaching and runoff	N2O	37								0.2	0.2	0.7		0.5	1				
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	41	1			-0.5	-0.5										1		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	42		1	-0.1		-0.1											1	
4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	43								0.5	0.5			0.3	0.3				1

Table 176 Correlation coefficients of emission factors (for a better readability, categories without any correlations have been hidden)..

Emission Factors

IPCC Source Category					Gas		1	2	3	5	6	7	11	12	13	14	15	16	17	18	19	20	34	35	36	37		43
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	1	1																					
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	2		1																				
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	3			1																			
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	5			0.8	1																		
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	6	1				1																	
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	7		0.7				1																
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	11							1															
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	12							0.7	1														
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	13								0.8	1													
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	14										1												
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	15	1				1						1											
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	16		0.7				0.9						1										
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	17	1				1						1		1									
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	18		0.7				0.9								1								
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	19		0.7				0.9								0.9	1							
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	20		0.3					0.9	0.5						0.5	0.9	1						
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		fertilizer	N2O	34																	1					
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		organic soil	N2O	35																	0.5	1				
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		deposition	N2O	36																	0.5	0.5	1			
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		leaching and runoff	N2O	37																	0.1	0.1	0.2	1		
4D2	4. Agriculture	D. Agricultural Soils; Pasture, Range and Paddock Manure			N2O	43																	0.5	0.5	0.2	0.2		1

Table 177 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	1

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

$$\mathrm{V} = \frac{\mathrm{s}}{\mathrm{AD}}, \qquad (1)$$

[AD] = [s] = 1 TJ/a; for normal distributions,

$$U = t_{95\%} \frac{s}{AD}; \quad t_{95\%} \approx 2 \qquad (1a)$$

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): $\mathrm{AD}_{1A}^{ls} = AD_{1A1} + AD_{1A2} + AD_{1A4a} + AD_{1A4b} + AD_{1A4c}$ (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 plus some adequate approach. As suggested by Dr. M.P.J. Pulles, TNO, Netherlands (Pulles 2005), the standard deviation may be set 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

$$\alpha^{(f)} = \frac{s_i^{(f)}}{AD_i^{(f)}} = \frac{s_{1A2}^{(f)}}{AD_{1A2}^{(f)}} = \frac{s_{1A4a}^{(f)}}{AD_{1A4a}^{(f)}} = ... = V_i^{(f)} = \frac{1}{2}U_i^{(f)} \quad (6)$$

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 Eq. (6), Eq. (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

$$\left(\alpha^{g}\right)^2 = \left(V_{1A}^{g}\right)^2 \cdot \frac{\left(AD_{1A}^{g}\right)^2 - AD_{1A1}^2}{AD_{1A2}^2 + AD_{1A4a}^2 + AD_{1A4b}^2 + AD_{1A5}^2}$$

$$\left(\alpha^{ls}\right)^2 = \left(V_{1A}^{ls}\right)^2 \cdot \frac{\left(AD_{1A}^{ls}\right)^2 - AD_{1A1}^2}{AD_{1A2}^2 + AD_{1A4a}^2 + AD_{1A4b}^2 + AD_{1A4c}^2}$$

$$\left(\alpha^{lm}\right)^2 = \left(V_{1A}^{lm}\right)^2 \cdot \frac{\left(AD_{1A}^{lm}\right)^2}{AD_{1A3a}^2 + AD_{1A3b}^2 + AD_{1A3e}^2 + AD_{1A5}^2} \quad (9)$$

$$(\alpha^{s})^2 = (V_{1A}^{s})^2 \cdot \frac{\left(AD_{1A}^{s}\right)^2 - AD_{1A1}^2}{AD_{1A2}^2}$$

$$\left(\alpha^{o}\right)^2 = \left(V_{1A}^{o}\right)^2 \cdot \frac{\left(AD_{1A}^{o}\right)^2 - AD_{1A2}^2}{AD_{1A2}^2}$$

The uncertainties for sub-sectors other than 1A1 may then be derived from equations (6) and (9). In our case, this yields (see Table 178 for input values)

$$U^{g} = 2\alpha^{g} = 0.090 = 9.0\%$$
$$U^{ls} = 2\alpha^{ls} = 0.017 = 1.7\%$$
$$U^{lm} = 2\alpha^{lm} = 0.014 = 1.4\% \qquad (10)$$
$$U^{s} = 2\alpha^{s} = 0.035 = 3.5\%$$
$$U^{o} = 2\alpha^{o} = 0.440 = 44.0\%$$

Table 178 Activity data and uncertainties key categories in 1A Fuel Combustion due to the data of inventory submission in April 2006 (FOEN 2006a).

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%
	expansion factors						*1.80*	*1.68*	*1.39*	*1.24*	*4.40*
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 Agricuture	---	7'171	---	---	---	---	1.7%	---		---
1A5	Others (Off-road)	318	---	7'952	---	---	9.0%	---	1.4%		---

In Table 178, “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

$$\varepsilon^{(f)} = \frac{U_{1A2}^{(f)}}{U_{1A}^{(f)}} = \frac{U_{1A4a}^{(f)}}{U_{1A}^{(f)}} = \frac{U_{1A4b}^{(f)}}{U_{1A}^{(f)}} \qquad (11)$$

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.

The discrepancy between simulated and reported values becomes apparent when Figure 5 is compared to Table 1. Note that it is not a relevant issue for the uncertainty analysis but is rather confusing for readers and reviewers who carefully study the numbers. For transparency reasons, the numbers are explained in Table 179.

The abolute 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 179).

