Switzerland's Greenhouse Gas Inventory 1990–2004

National Inventory Report 2006

Submission of 31 May 2006
to the United Nations Framework Convention on Climate Change

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Table of Contents

Glossary

AD	Activity data (e.g. energy consumption, animal population size)
BLW	Federal Office for Agriculture
Carbura	Schweiz. Zentralstelle für die Einfuhr flüssiger Brenn- und Treibstoffe
Cemsuisse	Verband der Schweizerischen Cementindustrie
CH_4	Methane
CHP	Combined heat and power production
CO	Carbon monoxide
CO_2, CO_2 eq	Carbon dioxide (equivalent)
CRF	Common reporting format
CSS	Mix of special waste with saw dust; used as fuel in cement kilns
EF	Emission factor
EMIS	Swiss national air pollution database
EMPA	Swiss Federal Laboratories for Material Testing and Research
DETEC	Department of the Environment, Transport, Energy and Communication
FAL	Swiss Federal Research Station for Agroecology and Agriculture
FCCC	Framework Convention on Climate Change
FOCA	Federal Office for Civil Aviation
FOAG	Swiss Federal Office for Agriculture
FOEN	Federal Office for the Environment (former name SAEFL)
Gg	Gigagram (10^9 g = 1'000 tons)
GHG	Greenhouse gas
GWP	Global Warming Potential
HFC	Hydrofluorocarbons (e.g. HFC-32 difluoromethane)
HFO	Heavy fuel oil
IDP	Inventory Development Plan
IPCC	Intergovernmental Panel on Climate Change
LFO	Light fuel oil (Gas oil)
LPG	Liquefied Petroleum Gas (Propane/Butane)
LTO	Landing-Takeoff-Cycle (Aviation)
LULUCF	Land Use and Land-Use Change and Forestry
MSW	Municipal solid waste
NCV	Net calorific value
NIR	National Inventory Report
NIS	National Inventory System
NMVOC	Non-methane volatile organic compounds

N_2O	Nitrous oxide (laughing gas)
NO_x	Nitrogen oxides
PFC	Perfluorinated carbon compounds (e.g. Tetrafluoromethane)
SAEFL	Swiss Agency for the Environment, Forests and Landscape (former name of Federal Office for the Environment FOEN)
SF_6	Sulphur hexafluoride
SFOE	Swiss Federal Office of Energy
SFSO	Swiss Federal Statistical Office
SO_2	Sulphur dioxide
SWISSMEM	Association of Swiss Mechanical and Electrical Engineering Industries
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
VTG	Verteidigung Luftwaffe (Federal Air Force Administration)

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 third National Inventory Report (NIR 2006) prepared under the UNFCCC. It includes, as a separate document, Switzerland's 2004 Inventory in the CRF.

On 9 July 2003, Switzerland ratified the Kyoto Protocol to the UNFCCC. The Swiss National Inventory System (NIS) according to Article 5.1 of the Kyoto Protocol is presently being implemented and will be fully operational later in 2006.

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 Swiss Federal Research Station for Agroecology and Agriculture (FAL) and the Federal Office for 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 third National Inventory Report, Switzerland took into account the findings of the 2004 in-country review, as well as the 2005 centralized review of its previous inventory submissions. Improvements are documented in the relevant chapters of this report. The Inventory Development Plan (Annex 6) has been updated accordingly.

It should be noted that the current report is the **second submission in 2006** (first submission: 12 April 2006). This second submission includes a number of improvements, e.g. the subtraction of Liechtenstein's energy related emissions, revised emissions from 1A3a Civil Aviation and the CH_4 and N_2O emissions for 2004 from sector 4 Agriculture, which had not been available yet for the submission in April 2006.

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, agriculture, land-use change and forestry (LUCF) and waste. The data are compiled at the FOEN in Internal Greenhouse Gas Files. 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) and in the IPCC Good Practice Guidance (IPCC 2000). The data in the FOEN inventory files are pre-processed in order to enable transfer to the Common Reporting Format (CRF) required for reporting under the UNFCCC.

All inventory data are assembled and prepared for input into the CRF tables by a specialized task force, the FOEN Inventory Group, which is responsible for ensuring the conformity of the inventory with 2003 UNFCCC guidelines. 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 analysis, and were responsible for performing some tasks relating to the inventory development plan. An inventory quality assurance and control system is being established in the context of the Swiss National Inventory System and is being introduced gradually, with full implementation later in 2006.

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. The NIR 2006 implements recommendations of the UNFCCC reviews by providing more detailed descriptions of the methodologies and results than the NIR 2005. A number of methodologies and input data on emission factors and activities have been revised and updated. In a few instances, results are not yet available for this April 2006 submission (see the notes in the chapters concerned). Any improvements will be reflected in the resubmission of the 2004 GHG Inventory in May 2006 or in the documentation of the Initial Report under Article 7.4 of the Kyoto Protocol.

Chapter 9 explains and justifies recalculations that have been performed since the last inventory submission to the UNFCCC Secretariat in 2005.

Trend Summary: National GHG Emissions and Removals

In 2004, Switzerland emitted about 53’019 Gg (kilotonnes) CO_2 equivalent, or 7.15 tonnes CO_2 equivalent per capita (CO_2 only: 6.13 tonnes per capita), to the atmosphere, not including CO_2 emissions/removals from Land-Use Change and Forestry (LUCF).

For 2004, 35 key categories were identified for the country’s level and trend analysis, covering approximately 97% of total CO_2-equivalent greenhouse gas (GHG) emissions. Approximately 40% of total GHG emissions derived from the two most important key sources: CO_2 from Fuel Combustion – Transport (source category 1A3b, road transportation, gasoline) and CO_2 from Fuel Combustion – Other Sectors (source category 1A4b, residential, liquid fuels).

Table 1 shows Switzerland’s annual GHG emissions by individual GHG from 1990 (base year) to 2004. Total annual GHG emissions do not show any significant trend. Fluctuations in total GHG emissions over the period 1990–2004 are less than 5%. In 2004, total gross GHG emissions (without LUCF) showed an increase of 0.4% as compared to the level recorded for 1990 (see also Table 2).

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	***2004/1990***
	CO_2 equivalent (Gg)															*%*
Net CO_2 emissions/removals	43'239	44'817	44'774	41'210	40'422	40'981	41'549	40'734	42'024	42'588	44'067	45'147	44'104	43'127	43'248	*0.0%*
Gross CO_2 emissions (without LUCF)	44'513	46'156	46'198	43'598	42'814	43'335	44'056	43'408	44'627	44'844	43'918	44'697	43'798	44'894	45'317	*1.8%*
CH_4	4'529	4'507	4'355	4'278	4'080	4'080	3'994	3'921	3'861	3'861	3'769	3'795	3'705	3'678	3'683	*-18.7%*
N_2O	3'541	3'548	3'529	3'479	3'434	3'349	3'388	3'285	3'275	3'253	3'264	3'233	3'225	3'157	3'156	*-10.9%*
HFCs	0.02	0.2	6.1	13	30	152	193	258	311	360	418	493	503	539	618	---
PFCs	100	85	69	30	18	15	17	24	28	40	93	52	50	73	67	*-32.9%*
SF_6	143	146	148	126	112	98	94	131	161	147	193	235	210	187	176	*22.8%*
Total (with net CO_2 emissions/removals)	51'552	53'103	52'881	49'136	48'096	48'674	49'236	48'353	49'661	50'249	51'805	52'956	51'798	50'762	50'950	*-1.2%*
Total (without CO_2 from LUCF)	**52'826**	**54'442**	**54'305**	**51'524**	**50'488**	**51'029**	**51'743**	**51'027**	**52'263**	**52'505**	**51'655**	**52'506**	**51'493**	**52'529**	**53'019**	***0.4%***

Table 1 Summary of Switzerland’s GHG emissions in CO_2 equivalent (Gg), 1990–2004 (CRF Table 10s5).

With regard to the distribution of emissions by individual greenhouse gas, CO_2 is the largest single contributor to emissions, accounting for 85.5% of total gross GHG emissions (excluding LUCF) in 2004 (1990: 84.3%). The share of CH_4 decreased from 8.6% (1990) to 6.9% (2004). Over the same period, the share of N_2O decreased from 6.7% to 6.0%, while the share of synthetic gases increased from 0.5% to 1.6%.

Greenhouse Gas Emissions	1990		1995		2000		2004	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
Gross CO_2 emissions (without LUCF)	44'513	84.3%	43'335	84.9%	43'918	85.0%	45'317	85.5%
CH_4	4'529	8.6%	4'080	8.0%	3'769	7.3%	3'683	6.9%
N_2O	3'541	6.7%	3'349	6.6%	3'264	6.3%	3'156	6.0%
HFCs	0	0.0%	152	0.3%	418	0.8%	618	1.2%
PFCs	100	0.2%	15	0.0%	93	0.2%	67	0.1%
SF_6	143	0.3%	98	0.2%	193	0.4%	176	0.3%
Total (without CO_2 from LUCF)	**52'826**	**100%**	**51'029**	**100%**	**51'655**	**100%**	**53'019**	**100%**

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

Figure 1 shows the shares of 2004 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 1990–2004.