Table 179 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
simulated values				**1990**		
absolute	Gg CO_2 eq	52'646	50'661	55'392	-1'985	2'746
relative	%	100.0%	96.2%	105.2%	-3.8%	5.2%
values of CRF						
absolute	Gg CO_2 eq	52'800	50'809	55'554	-1'991	2'754
relative	%	100.0%	96.2%	105.2%	-3.8%	5.2%
simulated values				**2006**		
absolute	Gg CO_2 eq	53'088	51'254	55'520	-1'834	2'432
relative	%	100.0%	96.5%	104.6%	-3.5%	4.6%
values of CRF						
absolute	Gg CO_2 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 14, Table 180 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 180 Activity data, emission factors, emissions and their corresponding uncertainties of key categories in Monte Carlo simulation (to be compared with Table 14)

IPPC Source Category			Gas	Activity Data year t (2006)		Uncertainty of activity data	Emission factor year t		Uncertainty of emission factor	Emissions year t	Uncertainty of emissions
						%			%	(Gg CO2 equivalent)	%
1A A. Fuel Combustion											
1A1	1. Energy Industries	Gaseous Fuels	CO2	5843	TJ	4.9	55	t/TJ	4.5	321	6.7
1A1	1. Energy Industries	Liquid Fuels	CO2	14949	TJ	1.0	61	t/TJ	0.5	912	1.1
1A1	1. Energy Industries	Other Fuels	CO2	48900	TJ	9.8	45	t/TJ	29.4	2181	31.0
1A1	1. Energy Industries	Solid Fuels	CO2	1995	TJ	5.6	94	t/TJ	4.9	188	7.4
1A1	1. Energy Industries	Other Fuels	N2O	48900	TJ	9.8	2	t/TJ	78.4	121	79.3
1A2	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	38089	TJ	8.8	55	t/TJ	4.5	2095	9.9
1A2	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	38694	TJ	1.6	74	t/TJ	0.5	2864	1.7
1A2	2. Manufacturing Industries and Construction	Other Fuels	CO2	5319	TJ	43.2	58	t/TJ	29.4	307	52.8
1A2	2. Manufacturing Industries and Construction	Solid Fuels	CO2	7351	TJ	6.9	96	t/TJ	4.9	708	8.5
1A3a	3. Transport; Civil Aviation		CO2	1658	TJ	1.4	73	t/TJ	0.5	121	1.5
1A3b	3. Transport; Road Transportation	Diesel	CO2	64417	TJ	1.4	74	t/TJ	0.5	4741	1.5
1A3b	3. Transport; Road Transportation	Gasoline	CO2	144611	TJ	1.4	74	t/TJ	0.5	10687	1.5
1A3b	3. Transport; Road Transportation	Gasoline	CH4	144611	TJ	1.4	0	t/TJ	55.5	19	55.9
1A3e	3. Transport; Other Transportation (military aviation)		CO2	1672	TJ	1.4	73	t/TJ	0.5	122	1.5
1A4a	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	25987	TJ	8.8	55	t/TJ	4.5	1429	9.9
1A4a	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	50897	TJ	1.6	74	t/TJ	0.5	3741	1.7
1A4b	4. Other Sectors; Residential	Gaseous Fuels	CO2	40649	TJ	1.6	55	t/TJ	4.5	2236	4.8
1A4b	4. Other Sectors; Residential	Liquid Fuels	CO2	124415	TJ	1.6	74	t/TJ	0.5	9145	1.7
1A4c	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	7171	TJ	1.6	74	t/TJ	0.5	528	1.7
1A5	5. Other	Liquid Fuels	CO2	7952	TJ	1.4	74	t/TJ	0.5	586	1.5
1A5	5. Other	Gaseous Fuels	CO2	318	TJ	8.8	55	t/TJ	4.5	18	9.9
1B B. Fugitive Emissions from Fuels											
1B2	2. Oil and Natural Gas		CH4	---	---	---	---	---	---	174	49.0
2 Industrial Processes											
2A1	A. Mineral Products; Cement Production-CO2		CO2	3452	kt	2.0	1	t/t	5.9	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	29.4	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
4 Agriculture											
4A	A. Enteric Fermentation		CH4	---	---	---	---	---	---	2303	18.3
4B	B. Manure Management		CH4	---	---	---	---	---	---	502	54.5
4B	B. Manure Management	liquid	N2O	74972190	kgN	28.9	0.00	kgN2O-N	0.0	37	50.6
4B	B. Manure Management	solid	N2O	37644454	kgN	28.9	0.02	kgN2O-N	61.3	367	57.3
4D1	D. Agricultural Soils; Direct Soil Emissions	fertilizer	N2O	187097570	kgN	11.1	0.01	kgN2O-N	78.4	1139	79.5
4D1	D. Agricultural Soils; Direct Soil Emissions	organic soil	N2O	17000	ha	28.8	8.00	kgN2O-N	79.6	66	88.1
4D3	D. Agricultural Soils; Indirect Emissions	deposition	N2O	48273714	kgN	40.6	0.01	kgN2O-N	88.2	235	101.1
4D3	D. Agricultural Soils; Indirect Emissions	leaching and runo	N2O	36759583	kgN	21.6	0.03	kgN2O-N	231.3	448	294.9
6 Waste											
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 181 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 year t (2006).

Table 181: Tier 2 Uncertainty calculation and reporting for all sources, including non-key categories.

A					B	C	D	E	F	G
IPPC Source Category					Gas	Base year (1990) emissions	Year t (2006) emissions	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t
						(Gg CO2 equivalent)	(Gg CO2 equivalent)	% below (2.5 percentile)	(97.5 percentile)	(%)
Key Categories										
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	235	321	93	107	0.040
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691	912	99	101	0.019
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1520	2181	72	134	1.270
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	47	188	93	108	0.026
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48	121	21	180	0.181
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1063	2095	90	110	0.390
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3387	2864	98	102	0.094
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	157	307	53	158	0.305
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1388	708	92	109	0.113
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	253	121	99	101	0.003
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2624	4741	98.5	101.5	0.131
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11363	10687	98.5	101.5	0.307
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	92	19	44	156	0.020
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200	122	99	101	0.003
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	942	1429	90	110	0.266
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4392	3741	98	102	0.121
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1407	2236	95	105	0.202
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10216	9145	98	102	0.297
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	553	528	98	102	0.017
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	449	586	99	101	0.016
1A5	1. Energy	A. Fuel Combustion	5. Other	Gaseous Fuels	CO2	9	18	90	110	0.003
1B2	1. Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas		CH4	380	174	51	149	0.161
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2525	1813	94	106	0.211
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112	177	61	139	0.131
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139	19	70	130	0.011
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100	3	56	144	0.002
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0	69	63	137	0.048
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0	549	82	118	0.186
3	3. Solvent and Other Product Use				CO2	357	186	51	149	0.171
4A	4. Agriculture	A. Enteric Fermentation			CH4	2475	2303	82	118	0.794
4B	4. Agriculture	B. Manure Management			CH4	557	502	45	155	0.514
4B	4. Agriculture	B. Manure Management		liquid	N2O	42	37	15	112	0.033
4B	4. Agriculture	B. Manure Management		solid	N2O	406	367	38	150	0.386
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		fertilizer	N2O	1324	1139	21	181	1.708
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		organic soil	N2O	66	66	24	193	0.106
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		deposition	N2O	272	235	18	209	0.421
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		leaching and run	N2O	546	448	8	482	1.995
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693	291	41	159	0.321
6B	6. Waste	B. Wastewater Handling			N2O	191	212	2	198	0.390
6D	6. Waste	D. Other			CH4	30	97	51	149	0.089
Non Key Categories										
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	1	1	71	129	0.000
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0	0	71	129	0.000
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0	0	71	129	0.000
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0	0	71	129	0.000
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0	0	22	178	0.000
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2	3	22	178	0.004