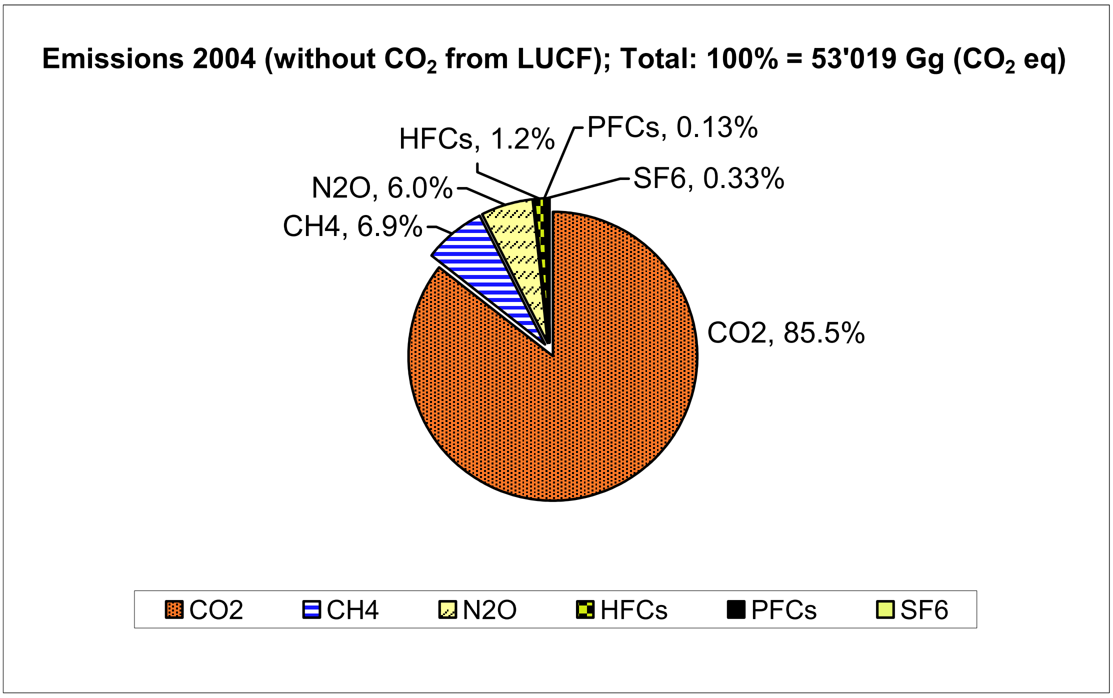

Figure 1 Contribution of individual gases to Switzerland's GHG emissions (without CO_2 from LUCF), 2004.

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. The Energy sector (sector 1) is the largest source of national emissions. A slight upward trend is found for the Energy sector for the period 1994–2004. Year-to-year variations are mainly caused by changing winter temperatures. The emissions from all other sectors have decreased during this period.

Greenhouse Gas Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2004/1990
	CO_2 equivalent (Gg)															%
1 Energy	42'045	44'044	44'212	41'844	40'927	41'624	42'541	42'076	43'294	43'493	42'419	43'173	42'303	43'414	43'745	*4.0%*
2 Industrial Processes	3'183	2'825	2'664	2'350	2'491	2'407	2'251	2'182	2'288	2'380	2'673	2'786	2'721	2'727	2'886	*-9.4%*
3 Solvent and Other Product Use	466	444	424	400	385	367	346	324	302	292	281	270	257	247	233	*-50.1%*
4 Agriculture	6'090	6'098	5'980	5'965	5'809	5'761	5'750	5'593	5'557	5'544	5'506	5'528	5'472	5'380	5'413	*-11.1%*
5 Land-Use Change and Forestry	-1'273	-1'339	-1'424	-2'388	-2'392	-2'355	-2'507	-2'674	-2'602	-2'256	149	450	305	-1'766	-2'069	*62.5%*
6 Waste	1'041	1'031	1'025	965	876	869	855	853	822	797	776	749	740	760	743	*-28.6%*
Total (with net CO_2 emissions/removals)	51'552	53'103	52'881	49'136	48'096	48'674	49'236	48'353	49'661	50'249	51'805	52'956	51'798	50'762	50'950	*-1.2%*
Total (without CO_2 from LUCF)	**52'826**	**54'442**	**54'305**	**51'524**	**50'488**	**51'029**	**51'743**	**51'027**	**52'263**	**52'505**	**51'655**	**52'506**	**51'493**	**52'529**	**53'019**	***0.4%***

Table 3 Switzerland's GHG emissions/removals by source and sink categories in CO_2 equivalent (Gg), 1990–2004.

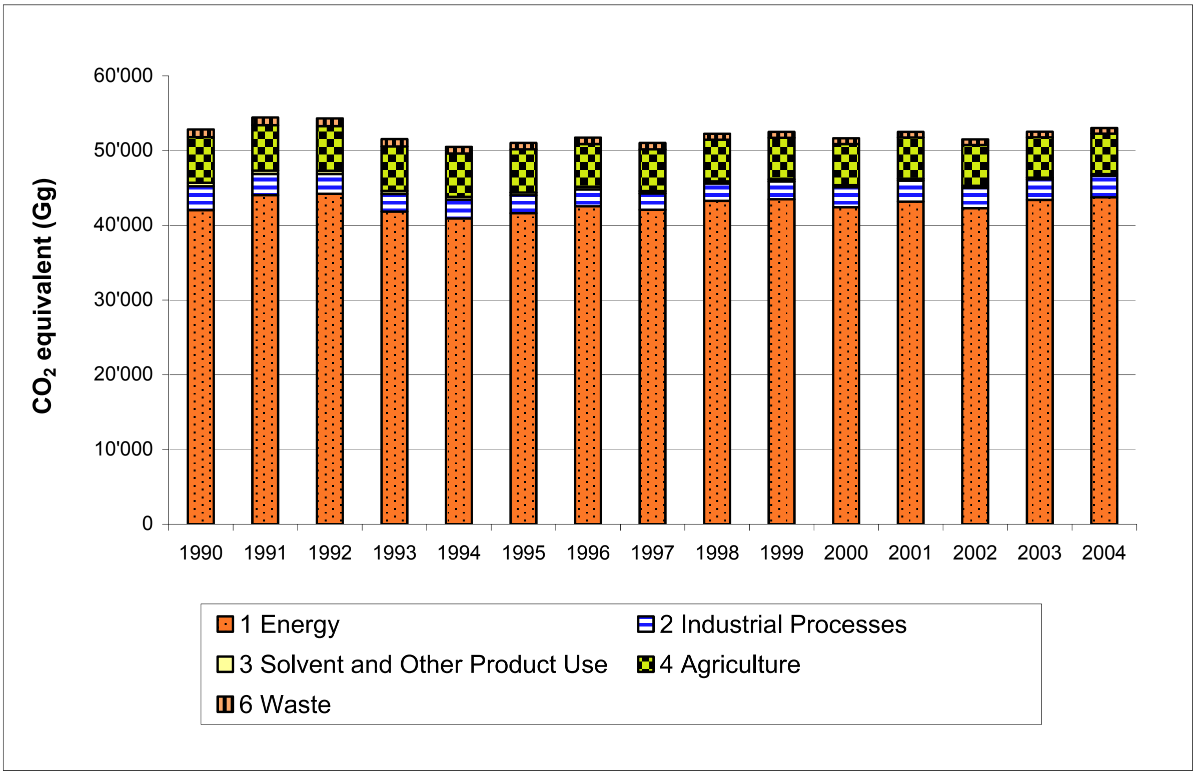

Figure 2 Switzerland's greenhouse gas emissions in CO_2 equivalent (Gg) by main source categories, 1990–2004 (without CO_2 from LUCF).

Total gross emissions (excluding LUCF) remained almost unchanged from 1990 to 2004, with an increase of 0.4% in 2004 compared to 1990. Total emissions including net CO_2 emissions/removals show a decrease of 1.2% over the same period. Heavy storms in 1990 and, in particular, at the end of 1999 led to significant reductions in net removals within the LUCF sector (visible over several years due to 3-year averaging of the storm effects). Removals from LUCF have now returned to the levels prevailing in the 1990s.

Table 4 shows the contributions of individual sectors to total gross emissions for selected years in more detail. Between 1990 and 2004, the relative contribution of source category 1 (Energy) increased from 79.6% to 82.5%, whereas decreases were seen from 6.0% to 5.4% for category 2 (Industrial Processes), from 11.5% to 10.2% for category 4 (Agriculture), and from 2% to 1.4% for category 6 (Waste).

Greenhouse Gas Source Categories	1990		1995		2000		2004	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1 Energy	42'045	79.6%	44'212	81.4%	40'927	81.1%	43'745	82.5%
2 Industrial Processes	3'183	6.0%	2'664	4.9%	2'491	4.9%	2'886	5.4%
3 Solvent and Other Product Use	466	0.9%	424	0.8%	385	0.8%	233	0.4%
4 Agriculture	6'090	11.5%	5'980	11.0%	5'809	11.5%	5'413	10.2%
6 Waste	1'041	2.0%	1'025	1.9%	876	1.7%	743	1.4%
Total (without CO_2 from LUCF)	**52'826**	**100%**	**54'305**	**100%**	**50'488**	**100%**	**53'019**	**100%**

Table 4 Switzerland's total gross GHG emissions (excluding LUCF) in CO_2 equivalent (Gg) by source category, selected years.

Acknowledgements

We would like to thank all institutions, companies and individuals that contributed in some form to the Swiss national GHG Inventory as data suppliers, experts or reviewers.

In particular, the support of the Office of Environmental Protection of the Principality of Liechtenstein was highly appreciated.

We also gratefully acknowledge the support and suggestions we received from M.P.J. Tinus Pulles and Suvi Monni related to the performance of the Monte Carlo simulations.

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). The present report is Switzerland's third National Inventory Report prepared under the UNFCCC. It includes, as a separate document, Switzerland's 2004 Inventory in the CRF (FOEN 2006).

On 9 July 2003, Switzerland ratified the Kyoto Protocol to the UNFCCC. The Swiss National Inventory System (NIS) according to Article 5.1 of the Kyoto Protocol is presently being implemented and will be fully operational later in 2006.

It should be noted that the present report is the second submission in 2006 (first submission: 12 April 2006). This resubmission includes the following improvements:

- Subtraction of the energy related emissions of the Principality of Liechtenstein following the preparation of the Liechtenstein GHG inventory in line with Kyoto Protocol reporting requirements. So far, Switzerland's GHG inventory and, correspondingly, the National Inventory Report included these emissions. Switzerland and Liechtenstein form a customs and monetary union, leading to unrestricted exchange of goods including, for example, fossil fuels. The separation of the emissions of the Principality of Liechtenstein is based on greenhouse gas inventories of the years 1990 and 2004 which have become available in 2006.
- Revised emissions from 1A3a, Civil Aviation, based on a Tier 3a method (replacing a Tier 2 method).
- CO_2 emissions from NMVOC of sector 1B, Fugitive Emissions, and CO_2 emissions from post combustion of NMVOC of sector 3, Solvent and Other Product Use, which both have not been reported previously.
- CH_4 and N_2O emissions for 2004 from sector 4, Agriculture, which were not available yet for the April 2006 submission.

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), which is the entity with overall responsibility for the national GHG inventory.

As part of a comprehensive 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. 5.1 of the Kyoto Protocol, the project encompasses the following elements:

- Establishment of agreements with partner agencies, relating to
  - roles and responsibilities,
  - participation in the inventory development process,

  - data use, communication and publication
- Inventory Development Plan
- Setting-up of the QA/QC system
- Official consideration and approval of data
- Upgrading and updating of the national air pollution database (EMIS)
- Data documentation and storage

An FOEN Inventory Group has been formed to implement and run the NIS. Information relating to the Swiss GHG Inventory is made publicly accessible through the website www.climatereporting.ch, where detailed contact information is also available.

1.3. Process for Inventory Preparation

Figure 3 gives a schematic overview of the institutional setting of the process of inventory preparation within the NIS.

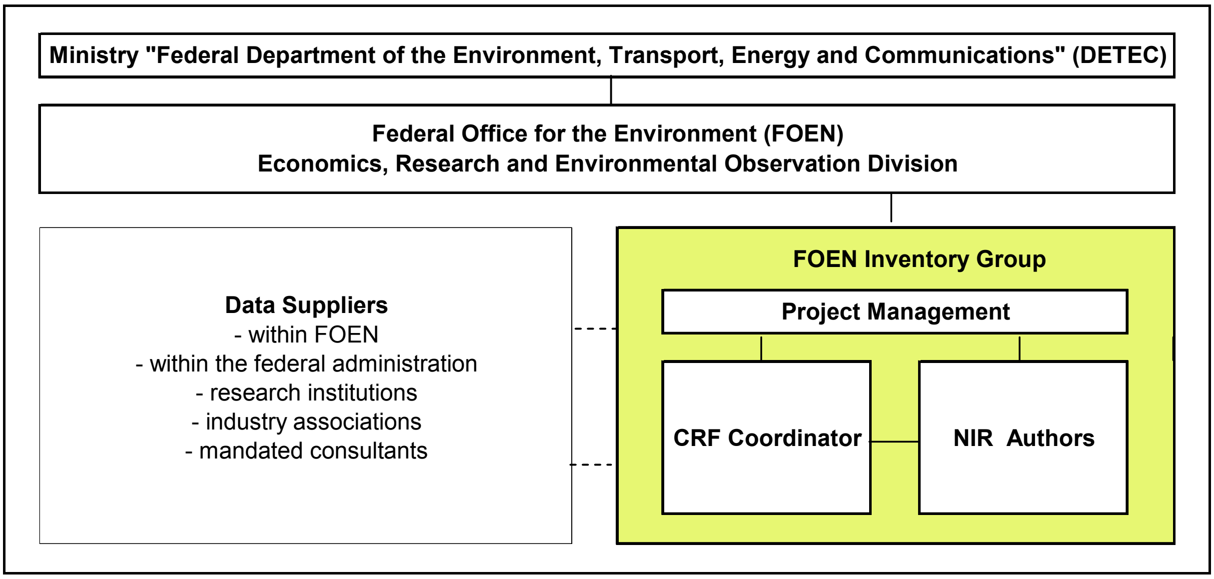

Figure 3 Institutional setting of the process of inventory preparation.

The FOEN Inventory Group consists of the internal project team, including a GHG inventory project leader, a QA/QC expert, a CRF compilation specialist, and database specialists. The integration of an expert dedicated to the improvement of quality management procedures by the end of 2005 was an important milestone in upgrading the inventory system with a view to compliance with reporting requirements.

The Inventory Group is supported by mandated external experts contributing to the preparation of the yearly inventory submission, in particular the National Inventory Report.

The Inventory Group collaborates with several divisions within the Office, as well as with several other government agencies that supply relevant data. In addition, certain data are acquired through consultants or industry associations (see Table 5).

The roles and responsibilities of the different contributors are defined through

- memoranda of understanding within the FOEN,

- agreements with the other government agencies involved,
- agreements with research institutions and industry associations, and
- contracts with consultants.

Conclusion of memoranda of understanding, agreements and contracts is under way and will be completed by September 2006.

The FOEN maintains internal GHG inventory files, which contain all the basic data needed to prepare the UNFCCC Greenhouse Gas Inventory in the CRF. The underlying data used to compile the internal inventory files are collected by the various data suppliers. Figure 4 illustrates in a simplified manner the data collection and processing steps leading to the CRF tables required for reporting under the UNFCCC. The FOEN internal GHG inventory files will be replaced by a comprehensive data set produced by the national air pollution database EMIS as of the 2007 inventory submission (see Chapter 1.4.3).

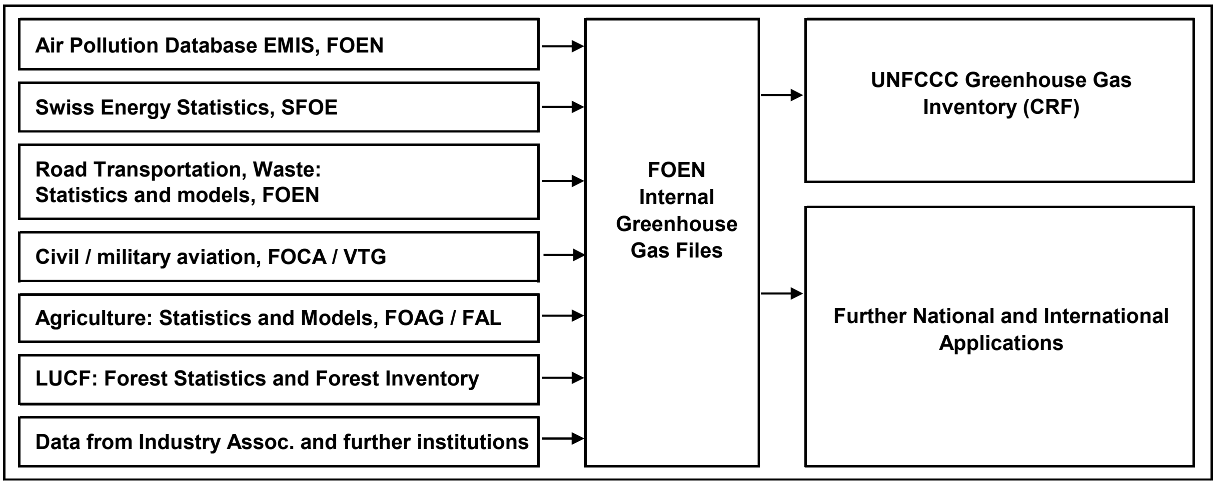

Figure 4 Data collection for FOEN Internal GHG Files and CRF tables.

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 Guidance, are to be taken into account. Supervision of data suppliers by the FOEN Inventory Group, together with QA/QC and review procedures, provides additional safeguards to maintain or improve the consistency, completeness and accuracy of inventory data.

The data suppliers are listed in the following table.

	Institution	Subject	Data supplied for source category...												References
			1A1	1A2	1A3	1A4	1A5	1B	R.A.	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 2006
2	FOEN, Air Pollution Control	Off-road database			x		x								SAEFL 2005a
3	FOEN, Waste and Raw Materials	Waste Statistics	x	x										x	SAEFL 2005c
4	FOEN, Forest Division	Forest Statistics											x		SAEFL 2005b
5	SFOE	Global Energy Statistics	x	x	x	x		x	x						SFOE 2005
6	FOCA/BAZL	Air traffic			x										FOCA 2004
7	Betriebe Luftwaffe	Military Aviation			x										VTG 2006
8	SFSO	Agric. + Land use data										x	x	x	SFSO 1996, 2004a/b
9	FAL	Agric. + Land use change										x	x		SBV 2004; SFSO 1996, 2004a/b
10	WSL	National Forest Inventory											x		SFSO 1996, SAEFL 2005b
11	Cepe/Basics	Energy Consumption		x		x									Cepe 2005, Basics 2005
12	Carbotech	Import Statistics syn. gases								x					SAEFL 2005
13	Ind. suppliers: SGCI, Swissmem, VSAI etc.	Synthetic gases								x					Carbotech 2006
14	Swiss Petroleum Ass. (Erdölvereinigung)	Oil Statistics							x						EV 2005
15	Cemsuisse	Cement, clinker prod.		x						x					cemsuisse 2004
	Data suppliers (sporadic updates)														
16	SVGW	Gas distribution losses						x							Xinmin 2004
17	EMPA	Various emission factors	x	x	x	x									see Annex A2.2.1
18	INFRAS	On-road Emission Model			x										SAEFL 2004a
19	Electrowatt	Off-road activity data			x	x	x								SAEFL 2005a
20	TTM Meier	Off-road emission factors			x	x	x								SAEFL 2005a, TTM 2005
21	INFRAS	Off-road emission model			x	x	x								SAEFL 2005a
22	Sigmaplan, Meteotest	LULUCF											x		FOEN 2006b (Annex 4)

Table 5 Data suppliers 1–15 provide annual updates, suppliers 16–22 provide sporadic updates.

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), as adopted by the UNFCCC.

To date, emissions have been calculated, in part, by multiplying emission factors and activity rates in the "FOEN internal GHG inventory files" [1]. For the other part, emissions have been calculated by the data suppliers listed in Figure 4 (e.g. for agriculture). In the latter cases, the resulting emission data have been directly inserted into the FOEN internal GHG inventory files. This procedure has been used for the previous and the present submission.

For future submissions, the FOEN internal GHG inventory files will be replaced by the Swiss national air pollution database EMIS, which was redesigned and extended during 2005 to serve climate policy purposes as well. For the present submission, a number of source categories have been remodelled in EMIS, which allowed the findings of the internal GHG files to be updated. For further details, see Chapter 1.4.3 below.

The National Approach for source category 1 Energy is based on the statistics for fuel consumption (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.

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[1] Formerly called "SAEFL internal GHG inventory files".