(cont'd next page)

(cont'd)

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	71	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	3	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_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	1	1	41	159	0.001
1A3_o	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	2	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
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		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
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2	4	71	129	0.002
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	3	1	71	129	0.001
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	8	18	71	129	0.010
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	1	1	22	178	0.001
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11	9	22	178	0.014
1A4a	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_o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40	46	98	102	0.002
2A_o	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
2B	2. Industrial Proc.	B. Chemical Industry			N2O	174	144	60	140	0.109
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	NA,NO	36	92	108	0.005
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			PFC	0	0	-	-	0.000
2E	2. Industrial Proc.	E. Production of Halocarbons and SF6			CO2	0	0	-	-	0.000
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0	53	85	115	0.015
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F8-SF6			SF6	80	42	78	122	0.017

(cont'd next page)

(cont'd)

2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-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 Perzentile im Verhältnis zum Calculated Mean			53102	97	105	

Annex 2: Energy

A2.1 Swiss Energy Flux

The diagrams show a summary of the Swiss energy flux 2006 and 1990 as published by the Swiss Federal Office of Energy (SFOE 2007). Diagram languages are German and French.

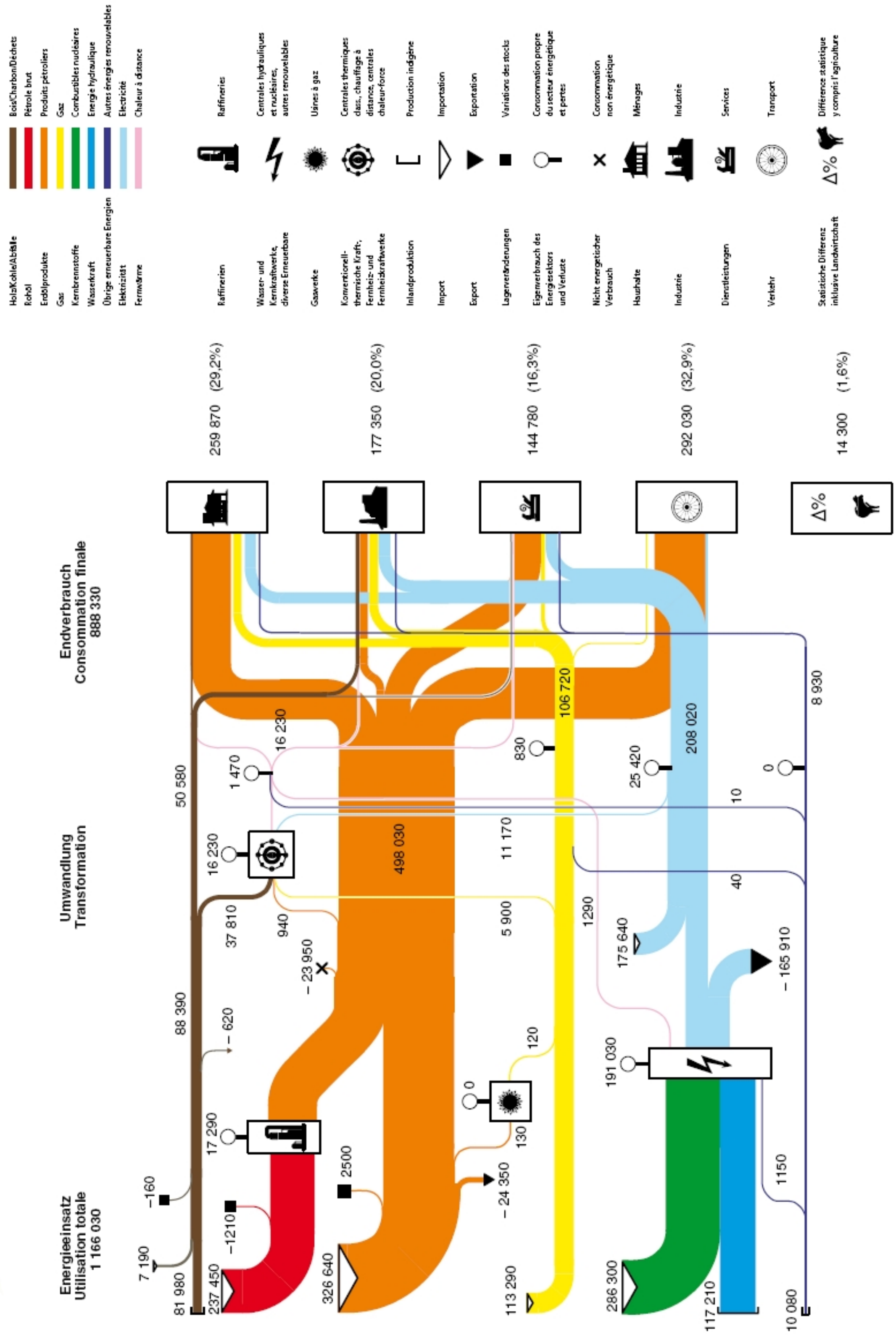


Figure 44 Energy flux in Switzerland 2006 (SFOE 2007)