[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, 1A5 Off-road: CORINAIR 2003 (for CO_2 also Reference Approach).
  Emission factors: Country-specific; exception N_2O: IPCC default.
- 1A3 Transport: CO_2 Reference Approach and National Approach based on oil imports, refinery production numbers, fuel statistics and carbon content of the fuels.
  Other gases: country-specific bottom-up model for activities and emission factors.
  Exception: N_2O emission factors for aviation are IPCC default values.

2 Industrial Processes

- 2A1 Cement Production: IPCC Tier 2 method.
  Emission factors: Country-specific.
- 2C Metal Production: CORINAIR, Tier 2 method for CO_2, and Tier 3b method for PFCs.
  Emission factors: Country-specific.
- 2F Consumption of Halocarbons and SF_6: CORINAIR, Tier 2 method with two different approaches (statistics, surveys).
  Emission factors: Country-specific.

4 Agriculture

- 4A Enteric Fermentation (CH_4), 4D Agricultural Soils (N_2O): Country-specific model corresponding to an extension of the IPCC Tier 2 method.
  Emission factors: Country-specific.

6 Waste

- 6A Solid Waste Disposal on Land (CH_4): IPCC 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 overall energy consumption as well as 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 2005). 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 1.48% in 2004 (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 (EMIS 2006). 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. Its structure corresponds to the EMEP/CORINAIR system for classifying emission-generating activities. EMEP/CORINAIR uses the Nomenclature for Reporting ("NFR code", UNECE/EMEP 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, dust, Pb, Zn, Cd, Hg, PCDD/PCDF, HF, CH_4, CO_2 (fossil origin), CO_2 (from biomass) and PM10. The input data originate from a variety of sources, such as production data and emission factors from industry and industry associations, or agriculture statistics. EMIS is documented in an internal FOEN manual for the database (EMIS 2006).

The original EMIS database underwent a full redesign in 2005. 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. For the present April 2006 submission, emissions from EMIS that are relevant for the GHG inventory (in particular, non-energy-related emissions) were exported for the last time to the FOEN internal GHG inventory files and then transferred to produce the CRF tables. A number of emission estimates were generated independently by the Internal Greenhouse Gas Files and by the new EMIS database, both using the same updated emission factors and activity data. The results were compared, and differences were used to identify and eliminate bugs. The output of the two approaches has proven to be fully congruent.

For future submissions, CRF tables will be generated with EMIS via the CRF Reporter. All data from sources which up to now were fed directly into the FOEN Internal GHG Files are to be incorporated into the EMIS database. The sources in question 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, and the National Forest Inventory and National Forest Statistics; data on synthetic GHG emissions stem directly from the relevant industry associations (see Figure 4).

1.5. Key Categories

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%. The same detailed disaggregation as in 2005 has been used to identify important sub-sources (see Inventory Development Plan in Annex 4). A more detailed description of the key category analysis and the level of disaggregation is provided in Annex 1.

No Tier 2 key category analysis is carried out. This would require a Tier 2 uncertainty analysis for the whole inventory. For the present submission, such an uncertainty analysis has been performed, but only for the key categories and not for all categories of the inventory.

For the key category analysis, the category 2F Consumption of Halocarbons and SF_6 has been separated into four sub-categories:

- 2F, sum of PFC (No. 26 in Table 6)
- 2F_o (HFC), sum of HFC without HFC from 2F1 (No. 27 in Table 6)
- 2F1, HFC from 2F1 Refrigeration and Air Conditioning Equipment (No. 28 in Table 6)
- 2F_o (SF_6), sum of SF_6 without SF_6 from 2F7 (no longer a key category as in previous years, therefore not contained in Table 6)

Due to the emission dynamics within these groups, three of the four categories appear as key categories by trend (Table 6): while HFCs were not present in 1990, 73.9 t CO_2 equivalent were emitted in 2004.

For 2004, 38 key categories have been identified:

No.	IPCC Source Categories (and fuels if applicable)				Direct GHG	Result level assessment	Result trend assessment
1	1A1	1. Energy	A. Fuel Combustion	Gaseous Fuels	CO2	KC level	KC trend
2	1A1	1. Energy	A. Fuel Combustion	Liquid Fuels	CO2	KC level	KC trend
3	1A1	1. Energy	A. Fuel Combustion	Other Fuels	CO2	KC level	KC trend
4	1A1	1. Energy	A. Fuel Combustion	Other Fuels	N2O	-	KC trend
5	1A1	1. Energy	A. Fuel Combustion	Solid Fuels	CO2	-	KC trend
6	1A2	1. Energy	A. Fuel Combustion	Gaseous Fuels	CO2	KC level	KC trend
7	1A2	1. Energy	A. Fuel Combustion	Liquid Fuels	CO2	KC level	KC trend
8	1A2	1. Energy	A. Fuel Combustion	Other Fuels	CO2	KC level	KC trend
9	1A2	1. Energy	A. Fuel Combustion	Solid Fuels	CO2	KC level	KC trend
10	1A3a	1. Energy	A. Fuel Combustion		CO2	-	KC trend
11	1A3b	1. Energy	A. Fuel Combustion	Diesel	CO2	KC level	KC trend
12	1A3b	1. Energy	A. Fuel Combustion	Gasoline	CO2	KC level	-
13	1A3b	1. Energy	A. Fuel Combustion	Gasoline	CH4	-	KC trend
14	1A3e	1. Energy	A. Fuel Combustion		CO2	-	KC trend
15	1A4a	1. Energy	A. Fuel Combustion	Gaseous Fuels	CO2	KC level	KC trend
16	1A4a	1. Energy	A. Fuel Combustion	Liquid Fuels	CO2	KC level	KC trend
17	1A4b	1. Energy	A. Fuel Combustion	Gaseous Fuels	CO2	KC level	KC trend
18	1A4b	1. Energy	A. Fuel Combustion	Liquid Fuels	CO2	KC level	KC trend
19	1A4c	1. Energy	A. Fuel Combustion	Liquid Fuels	CO2	KC level	-
20	1A5	1. Energy	A. Fuel Combustion	Liquid Fuels	CO2	KC level	KC trend
21	1B2	1. Energy	B. Fugitive Emissions from Fuels		CH4	-	KC trend
22	2A1	2. Industrial Processes	A. Mineral Products; Cement Production-CO2		CO2	KC level	KC trend
23	2B	2. Industrial Processes	B. Chemical Industry		N2O	-	KC trend
24	2C3	2. Industrial Processes	C. Metal Production; Aluminium Production-PFC		PFC	-	KC trend
25	2C3	2. Industrial Processes	C. Metal Production; Aluminium Production-CO2		CO2	-	KC trend
26	2F	2. Industrial Processes	F. Consumption of Halocarbons and SF6		PFC	-	KC trend
27	2F_o	2. Industrial Processes	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	-	KC trend
28	2F1	2. Industrial Processes	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	KC level	KC trend
29	3	3. Solvent and Other Product Use			CO2	-	KC trend
30	3	3. Solvent and Other Product Use			N2O	-	KC trend
31	4A	4. Agriculture	A. Enteric Fermentation		CH4	KC level	KC trend
32	4B	4. Agriculture	B. Manure Management		N2O	KC level	KC trend
33	4B	4. Agriculture	B. Manure Management		CH4	KC level	-
34	4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions		N2O	KC level	KC trend
35	4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	KC level	KC trend
36	6A	6. Waste	A. Solid Waste Disposal on Land		CH4	KC level	KC trend
37	6B	6. Waste	B. Wastewater Handling		N2O	KC level	-
38	6D	6. Waste	D. Other		CH4	-	KC trend

Table 6 List of Switzerland's Key Categories 2004 sorted by category codes.

Of the 38 key categories, 21 are in sector 1 Energy, accounting for 81.2% of total CO_2-equivalent emissions in 2004. The other key categories are from sectors 2 Industrial Processes (4.7%), 3 Solvent and other Product Use (0.4%), 4 Agriculture (9.8%), and 6 Waste (1.2%). There are two major key sources:

- 1A3b Energy, Fuel Combustion, Road Transportation, gasoline, CO_2, level contribution 21.4%,
- 1A4b Energy, Fuel Combustion, Other Sectors, Residential, liquid fuels, CO_2, level contribution 17.8%.