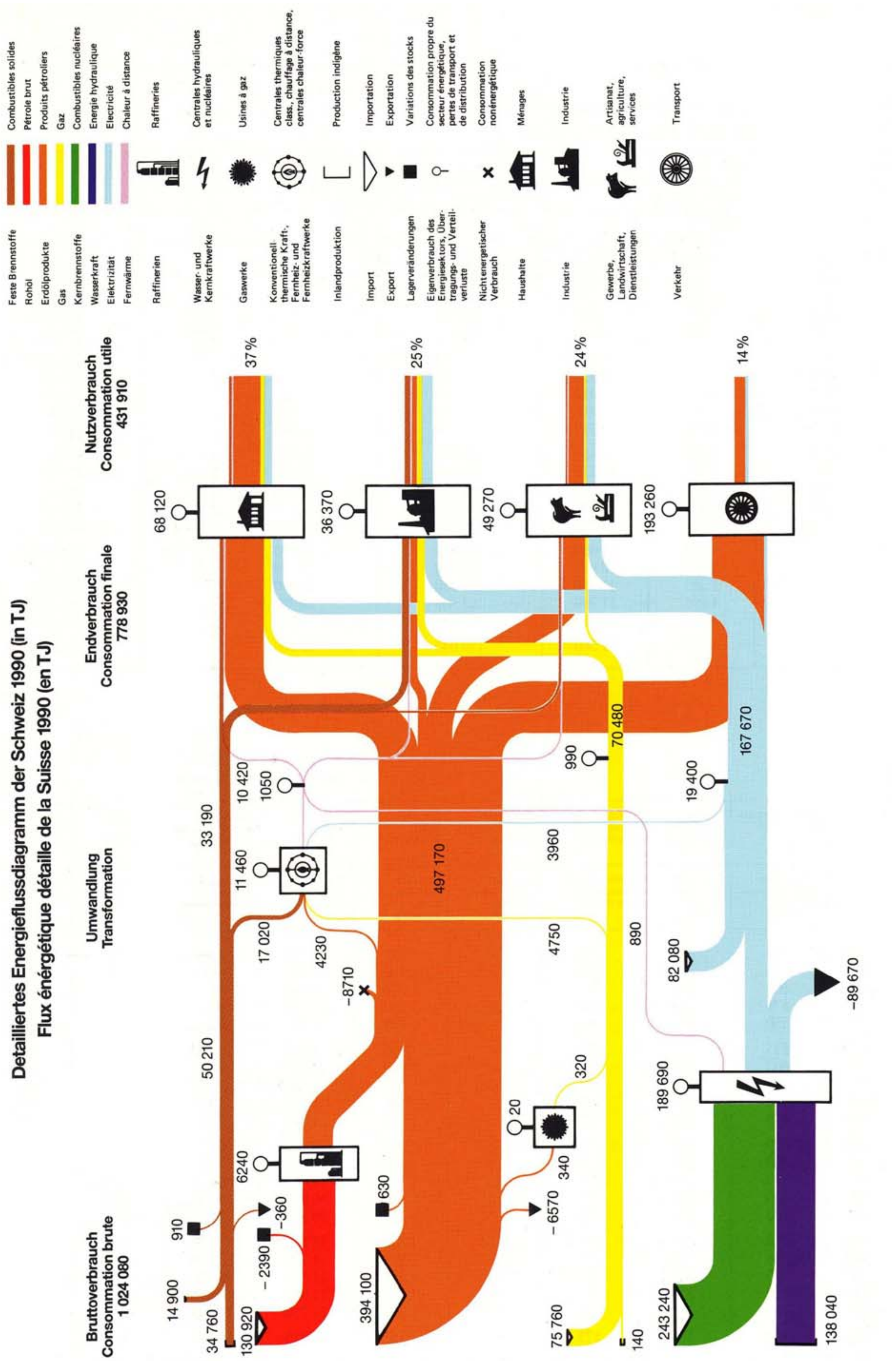


Figure 45 Energy flux in Switzerland 1990 (SFOE 1990)

A2.2 Carbon Dioxide (CO_2)

The main sources for calculating CO_2 emissions of Switzerland are the
a) net calorific values of the fuels (SFOE 2001)
b) CO_2 emission factors of the fuels (SFOE 2001)
c) Swiss overall energy statistics 2006 (SFOE 2007).

A2.2.1 Net calorific values (energy content) and density of fossil fuels

Table 182 NCV from SFOE 2001.

Fuel	Net calorific values (NCV)		Density
	GJ / t	GJ / volume	t / volume
Hard Coal	26.3	---	---
Gas Oil	42.6	36.0 / 1000 l	0.845 t / 1000 l
Residual Fuel Oil	41.2	39.1 / 1000 l	0.950 t / 1000 l
Natural Gas	46.5	36.3 / 1000 Nm^3	0.780 t / 1000 Nm^3
Gasoline	42.5	31.7 / 1000 l	0.745 t / 1000 l
Diesel Oil	42.8	35.5 / 1000 l	0.830 t / 1000 l
Propane/Butane (LPG)	46.0	---	---
Jet Kerosene	43.0	34.4 / 1000 l	0.800 t / 1000 l
Lignite	20.1	---	---

The NCV of fossil fuels is assumed to be constant over the period 1990 to 2006.

A2.2.2 CO_2 emission factors of fossil fuels

Table 183 CO_2 emission factors (SFOE 2001). The value for natural gas also holds for CNG (compressed natural gas). The CO_2 emission factor of fossil fuels is assumed to be constant from 1990 to 2006.

CO_2 Emission Factor			
Fuel	t CO_2 / TJ	t CO_2 / t	t CO_2 / volume
Hard Coal	94.0	2.47	---
Gas Oil	73.7	3.14	2.65t / 1000 liter
Residual Fuel Oil	77.0	3.17	3.01t / 1000 liter
Natural Gas	55.0	2.56	2.00t / 1000 Nm^3
Gasoline	73.9	3.14	2.34t / 1000 liter
Diesel Oil	73.6	3.15	2.61t / 1000 liter
Propane/Butane (LPG)	65.5	---	---
Jet Kerosene	73.2	3.15	2.52t / 1000 liter
Lignite	104.0	2.09	---

A2.3 Sulphur Dioxide (SO_2)

Table 184 Sulphur content and SO_2 emission factors. For explanations see next page.

year	maximum legal limit of sulphur content					
	Diesel oil	Gasoline	Gas oil	Natural gas	Res. fuel oil	Coal
	ppm	ppm	ppm	ppm	%	%
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	50	50	2000	190	1.0	1.0
2006	50	50	2000	190	1.0	1.0

year	Effective sulphur content					
	Diesel oil	Gasoline	Gas oil	Natural gas	Res. fuel oil	Coal
	ppm	ppm	ppm	ppm	%	%
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	8	700	11.6	0.76	0.9
2005	10	8	700	11.6	0.76	0.9
2006	10	8	700	11.6	0.76	0.9

year	Effective SO_2 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	0.5	0.4	32.9	0.50	369	350
2005	0.5	0.4	32.9	0.50	369	350
2006	0.5	0.4	32.9	0.50	369	350

Explanation to Table 184

- For liquid and solid fuels the SO_2 emission factors are determined by the sulphur content. The upmost lines in Table 184 “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 184 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 184 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_2

$$\frac{M_{SO_2}}{M_S}\frac{S}{NCV} = 2\frac{S}{NCV}$$

- 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_2) 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 corresponging to 1.4% (500 kg/TJ).
- Residual fuel oil: OAPC Annex 5, §11, lit.2 sets 2.8% for the legal limit. Simultaneously, OAPC despenses 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.

A2.4 Emissions from Fuel Consumption

A2.4.1 Disaggregation of Fuel Consumption

Swiss overall energy statistics 2006

The consumption of Solid, Liquid, Gaseous and Other Fuels in the Swiss overall energy statistics 2006 (SFOE 2007) 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 2006 of Basics (Basics 2007) 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 the Swiss energy agency for industry (Energieagentur der Wirtschaft EnAW, for 1990 and 2000 to 2006), industry data from annual reports, fuel supply data from CARBURA for 1985 to 2006, 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 2007) provided the basis to estimate the fuel consumption of the services and institutional sector in Switzerland from 1990 to 2006. 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):

$$(1) \qquad F_{1A2} = F_{1A2+4a} \cdot \frac{F_{1A2}^{Model}}{F_{1A2}^{Model} + F_{1A4a}^{Model}}$$

(2) $$F_{1A4a} = F_{1A2+4a} \cdot \frac{F_{1A4a}^{Model}}{F_{1A2}^{Model} + F_{1A4a}^{Model}}$$

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) $$F_{1A2a} = F_{1A2a}^{Model};\ F_{1A2b} = F_{1A2b}^{Model};\ F_{1A2c} = F_{1A2c}^{Model};\ F_{1A2d} = F_{1A2d}^{Model};$$
$$F_{1A2e} = F_{1A2e}^{Model}$$

(4) $$F_{1A2f} = F_{1A2} - \sum_{i=a}^{e} F_{1A2i}^{Model}$$

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.

In previous submissions from Switzerland, exceptions were made for coal and residual fuel oil, for which activity data were taken from Basics in absolute terms, because it was assumed that the Swiss overall energy statistics would underestimate coal and heavy fuel consumption occurring due to a reduction of mandatory stocks (FDEA 2003); this exception is no longer made, as the Swiss overall energy statistics showed an increase in coal consumption while the data from Basics did not. The differences between the Swiss overall energy statistics and the data from Basics became large and the Swiss overall energy statistics was considered to be more reliable than the data from Basics.

A2.5 Civil Aviation

This paragraph contains further information to the emission modelling. More complete information will be available in FOCA (2006, 2007) and on request for reviewers by FOCA.

Emission factors

Table 185 Aircraft cruise factors, used for cruise emission calculation (extract of list of 671 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 186 LTO-cycle times (minutes). Swiss FOCA does not use all ICAO standard cycle times for all 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.

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 187 Aircraft-Engine Combinations and associated codes for SWISS FOCA emissions database. (Extract from list of 14043 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-Ho-neywell
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 188 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	Move-ments	Type	Aircraft ICAO	Engine Name	Fuel (LTO) tons	Emissions (LTO) in tons					
	Km		No.					CO_2	H_2O	SO_2	NO_x	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	Move-ments	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

A2.6 Road Transportation

A2.6.1 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 189 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 190 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*AE1+0.33*AE2	116	0.5*AG1+0.5*AG2	118	0.75*AS1+0.25*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*(AE1, AE2, A3, A4)	103	0.5*AG2+0.5*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*(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*LS1+0.5*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*LE3+0.5*LE5	42	0.5*LE3+0.5*LE5	42	0.5*LE3+0.5*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*LE3+0.5*LE5 +0.25*LE6	34	0.25*LE3+0.5*LE5 +0.25*LE6	34	0.25*LE3+0.5*LE5 +0.25*LE6	34
Urban_L2	Main road, with traffic light system, medium hold-ups	0.67*LE5+0.33*LE6	28	0.67*LE5+0.33*LE6	28	0.67*LE5+0.33*LE6	28
Urban_L3	Main road, with traffic light system, major hold-ups	0.33*LE5+0.67*LE6	24	0.33*LE5+0.67*LE6	24	0.33*LE5+0.67*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 191 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, mediurm/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. 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 192 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.

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_2O 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 193 N_2O 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_2O 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

A2.6.2 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.

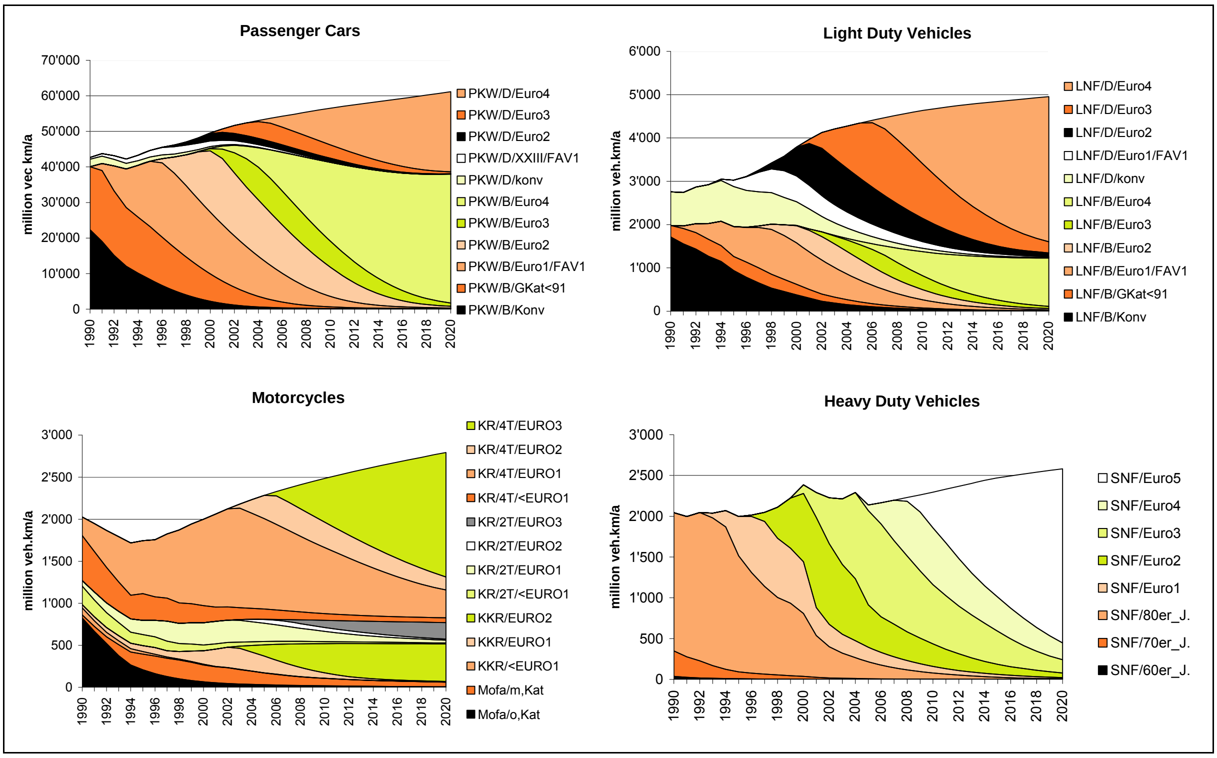


Figure 46 Mileage composition by emission concept (in million vehicle kilometres per year), SAEFL 2004.