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

No.	IPCC Source Categories (and fuels if applicable)			Direct GHG	1990 Gg CO2 eq	2004 Gg CO2 eq	Contribut. Level	Level cumulated	Contrib. Trend	Result level assessment	Result trend assessment
12	1A3b	1A. Fuel Combustion	Gasoline	CO2	11'332.2	11'363.4	21.43%	21.43%	0.1%	KC level	-
18	1A4b	1A. Fuel Combustion	Liquid Fuels	CO2	10'215.6	9'422.8	17.77%	39.21%	7.4%	KC level	KC trend
16	1A4a	1A. Fuel Combustion	Liquid Fuels	CO2	4'375.4	3'999.7	7.54%	46.75%	3.5%	KC level	KC trend
11	1A3b	1A. Fuel Combustion	Diesel	CO2	2'412.0	3'606.7	6.80%	53.55%	10.6%	KC level	KC trend
7	1A2	1A. Fuel Combustion	Liquid Fuels	CO2	3'392.4	2'911.3	5.49%	59.04%	4.4%	KC level	KC trend
31	4A	4A. Enteric Fermentation		CH4	2'766.8	2'515.7	4.74%	63.79%	2.3%	KC level	KC trend
17	1A4b	1A. Fuel Combustion	Gaseous Fuels	CO2	1'364.9	2'249.7	4.24%	68.03%	7.9%	KC level	KC trend
6	1A2	1A. Fuel Combustion	Gaseous Fuels	CO2	1'064.1	2'029.1	3.83%	71.86%	8.6%	KC level	KC trend
3	1A1	1A. Fuel Combustion	Other Fuels	CO2	1'519.2	1'925.5	3.63%	75.49%	3.6%	KC level	KC trend
22	2A1	2A. Mineral Products; Cement Production-CO2		CO2	2'524.8	1'714.2	3.23%	78.72%	7.3%	KC level	KC trend
15	1A4a	1A. Fuel Combustion	Gaseous Fuels	CO2	941.0	1'415.2	2.67%	81.39%	4.2%	KC level	KC trend
34	4D1	4D. Agricultural Soils; Direct Soil Emissions		N2O	1'389.8	1'223.3	2.31%	83.70%	1.5%	KC level	KC trend
2	1A1	1A. Fuel Combustion	Liquid Fuels	CO2	691.2	849.6	1.60%	85.30%	1.4%	KC level	KC trend
19	1A4c	1A. Fuel Combustion	Liquid Fuels	CO2	713.4	727.7	1.37%	86.67%	0.1%	KC level	-
35	4D3	4D. Agricultural Soils; Indirect Emissions		N2O	818.9	679.3	1.28%	87.96%	1.3%	KC level	KC trend
20	1A5	1A. Fuel Combustion	Liquid Fuels	CO2	512.9	668.9	1.26%	89.22%	1.4%	KC level	KC trend
28	2F1	2F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.0	544.6	1.03%	90.24%	4.9%	KC level	KC trend
9	1A2	1A. Fuel Combustion	Solid Fuels	CO2	1'391.2	541.4	1.02%	91.27%	7.6%	KC level	KC trend
33	4B	4B. Manure Management		CH4	452.3	404.0	0.76%	92.03%	0.4%	KC level	-
32	4B	4B. Manure Management		N2O	448.2	396.8	0.75%	92.78%	0.5%	KC level	KC trend
1	1A1	1A. Fuel Combustion	Gaseous Fuels	CO2	234.8	374.2	0.71%	93.48%	1.2%	KC level	KC trend
36	6A	6A. Solid Waste Disposal on Land		CH4	693.0	348.6	0.66%	94.14%	3.1%	KC level	KC trend
8	1A2	1A. Fuel Combustion	Other Fuels	CO2	156.9	286.4	0.54%	94.68%	1.2%	KC level	KC trend
37	6B	6B. Wastewater Handling		N2O	189.4	208.1	0.39%	95.07%	0.2%	KC level	-
29	3	3. Solvent and Other Product Use		CO2	357.0	182.5	0.34%	95.42%	1.6%	-	KC trend
21	1B2	1B. Fugitive Emissions from Fuels		CH4	379.8	177.9	0.34%	96.09%	1.8%	-	KC trend
10	1A3a	1A. Fuel Combustion		CO2	252.6	143.7	0.27%	96.66%	1.0%	-	KC trend
4	1A1	1A. Fuel Combustion	Other Fuels	N2O	48.4	112.8	0.21%	97.33%	0.6%	-	KC trend
14	1A3e	1A. Fuel Combustion		CO2	200.0	109.1	0.21%	97.74%	0.8%	-	KC trend
5	1A1	1A. Fuel Combustion	Solid Fuels	CO2	47.0	105.4	0.20%	97.94%	0.5%	-	KC trend
38	6D	6D. Other		CH4	30.3	91.4	0.17%	98.29%	0.5%	-	KC trend
27	2F_o	2F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	0.0	73.9	0.14%	98.59%	0.7%	-	KC trend
25	2C3	2C. Metal Production; Aluminium Production-CO2		CO2	139.3	71.8	0.14%	98.72%	0.6%	-	KC trend
26	2F	2F. Consumption of Halocarbons and SF6		PFC	0.0	55.9	0.11%	98.83%	0.5%	-	KC trend
30	3	3. Solvent and Other Product Use		N2O	109.4	50.4	0.09%	98.93%	0.5%	-	KC trend
13	1A3b	1A. Fuel Combustion	Gasoline	CH4	91.3	22.9	0.04%	99.49%	0.6%	-	KC trend
23	2B	2B. Chemical Industry		N2O	100.8	16.1	0.03%	99.67%	0.8%	-	KC trend
24	2C3	2C. Metal Production; Aluminium Production-PFC		PFC	100.2	11.4	0.02%	99.80%	0.8%	-	KC trend

Table 7 Details of Switzerland's Key Categories: contributions in level and trend analysis, and cumulative level contributions ("level cum."). The numbers (No.) correspond to those in Table 6.

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

1.6.1. The QA/QC system

Since autumn 2004, implementation of the National Inventory System, including the QA/QC system, has been under way. Major elements of the QA/QC system (in line with the structure proposed in IPCC 2000) and their implementation status are summarized below. The detailed "Description of the Swiss QA/QC system" is being submitted to the UNFCCC Secretariat as a supplement to this National Inventory Report (FOEN 2006).

a) Inventory agency responsible for coordinating QA/QC activities

The FOEN Inventory Group (see Figure 3) has overall responsibility for coordinating QA/QC activities for the national inventory. By the end of 2005, a QA/QC officer had joined the FOEN Inventory Group. One of his main tasks is to ensure the application of QA/QC standards both within the FOEN Inventory Group and in outside agencies (external consultants, data suppliers).

b) QA/QC plan

The QA/QC plan contains a description of current QA/QC activities and procedures, key findings, and planned improvements. It will be reviewed annually and modified by the FOEN Inventory Group if necessary.

c) QC procedures

All experts involved in inventory preparation have to complete checklists to document their QC activities. The checklists contain all the items listed in the Good Practice Guidance (IPCC 2000; Table 8.1; corresponds to Tier 1 QC).

Standard Operating Procedures to ensure agreed standards within the inventory compilation process are currently being developed (priority will be given to key categories).

d) QA review procedures

QA procedures include an internal review of the NIR by members of the FOEN Inventory Group prior to submission. Every year, external experts are mandated to review selected key categories after submission. Additionally, the results of the UNFCCC inventory reviews are analysed and used to update the Inventory Development Plan.

e) Reporting, documentation, and archiving procedures

A method is currently being implemented to ensure systematic documentation of all essential decisions reached by the experts involved in the planning, preparation and compilation of the inventory. Starting with preparations for NIR 2007, the results of all QA/QC activities and procedures will be documented and archived for consultation by reviewers.

1.6.2. Time Schedule of Inventory Preparation

The approximate yearly cycle of inventory preparation is shown in Table 8.

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Inventory Management												
Yearly kick-off meeting												
Supervision of emission caculation												
Supervision of editing of NIR												
Archiving												
QC												
Review report UNFCCC												
QA												
Submission												
Emissions, Removals / GHG inventory												
Data collection			Energy data				Non Energy data					
Emission/removal calculation												
CRF tables												
Key Source Analysis												
Uncertainty analysis												

Table 8 Schedule for inventory preparation.

1.6.3. Treatment of Confidential Data

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 of HFCs, PFCs and SF_6 are only partly presented at the most disaggregated level, for reasons of confidentiality. However, total emissions are reported in aggregated tables. Confidential data will be made available by the FOEN in line with the procedures agreed under the UNFCCC for in-country review of the inventory.

1.7. Uncertainty Evaluation

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. Uncertainty of key categories is 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 sources are included, partly on an aggregated level. In Tier 2 analysis, only key categories are included. In both analyses, residual non-key categories are treated as an additional single “category” with an estimated error in the virtual activity data and in the virtual emission factor. This allows the uncertainty of the whole Swiss inventory to be estimated. In this section, the aggregated results are presented. 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. For other sources, a qualitative rather than quantitative estimate of uncertainties is given.

As the IPCC Guidelines suggest (IPCC 1997a), uncertainties are expressed as half of the 95% confidence interval.

The uncertainty analysis presented in the next paragraphs is not based on the data of the current GHG inventory (May 2006) but on the data submitted in April 2006 (FOEN 2006a). On the level of the emissions, the modifications carried out since the April submission (see Chapter 1.1) are modest: The national total of 2004 emissions (without CO_2 from LUCF) changed from 53’034 Gg CO_2 eq (April 2006 submission) to 53’019 Gg CO_2 eq (present submission). For that reason, the management of the FOEN Inventory Group decided to abandon new runs of the uncertainty analysis. Therefore, the input data and the uncertainty results shown in paragraphs 1.7.1 to 1.7.5 relate to the data submitted in April 2006 and deviate slightly from the data of the current submission. Presumably, the uncertainty results would only change marginally when applying the emission data of the current submission.

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 2005) 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.

All uncertainty figures correspond to the standard deviation. Distributions are assumed to be symmetric in the Tier 1 method. For the Monte Carlo simulation, asymmetric distributions were also adopted.

Uncertainties in the GWP values were not taken into account.

Compared to the submission April 2005 (FOEN 2006a), significant progress has been made by running a Monte Carlo simulation. However, the uncertainty analysis still needs further improvement. An important step will be to further motivate institutions to supply not only data but also estimates of associated uncertainties. Also, it is planned to carry out the Monte Carlo simulation for all (not only key) categories, as well as for LULUCF categories.

1.7.2. Uncertainty Estimates

For non-key categories, the NIR provides qualitative estimates of uncertainties. Here, the following terms are used:

- high data quality – uncertainty ±5%,
- medium data quality – uncertainty ±20%,
- low data quality – uncertainty ±50%.

1.7.3. Results of Tier 1 Uncertainty Evaluation

a) Results for the submission April 2006

The results of the Tier 1 uncertainty analysis for GHG emissions from key categories (according to the key category analysis of the submission April 2000, FOEN 2006a) in Switzerland are summarized in Table 9 and Table 10. 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 **3.34%** (level uncertainty). Trend uncertainty is **2.43%**.

It should be noted that the present results of the Tier 1 uncertainty analysis for GHG emissions from key sources in Switzerland do 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 to 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 estimated to be very small).

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

A	B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category	Gas	Base year emissions 1990	Year 2004 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
		Input data	Input data	Input data	Input data	Calc/Input						
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	%	%	%
1. CO2 emissions from Fuel Combustion												
1A 1. Energy A. Fuel Combustion Gaseous fuels	CO2	3'714.50	6'186.06	5.0	4.6	6.8	0.792	0.0464	0.1172	0.21	0.83	0.86
1A 1. Energy A. Fuel Combustion Liquid fuels	CO2	34'319.03	34'143.58	1.4	0.6	1.5	0.954	-0.0067	0.6471	0.00	1.26	1.26
1A 1. Energy A. Fuel Combustion Solid fuels	CO2	1'490.48	566.35	18.4	5.0	19.1	0.203	-0.0177	0.0107	-0.09	0.28	0.29
1A 1. Energy A. Fuel Combustion Other fuels	CO2	1'676.11	2'211.82	10.0	30.0	31.6	1.319	0.0100	0.0419	0.30	0.59	0.66
Total CO2 Emissions Fuel Combustion	CO2	41'200.11	43'107.80									

A	B	C	D	E	F	G	H	I	J	K	L	M
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%	%	%	%	%	%
2. Non-CO2 Emissions from Fuel Combustion and Other Key Sources												
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Other Fuels	N2O	48.42	112.78	10.0	80.0	80.6	0.171	0.0012	0.0021	0.10	0.03	0.10
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Tı Gasoline	CH4	91.78	23.07	10.0	*59.2*	60.0	0.026	-0.0013	0.0004	-0.08	0.01	0.08
1B2 1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	CH4	385.75	182.92		*50.0*	50.0	0.172	-0.0039	0.0035	-0.19	0.00	0.19
2A1 2. Industrial Proc. A. Mineral Products; Cement Production-CO2	CO2	2'524.77	1'714.25	2.0	6.0	6.3	0.204	-0.0156	0.0325	-0.09	0.09	0.13
2B 2. Industrial Proc. B. Chemical Industry	N2O	100.75	16.12	10.0	40.0	41.2	0.013	-0.0016	0.0003	-0.06	0.00	0.06
2C3 2. Industrial Proc. C. Metal Production; Aluminium Production-PFC	PFC	100.17	11.40	5.0	48.7	49.0	0.011	-0.0017	0.0002	-0.08	0.00	0.08
2C3 2. Industrial Proc. C. Metal Production; Aluminium Production-CO2	CO2	139.26	70.24	5.0	30.0	30.4	0.040	-0.0013	0.0013	-0.04	0.01	0.04
2F 2. Industrial Proc. F. Consumption of Halocarbons and SF6	PFC	0.04	55.89		17.6	17.6	0.019	0.0011	0.0011	0.02	0.00	0.02
2F1 2. Industrial Proc. F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	544.59		13.8	13.8	0.142	0.0103	0.0103	0.14	0.00	0.14
2F_o 2. Industrial Proc. F. Consumption of Halocarbons and SF6 without 2F1-HFC	HFC	0.00	73.91		21.9	21.9	0.030	0.0014	0.0014	0.03	0.00	0.03
3 3. Solvent and Other Product Use	CO2	337.49	122.10		50.0	50.0	0.115	-0.0041	0.0023	-0.21	0.00	0.21
3 3. Solvent and Other Product Use	N2O	109.41	50.36		80.0	80.0	0.076	-0.0011	0.0010	-0.09	0.00	0.09
4A 4. Agriculture A. Enteric Fermentation	CH4	2'766.81	2'492.07	20.0	12.7	23.7	1.114	-0.0055	0.0472	-0.07	1.34	1.34
4B 4. Agriculture B. Manure Management	CH4	452.34	399.86	20.0	36.4	41.5	0.313	-0.0010	0.0076	-0.04	0.21	0.22
4B 4. Agriculture B. Manure Management	N2O	448.20	396.68	20.0	71.4	74.2	0.555	-0.0010	0.0075	-0.07	0.21	0.22
4D1 4. Agriculture D. Agricultural Soils; Direct Soil Emissions	N2O	1'389.82	1'207.74	10.0	79.8	80.4	1.832	-0.0036	0.0229	-0.29	0.32	0.43
4D3 4. Agriculture D. Agricultural Soils; Indirect Emissions	N2O	818.89	682.60	15.0	*93.9*	95.1	1.224	-0.0027	0.0129	-0.25	0.27	0.37
6A 6. Waste A. Solid Waste Disposal on Land	CH4	693.04	348.63	20.0	*56.6*	60.0	0.394	-0.0066	0.0066	-0.37	0.19	0.42
6D 6. Waste D. Other	CH4	30.34	91.38	10.0	*49.0*	50.0	0.086	0.0012	0.0017	0.06	0.02	0.06
Rest of sources	CO2	1'123.50	1'329.95	20.0	*34.6*	40.0	1.003	0.0038	0.0252	0.13	0.71	0.73
Total non-CO2 emissions from Fuel Combustion and other Key Sources		11'560.81	9'926.54									

A	B	C	D	E	F	G	H	I	J	K	L	M
		Gg CO2 equivalent	Gg CO2 equivalent									
3. Total (combined uncertainty of 1. and 2.)												
Total Emissions	all gases	52'760.92	53'034.33									
Total Uncertainties						Overall uncertainty in the year (%)	**3.34**				Trend uncertainty (%)	**2.43**

Table 9 Tier 1 Uncertainty Calculation and Reporting for sources in Switzerland 2004 (IPCC 2000, Table 6.1). Note that the emissions 1990 and 2004 correspond to the values of the submission April 2006, which may slightly deviate from the data of the current submission.

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-PFC	PFC	M	M		Section 4.4.3
2C3	2. Industrial Proc. C. Metal Production; Aluminium Production-CO2	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
3	3. Solvent and Other Product Use	N2O	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 10 Tier 1 Uncertainty Calculation and Reporting for sources in Switzerland 2004 (Continued).

A	B	C	D	E	F	G	H
IPCC Source category	Gas	Base year emissions 1990	Year 2004 emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t
		Input data	Input data	Input data	Input data	Calc/Input	
		Gg CO2 equivalent	Gg CO2 equivalent	%	%	%	%
4D1 4. Agriculture D. Agricultural Soils; Direct Soil Emissions	N2O	1'389.82	1'207.74	10.0	79.8	80.4	1.832
1A 1. Energy A. Fuel Combustion Other fuels	CO2	1'676.11	2'211.82	10.0	30.0	31.6	1.319
4D3 4. Agriculture D. Agricultural Soils; Indirect Emissions	N2O	818.89	682.60	15.0	93.9	95.1	1.224
4A 4. Agriculture A. Enteric Fermentation	CH4	2'766.81	2'492.07	20.0	12.7	23.7	1.114
Rest of sources	CO2	1'123.50	1'329.95	20.0	34.6	40.0	1.003
1A 1. Energy A. Fuel Combustion Liquid fuels	CO2	34'319.03	34'143.58	1.4	0.6	1.5	0.954
1A 1. Energy A. Fuel Combustion Gaseous fuels	CO2	3'714.50	6'186.06	5.0	4.6	6.8	0.792
4B 4. Agriculture B. Manure Management	N2O	448.20	396.68	20.0	71.4	74.2	0.555
6A 6. Waste A. Solid Waste Disposal on Land	CH4	693.04	348.63	20.0	56.6	60.0	0.394
4B 4. Agriculture B. Manure Management	CH4	452.34	399.86	20.0	36.4	41.5	0.313
2A1 2. Industrial Proc. A. Mineral Products; Cement Production-CO2	CO2	2'524.77	1'714.25	2.0	6.0	6.3	0.204
1A 1. Energy A. Fuel Combustion Solid fuels	CO2	1'490.48	566.35	18.4	5.0	19.1	0.203
1B2 1. Energy B. Fugitive Emissions 2. Oil and Natural Gas	CH4	385.75	182.92		50.0	50.0	0.172
1A1 1. Energy A. Fuel Combustion 1. Energy Industries Other Fuels	N2O	48.42	112.78	10.0	80.0	80.6	0.171
2F1 2. Industrial Proc. F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.	HFC	0.02	544.59		13.8	13.8	0.142
3 3. Solvent and Other Product Use	CO2	337.49	122.10		50.0	50.0	0.115
6D 6. Waste D. Other	CH4	30.34	91.38	10.0	49.0	50.0	0.086
3 3. Solvent and Other Product Use	N2O	109.41	50.36		80.0	80.0	0.076
2C3 2. Industrial Proc. C. Metal Production; Aluminium Production-CO2	CO2	139.26	70.24	5.0	30.0	30.4	0.040
2F_o 2. Industrial Proc. F. Consumption of Halocarbons and SF6 without 2F1-HFC	HFC	0.00	73.91		21.9	21.9	0.030
1A3b 1. Energy A. Fuel Combustion 3. Transport; Road Tı Gasoline	CH4	91.78	23.07	10.0	59.2	60.0	0.026
2F 2. Industrial Proc. F. Consumption of Halocarbons and SF6	PFC	0.04	55.89		17.6	17.6	0.019
2B 2. Industrial Proc. B. Chemical Industry	N2O	100.75	16.12	10.0	40.0	41.2	0.013
2C3 2. Industrial Proc. C. Metal Production; Aluminium Production-PFC	PFC	100.17	11.40	5.0	48.7	49.0	0.011

Table 11 Ranked Combined Level Uncertainties for sources in Switzerland. Note that the emissions 1990 and 2004 correspond to the values of the submission April 2006, which may slightly deviate from the data of the current submission.

Ranked by their contribution to uncertainty in the total national emissions level (cf. Column H, Table 11), direct and indirect 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 5.5% 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).

a) Comparison with the previous submission

For the data of the submission April 2006 (FOEN 2006a), an overall uncertainty of 3.34% has been calculated, which is greater than the value reported for the previous submission (2.97%). The difference is the result of several changes:

- In the previous submission, the term “uncertainty” was taken in many cases to be synonymous with the standard deviation. This interpretation was not in line with the recommendation of the IPCC Good Practice Guidance (IPCC 2000) and has therefore been changed.
- The uncertainties of the agricultural sector have been investigated in more detail (Leifeld 2005). As a consequence of this study, several uncertainties had to be adjusted. As shown above, the uncertainties of these categories are leading contributors to the overall uncertainty of the Swiss GHG inventory.

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 LUCF). 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 guess. The mean value of the probability distributions was set equal to the value of the greenhouse gas inventory. In most cases, normal distribution was assumed. However, for data with a high level of uncertainty, normal distribution would allow negative emissions. Thus, for these cases, log-normal distribution was used (cf. Annex A1.2.1). Log-normal distribution is positively skewed and produces only positive values, while the upper bound of emissions may be poorly known.

As a second step, emissions were calculated as emission factors multiplied by the relevant 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 greenhouse gas inventory and a corresponding probability distribution of the emissions.