A2.6.3 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.

A2.6.4 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_2 the hot exhaust emissions contribute to 95% of the total. Only 5% stem from cold start excess emissions. For CH_4 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_2O, no cold start emissions nor evaporative emissions are taken into account due to lack of data.

A2.7 Off-road Vehicles

A2.7.1 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 provisional 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 2007).

The modelling of the emission and of the fuel consumption are carried out by using the formula

$$E^{g}_{i,j,t,\tau} = N_{i,j,t} \cdot T_{i,j,t} \cdot \omega_{t-\tau} \cdot P_{i,j} \cdot L_{i,j} \cdot \nu_{t-\tau} \cdot \varepsilon^{g}_{i,j,\tau}$$

E: Emission and fuel consumption
N: number of vehicles
T: average operating hours per year
ω: age dependency
P: motor power in kW
L: load factor
ν: degradation factor (due to aging)
ε: emission factor in g/kWh
indices: g: gas (CH_4, N_2O, CO, NO_x, SO_2) and fuel consumption,
i off-road family (railway, navigation etc.),
j size class,
t: year (1980, 1985, 1990, 1995, 2000, … , 2020)
τ: year of construction (note: t - τ = 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.

A2.7.2 Emission and fuel consumption factors for off-road vehicles

The CO_2 emission factors are derived from fuel type and fuel consumption (see tables below). The emission factors for CH_4 and N_2O are only specified by the fuel type.

Table 194 CH_4 and N_2O emission factors (INFRAS 2007).

Gas	Diesel	Gasoline		CNG
		4-stroke	2-stroke	
	mg/kWh			
CH_4	6	500	4000	10'000/1'000
N_2O	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_4 IPCC recommends 18 mg/kWh for diesel oil, 72 mg/kWh for gasoline 4-stroke, 210 mg/kWh gasoline 2-stroke. For N_2O IPCC gives 2 mg/kWh (diesel oil and gasoline 4-stroke) and 6 mg/kWh (gasoline 2-stroke).

Table 195 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-IIIA 2007/2008**
Carbon monoxide (CO)					
<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
VOC					
<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
Nitrogen oxides (NOx)					
<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
Fuel consumption (FC)					
<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 196 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**
Carbon monoxide (CO)					
<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
VOC					
<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
Nitrogen oxides (NOx)					
<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
Fuel consumption (FC)					
<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 197 Emission and consumption factors for gasoline 2-stroke engines. PreEU-A etc. indicate emission standards.

Basic emission factors of equipment with 2-stroke gasoline engines (g/kWh)				
gas/fuel consumption	**PreEU-A <1995**	**PreEU-B 1995**	**PreEU-C 2000**	**EU-I 2004**
Carbon monoxide (CO)	645	640	620	600
VOC	260	250	150	100
Nitrogen oxides (NOx)	1.5	2	3	5
Fuel consumption (FC)	678	670	650	640

Table 198 Emission and consumption factors for rail vehicles with diesel engines. PreEU etc. indicate emission standards.

Basic emission factors of rail vehivles (g/kWh)				
power class	**PreEU <2000**	**UIC I 2000**	**UIC II 2003**	**EU IIIa 2007/2009**
Carbon monoxide (CO)				
<560 kW	3.1	3	2.5	3.5
>560 kW	4	4	3	3
VOC				
<560 kW	1.3	0.8	0.6	0.4
>560 kW	2.5	1.6	0.8	0.8
Nitrogen oxides (NOx)				
<560 kW	14.3	12	6	3.6
>560 kW	20	15	12	9.5
Fuel consumption (FC)				
<560 kW	285	283	283	283
>560 kW	285	285	283	283

Table 199 Emission and consumption factors for ships with diesel engines. PreSAV etc. indicate emission standards.

Basic emission factors of diesel engine ships (g/kWh)					
power class	**PreSAV <1995**	**SAV I 1995**	**SAV II 1997**	**EU I 2005**	**EU II 2010**
Carbon monoxide (CO)					
<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
VOC					
<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
Nitrogen oxides (NOx)					
<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
Fuel consumption (FC)					
<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 200 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 <1995	SAV II 1995	EU 1997	PreSAV 2005	SAV II 2010
Carbon monoxide (CO)					
<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
VOC					
<100 kW	10	10	10	5	5
>100 kW	5	5	5	5	5
Nitrogen oxides (NOx)					
<100 kW	15	15	10	9.8	5
>100 kW	15	15	10	6.5	4.5
Fuel consumption (FC)					
<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 201 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
Carbon monoxide (CO)						
<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
VOC						
<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
Nitrogen oxides (NOx)						
<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
Fuel consumption (FC)						
<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 202 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

A2.7.3 Activity data off-road vehicles

The activity data are described in detail in INFRAS (2007). Aggregated numbers are shown in the following tables.

Table 203 Number of vehicles per off-road family (INFRAS 2007)

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	327'501	326'743	340'468	342'910	345'613
Forestry	13'844	13'357	13'055	12'749	11'945
Garden/Hobby	749'010	809'043	871'060	852'931	834'800
Navigation	93'378	89'025	82'652	82'623	82'593
Railway	1'300	1'305	1'255	1'255	1'255
Military	1'340	1'340	1'340	1'340	1'340
Sum	**1'256'390**	**1'311'628**	**1'380'573**	**1'363'910**	**1'345'994**

Table 204 Operating hours per vehicle per year and (million) operating hours per off-road family (INFRAS 2007).

Family	1990	1995	2000	2005	2010
	operating hours per veh. per year				
Construction	299	353	383	386	387
Industry	601	627	643	643	646
Agriculture	119	118	112	108	104
Forestry	274	272	270	261	256
Garden/Hobby	58	59	60	60	60
Navigation	40	39	40	40	40
Railway	612	627	616	616	616
Military	51	53	54	52	49
Average	**92**	**95**	**95**	**94**	**93**

Family	1990	1995	2000	2005	2010
	mio. of operating hours				
Construction	16.75	18.52	18.38	18.26	17.76
Industry	8.38	11.52	14.63	14.63	14.59
Agriculture	38.98	38.46	38.01	37.03	36.08
Forestry	3.79	3.63	3.53	3.32	3.06
Garden/Hobby	43.43	47.94	52.53	51.37	50.23
Navigation	3.69	3.43	3.30	3.29	3.28
Railway	0.80	0.82	0.77	0.77	0.77
Military	0.07	0.07	0.07	0.07	0.07
Summe	**115.89**	**124.40**	**131.23**	**128.75**	**125.83**

Table 205 Fuel consumption of several off-road activities in 1'000 t/a (INFRAS 2007).

Fuel	**Family**	**1990**	**1995**	**2000**	**2005**	**2010**
		Fuel consumption in 1000 t/a				
Diesel	Construction	91.4	105.9	113.3	117.4	119.7
Diesel	Industry	25.2	32.0	38.8	39.2	38.7
Diesel	Agriculture	114.5	120.4	126.0	127.3	128.2
Diesel	Forestry	7.9	8.1	8.6	9.7	10.6
Diesel	Navigation	17.6	16.2	16.7	16.6	16.7
Diesel	Railway	20.5	23.1	23.9	25.3	26.8
Diesel	Military	1.1	1.1	1.2	1.1	1.1
Diesel	**Sum**	**278.1**	**306.9**	**328.4**	**336.7**	**341.8**
Gasoline	Construction	7.2	7.4	6.3	6.1	6.0
Gasoline	Industry	1.6	2.3	3.0	3.0	3.0
Gasoline	Agriculture	22.4	20.3	18.1	17.6	17.1
Gasoline	Forestry	3.6	3.4	3.3	2.8	2.4
Gasoline	Garden/Hobby	16.2	18.0	19.7	18.9	18.2
Gasoline	Navigation	13.8	12.8	13.7	15.4	16.1
Gasoline	Military	0.0	0.0	0.0	0.0	0.0
Gasoline	**Sum**	**64.9**	**64.4**	**64.2**	**63.9**	**62.8**
Gas Oil	**Navigation**	**3.9**	**4.2**	**4.3**	**4.3**	**4.3**
CNG	**Industry**	**3.4**	**5.1**	**6.8**	**6.8**	**6.9**

Annex 3: Industrial Processes

A3.1 Documentation of Model for Mobile Air-Conditioning / Cars

Table 206 Model structure and assumptions for calculating emissions from mobile air conditioning in cars (illustrative 2003 data).

Parameters for Car Air-Conditioning

Emission Factor 1995	8.5%	[% of initial charge/a]		Emissions from servicing and disposal are calculated separately
share recharged regularly	*6.0%*	Note: To correlate the data with import statistics the rehacrged amount is calculated.		
share not recharged	*2.5%*	This information is used for verification through Tier 1b.		
all units are imported with refrigerant charged				
Product life	12	[a]		
initial charge 1995 [kg]	0.81	Initial charge 2000	0.78	other years are inter-/extrapolated)
charge at end of lifetime	60%	[% of initial charge, as per literature]		
Disposal emissions	100%	up to 2004		
	30%	from 2005		
export of 2nd hand cars	50%			
Servicing emission factor	2 times	10%	of initial charge per lifetime	

Market growth rate 1%

Model for Car A/C emissions

Year	new registered cars (VSAI, EFKO)	Stock (B. f. Statistik)	Disposed cars	A/C units new cars Car-Input [%]	R134a [%]	Units R134	Stock of A/C units Stock [%]	units R134	Disposed units R134	initial charge kg / car
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 [t]	Stock [t]	Emissions Stock + Servicing [t]	Disposal [t]	Servicing [t]	Import for Servicing [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
2003	**189**	**1'082**	**107**	0.8	**19**	**62.1**
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

Annex 4: Agriculture

Livestock Population Data for N_2O Emission Calculation

Table 207 Livestock population data 2006 for N_2O calculation.

Animal 2006		Number of animals	kg N per head/year	FracGASM (6)	N volatilized (kg N)
Cattle		**1'566'800**			**31'488'344**
Mature dairy and mature non-dairy cattle		705'400	106.6	0.33	24'586'668
Young cattle		861'400	30.9	0.26	6'901'676
	Calves on milk and pre-weaned calves	*168'500*	*13.0*	*0.38*	*826'007*
	Breeding cattle 1st year	*223'200*	*25.0*	*0.23*	*1'266'660*
	Breeding cattle 2nd year	*210'200*	*40.0*	*0.23*	*1'908'616*
	Breeding cattle 3rd year	*110'100*	*55.0*	*0.23*	*1'374'712*
	Fattening calves	*35'300*	*8.0*	*0.38*	*106'314*
	Fattening cattle	*114'100*	*33.0*	*0.38*	*1'419'405*
Sheep		**450'900**	**6.1**	**0.15**	**406'749**
	Sheep places	*230'600*	*12.0*	*0.15*	*406'749*
Goats		**76'300**	**9.5**	**0.30**	**215'028**
	Goats places	*45'233*	*16.0*	*0.30*	*215'028*
Horses		**56'400**	**42.3**	**0.33**	**780'222**
	Pre-weaned foals	*3'100*	*17.0*	*0.33*	*17'331*
	Foals 1 year	*IE*			*IE*
	Foals 2 years	*IE*			*IE*
	Foals < 3 years	*6'400*	*42.0*	*0.33*	*87'963*
	Horses 3 years	*IE*			*IE*
	Horses more than 4 years	*IE*			*IE*
	Breeding mares and studs	*IE*			*IE*
	Other horses	*46'900*	*44.0*	*0.33*	*674'928*
Mules and Asses		**16'478**	**25.0**	**0.33**	**134'708**
	Mules and asses < 1year	*IE*			*IE*
	Mules and asses > 1 year	*IE*			*IE*
Swine		**1'634'700**	**10.5**	**0.47**	**7'992'184**
	Fattening pig places	*901'433*	*13.0*	*0.47*	*5'472'773*
	Breeding pig places	*154'150*	*35.0*	*0.47*	*2'519'465*
Poultry		**7'664'581**	**0.5**	**0.51**	**1'972'749**
	Young hens	*888'400*	*0.3*	*0.55*	*165'194*
	Laying hens	*2'147'300*	*0.7*	*0.55*	*834'175*
	Broilers	*4'481'300*	*0.4*	*0.49*	*873'191*
	Other poultry	*147'581*	*1.4*	*0.49*	*100'809*
Total		**11'466'159**		**0.33**	**42'989'983**

(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. Other sheep are not included.
(5) One goat place corresponds to one goat over 1.5 years. Goats younger than 1.5 years are not included.
(6) includes ammonia volatilization calculated for each species based on management practice and NOx emissions of 0.7% of the excreted N.