The Monte Carlo simulation then provided information on the standard distribution, 2.5 and 97.5 percentiles of emissions at the source category level and of total emissions as reported in the inventory.

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 than the uncertainty of the total source category. A detailed description of this analysis and the respective correlation coefficients can be found in Annex A1.2.1. 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, 2004). Hence for estimation of the uncertainty in the emission trends, the Monte Carlo simulation was run for the year 2004 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 not correlated with the activity data of 2004. On the other hand, the emission factors of the two years are assumed to be positively correlated. The probability distributions of the 1990 data are assumed to be of equal shape as the distributions derived for 2004.

d) Results

The Monte Carlo simulations reveal that the uncertainty distribution of the total emissions for 2004 (year t) is narrower than the distribution for the base year 1990. As expected, it is shifted towards higher mean emissions (cf. Figure 5).

The uncertainty estimates as derived from the Monte Carlo simulations on the key category level are shown in Table 12.

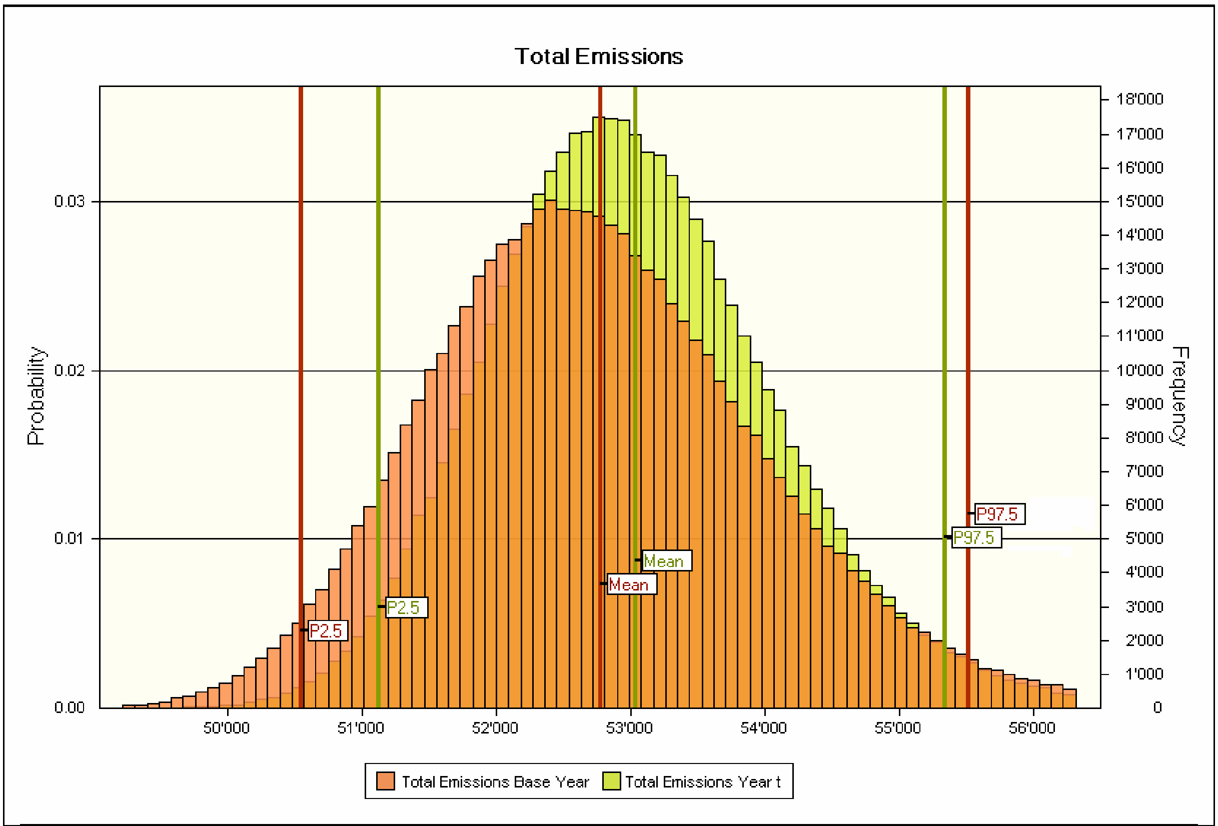

Figure 5 Probability distributions of total emissions for the base year (1990) and year t (2004). On the x-axis, the total emissions reported in the Swiss inventory (without CO_2 from LUCF) are given in Gg CO_2 equivalent. Number of Monte Carlo runs: 500'000. The vertical lines show simulated mean values (*Mean*) and the 2.5 (*P2.5*) and 97.5 (*P97.5*) percentile values.

A			B	C	D	E	F	G	H	I	J
IPPC Source Category			Gas	Base year (1990) emissions	Year t (2004) 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	377	93	107	0.05	60.5	51	70
1A1	1. Energy Industries	Liquid Fuels	CO2	691	955	99	101	0.03	38.2	36	41
1A1	1. Energy Industries	Other Fuels	CO2	1519	1925	73	134	1.12	26.7	-8	47
1A1	1. Energy Industries	Other Fuels	N2O	48	113	21	180	0.17	132.9	48	226
1A2	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1081	2051	90	110	0.38	89.8	70	109
1A2	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3411	2926	98	102	0.13	-14.2	-17	-11
1A2	2. Manufacturing Industries and Construction	Other Fuels	CO2	157	286	56	154	0.26	82.6	-18	172
1A2	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1387	532	82	119	0.19	-61.7	-83	-41
1A3b	3. Transport; Road Transportation	Diesel	CO2	2424	3623	98	102	0.13	49.5	46	53
1A3b	3. Transport; Road Transportation	Gasoline	CO2	11393	11426	98	102	0.40	0.3	-2	3
1A3b	3. Transport; Road Transportation	Gasoline	CH4	92	23	36	257	0.05	-74.9	-145	-27
1A3e	3. Transport; Other Transportation (mil. aviation)	Liquid Fuels	CO2	200	109	98	102	0.00	-45.5	-47	-44
1A4a	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	950	1441	90	110	0.27	51.8	36	68
1A4a	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4432	4046	98	102	0.18	-8.7	-12	-6
1A4b	4. Other Sectors; Residential	Gaseous Fuels	CO2	1409	2291	90	110	0.43	62.6	45	80
1A4b	4. Other Sectors; Residential	Liquid Fuels	CO2	10234	9438	98	102	0.42	-7.8	-11	-5
1A4c	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	713	728	98	102	0.03	2.0	-1	5
1A5	5. Other	Liquid Fuels	CO2	513	671	98	102	0.02	30.7	28	34
1B	B. Fugitive Emissions from Fuels										
1B2	2. Oil and Natural Gas		CH4	386	183	51	149	0.17	-52.6	-107	2
2	Industrial Processes										
2A1	A. Mineral Products; Cement Production-CO2		CO2	2525	1714	94	106	0.20	-32.1	-40	-24
2B	B. Chemical Industry		N2O	101	16	60	141	0.01	-84.0	-119	-50
2C3	C. Metal Production; Aluminium Production-PFC		PFC	100	11	52	148	0.01	-88.6	-137	-40
2C3	C. Metal Production; Aluminium Production-CO2		CO2	139	70	70	130	0.04	-49.6	-83	-16
2F	F. Consumption of Halocarbons and SF6		PFC	0.04	56	83	117	0.02	*	*	*
2F1	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.02	545	86	114	0.14	*	*	*
2F_o	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	0.00	74	79	121	0.03	*	*	*
3	Solvent and Other Product Use		CO2	337	122	51	149	0.11	-63.8	-116	-12
			N2O	109	50	22	178	0.07	-54.0	-140	33
4	Agriculture										
4A	A. Enteric Fermentation		CH4	2767	2492	77	123	1.09	-9.9	-41	21
4B	B. Manure Management		CH4	452	400	59	141	0.31	-11.6	-66	43
4B	B. Manure Management		N2O	448	397	33	269	0.88	-11.5	-114	85
4D1	D. Agricultural Soils; Direct Soil Emissions		N2O	1390	1208	31	273	2.75	-13.1	-125	90
4D3	D. Agricultural Soils; Indirect Emissions		N2O	819	683	29	284	1.64	-16.6	-149	102
6	Waste										
6A	A. Solid Waste Disposal on Land		CH4	693	349	41	159	0.39	-49.7	-116	16
6D	D. Other		CH4	30	91	51	149	0.08	201.2	46	357
	Other			1573	1612	61	139	1.19	2.4	-54	58
Total				52761	53034	96.4	104.4	3.98	0.52	-5.4	6.2

* Trend not calculated when base year emission ≈ 0

Table 12 Monte Carlo (Tier 2) uncertainty reporting. Note that the emissions 1990 and 2004 correspond to the values of the submission April 2006, which may slightly deviate from the data of the current submission.

The main results of the Monte Carlo simulation are (results hold for the data of submission April 2006, FOEN 2006a):

- The total uncertainty of the 2004 Swiss emissions is 3.98% (2'105 Gg CO_2 equivalent) of the total GHG emissions (53'034 Gg CO_2 equivalent, without CO_2 emissions from LUCF).
- The 95% confidence interval is slightly asymmetric and lies between 96.4% and 104.4% of the Swiss total GHG emissions. The end points are: 51'126 Gg (=53'034 Gg–1'908 Gg) and 55'346 Gg (=53'034 Gg+2'312 Gg).
- The change in total emissions between 1990 and 2004 is +0.52%. With a probability of 95%, the change lies within the range of -5.4% to +6.2%.

To study the influence of correlations, a sensitivity run was carried out with all correlations set equal to zero. The following results were found:

- The total uncertainty of the 2004 Swiss emissions is reduced from 3.98% (with correlations) to 3.19% (without correlations).
- The 95% confidence interval is reduced correspondingly and lies between 97.0% and 103.4% of the Swiss total GHG emissions (with correlations: 96.4% and 104.4%).
- The findings reveal that the net impact of the positive and negative correlations (see Table 138 and Table 139) is positive – i.e., the inclusion of correlations results in a 1.25-fold increase in the overall uncertainty of the GHG emissions.