Additional data for estimating enteric fermentation emission factors for cattle

Table 208 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[a]	Weight[a] kg	Weight Gain[a] kg/day	Feeding Situation /	Milk[b] kg/day	Work hrs/day	Pregnant[a] %	Digestibility of Feed %[d]	CH_4 Conversion[c] %	Em. Factor kg/head/year[e]
Mature dairy cattle	n.a.	650	0		13.5 – 15.6[c]	0	305 days of lactation	60%	6.00%	109.83
Mature non-dairy cattle	n.a.	550	0		6.8[a]	0	305 days of lactation	60%	6.00%	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%	0.00%	0
Pre-weaned calves	0-10 month	60-325	1	"Natura beef" production, milk from mother cow and additional feed.	0	0	0%	65%	6.00%	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%	6.00%	10.58
Breeding cattle 1	4-12 month	120-300	0.8	Premature race (Milk-race)	0	0	0%	60%	6.00%	35.12
Breeding cattle 2	12-28/30 month	300-600	0.8	Premature race (Milk-race)	0	0	0%	60%	6.00%	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%	6.00%	21.87
Fattening cattle	4-12 month	175-550	1.3	Feeding recommendations for fattening steers	0	0	0%	60%	6.00%	49.03

[a] data source: RAP 1999 and calculations according to Soliva 2006

[b] Milk production in kg/day is calculated by dividing the average annual milk production per head by 365 days.

[c] data source: Swiss farmers union (SBV 2007).

[d] data source: IPCC 1997c and IPCC 2000

[e] 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_4 emission factors

Table 209 Data for estimating manure management CH4 emission factors. Reference: IPCC 1997c, Tables B-1-B-7.

Data for estimating Manure Management CH_4 emission factors in Switzerland							
Type	Weight	Digestibility of	Energy Intake	Feed Intake	% Ash	VS	B_0
	kg [a]	Feed % [b]	MJ/day	kg/day	Dry Basis [b]	kg/head/day	m^3 CH_4/kg VS [b]
Mature dairy cattle	650	60	260-280	15.07 [c]	8	5.17-5.57	0.24
Mature non-dairy cattle	550	60	205.09	10.96 [c]	8	4.09	0.24
Calves on milk	60 – 200	65	47.62	2.02 [a]	8	0.83	0.17
Pre-weaned calves	60 – 325	65	55.73	2.98 [a]	8	0.97	0.17
Breeding calves	50 – 120	65	26.88	1.5 [a]	8	0.47	0.17
Breeding cattle 1	120 – 300	60	89.24	4.88 [a]	8	1.78	0.17
Breeding cattle 2	300 – 600	60	129.07	7.78 [a]	8	2.57	0.17
Fattening calves	70 – 175	65	55.58	3.27 [a]	8	0.97	0.17
Fattening cattle	175 – 550	60	124.59	6.82 [a]	8	2.48	0.17
Sheep	Not determined	60	21-24	2.19 [c]	8	0.40 [b]	0.19
Goats	Not determined	60	29-35	1.86 [c]	8	0.28 [b]	0.17
Horses	Not determined	70	132-177	7.12-7.94 [c]	4	1.72 [b]	0.33
Mules and Asses	Not determined	70	87-165	Not estimated	4	0.94 [b]	0.33
Swine	Not determined	75	35-40	Not estimated	2	0.50 [b]	0.45
Poultry	Not determined	Not estimated	1.6-1.9	Not estimated	Not estimated	0.10 [b]	0.32

[a] RAP 1999
[b] IPCC 1997c and IPCC 2000
[c] FAL/RAC 2001

Additional Data for N_2O Emission Calculation of Agricultural Soils

Table 210 Additional data for N_2O emission calculation of agricultural soils.

2006	Total crop production Crop(O) and Crop(BF) (kg DM)	Nitrogen incorporated with crop residues F(CR) (t N)	N2O emissions from crop residues (t N2O)	N fixed per kg crop (kg N/kg crop)	N fixed (kg N)	N2O emissions from N fixation (t N2O)
1. Cereals						
Wheat	450'670'000	3'358	66			
Barley	194'990'000	1'109	22			
Maize	128'435'000	1'077	21			
Oats	10'200'000	76	2			
Rye	7'310'000	59	1			
Other (please specify)						
Triticale	54'825'000	645	13			
Spelt	8'925'000	80	2			
Mix of fodder cereals	1'020'000	6	0			
Mix of bread cereals	85'000	1	0			
2. Pulse						
Dry bean	705'500	28	1	0.0443	36'728	0.7
Eiweisserbsen/peas	15'638'300	368	7	0.0330	607'134	11.9
Soybeans	2'550'000	106	2	0.0571	171'360	3.4
Other (please specify)						
Leguminous vegetables	2'599'740	267	5	0.0177	255'974	5.0
3. Tuber and Root						
Potatoes	86'240'000	375	7			
Other (please specify)						
Fodder beet	17'505'000	163	3			
Sugar beet	273'400'160	2'581	51			
5. Other (please specify)						
Grass	6'200'381'844	22'189	436	0.0050	32'260'320	612.6
Silage corn	1'375'433'400	325	6			
Green corn	233'823'678	34	1			
Fruit	58'948'350	236	5			
Vine	25'614'000	154	3			
Renewable energy crops	4'644'000	72	1			
Non-leguminous vegetables	54'883'200	858	17			
Sunflowers	11'560'000	245	5			
Tobacco	1'270'000	33	1			
Rape	47'970'000	746	15			
Total Non-leguminous	3'047'751'788	12'232	240		0	0
Total Leguminous	21'493'540	768	15		1'071'196	21.0
Total excluding grass	3'069'245'328	13'001	255		1'071'196	21.0
Total including grass	9'269'627'172	35'189	691		33'331'516	633.7