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 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 uncertainty of 3.98% for 2004 emissions. This value is somewhat larger then the result of Tier 1 uncertainty analysis (3.34%). The trend uncertainty of Tier 2 (5.8%) is larger than that of Tier 1 analysis (2.4%). 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 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 been 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) showed that the overall uncertainty decreases to 3.19% due to the splitting.

1.8. Completeness Assessment

Completeness is an issue addressed in the inventory development plan (see Annex 6). Data are now available for the missing sources listed in the previous NIR (FOEN 2006a). For the key categories, complete estimates of all known sources are accomplished for all gases. From today's knowledge the Swiss inventory is complete, except for the LULUCF sector which is not yet reported as required by decision 13/CP.9 for the years 1991 – 2004. A project is under way to fill in this gap and results will be available in autumn 2006.

2. Trends in Greenhouse Gas Emissions and Removals

This chapter gives an overview of Switzerland's GHG emissions/removals and trends for the period 1990–2004.

2.1. Aggregated Greenhouse Gas Emissions 2004

In 2004, Switzerland emitted 53'019 Gg CO_2 equivalent (without CO_2 from LUCF) to the atmosphere. The largest contributor gas is CO_2, and the most important sources of emissions are fuel combustion activities in the Energy sector. Table 13 shows emissions by gas and sector in Switzerland for the year 2004. A breakdown of Switzerland's total emissions by gas is given in Figure 6. Figure 7 charts the relative contributions of the individual sectors (except LUCF) to the emission of each GHG.

Emissions 2004	**CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	***Total***
	CO_2 equivalent (Gg)						
1 All Energy	43'119	270	356				***43'745***
2 Industrial Processes	2'000	7	16	618	67	176	***2'886***
3 Solvent Use	183		50				***233***
4 Agriculture (1 year average)		2'930	2'483				***5'413***
6 Waste	16	477	251				***743***
Total (without CO_2 from LUCF)	**45'317**	**3'683**	**3'156**	**618**	**67**	**176**	***53'019***
5 Land Use Change/Forestry	-2'069						***-2'069***
Total (with net CO_2 emissions/removals)	43'248	3'683	3'156	618	67	176	***50'950***
International Bunkers	3'433	1	33				***3'468***

Table 13 Switzerland's GHG emissions in CO_2 equivalent (Gg) by gas and sector, 2004.

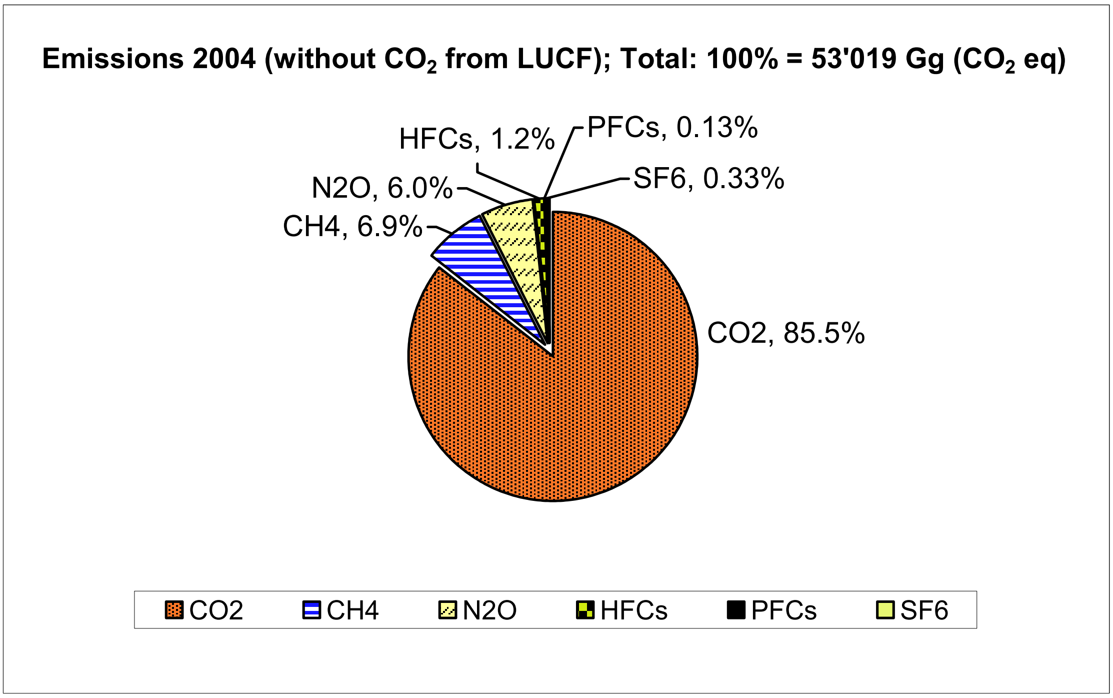

Figure 6 Switzerland's GHG emissions by gas (without CO_2 emissions from LUCF), 2004.

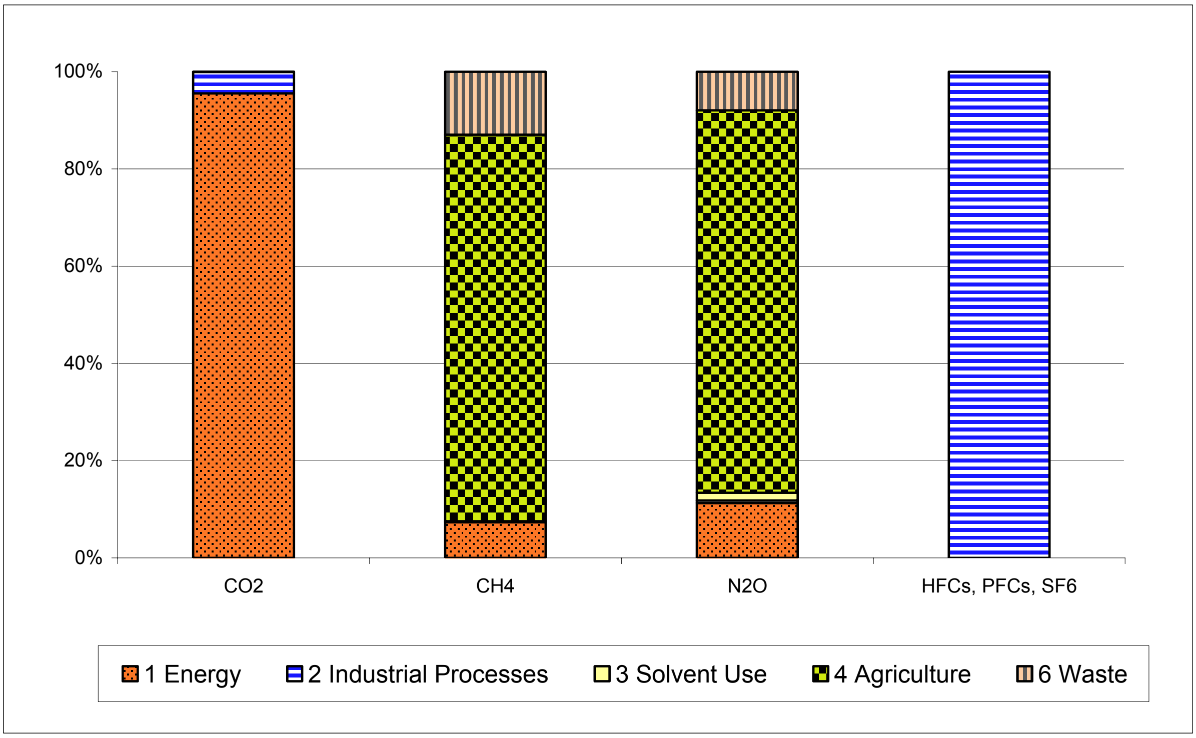

Figure 7 Relative contributions of the individual sectors (except LUCF) to GHG emissions, 2004.

Fuel combustion within the Energy sector was by far the largest source of emissions of CO_2 in 2004. 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 1990–2004 are summarized in Table 14.

Greenhouse Gas Emissions	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	***2004/1990***
	CO_2 equivalent (Gg)															*%*
Net CO_2 emissions/removals	43'239	44'817	44'774	41'210	40'422	40'981	41'549	40'734	42'024	42'588	44'067	45'147	44'104	43'127	43'248	*0.0%*
Gross CO_2 emissions (without LUCF)	44'513	46'156	46'198	43'598	42'814	43'335	44'056	43'408	44'627	44'844	43'918	44'697	43'798	44'894	45'317	*1.8%*
CH_4	4'529	4'507	4'355	4'278	4'080	4'080	3'994	3'921	3'861	3'861	3'769	3'795	3'705	3'678	3'683	*-18.7%*
N_2O	3'541	3'548	3'529	3'479	3'434	3'349	3'388	3'285	3'275	3'253	3'264	3'233	3'225	3'157	3'156	*-10.9%*
HFCs	0.02	0.2	6.1	13	30	152	193	258	311	360	418	493	503	539	618	---
PFCs	100	85	69	30	18	15	17	24	28	40	93	52	50	73	67	*-32.9%*
SF_6	143	146	148	126	112	98	94	131	161	147	193	235	210	187	176	*22.8%*
Total (with net CO_2 emissions/removals)	51'552	53'103	52'881	49'136	48'096	48'674	49'236	48'353	49'661	50'249	51'805	52'956	51'798	50'762	50'950	*-1.2%*
Total (without CO_2 from LUCF)	**52'826**	**54'442**	**54'305**	**51'524**	**50'488**	**51'029**	**51'743**	**51'027**	**52'263**	**52'505**	**51'655**	**52'506**	**51'493**	**52'529**	**53'019**	***0.4%***

Table 14 Switzerland's GHG emissions in CO_2 equivalent (Gg) by gas, 1990–2004 (corresponds to CRF table 10s5, upper half). The column on the far right (digits in italics) indicates the percentage change in emissions in 2004 as compared to the base year 1990.

The emission trends for individual gases are as follows (see Table 14 above, Table 15 and Figure 8 below):

- Total gross emissions (without CO_2 from LUCF) were almost constant, with fluctuations within a range of less than 5%. The 2004 total emissions increased by 0.4% as compared to the emissions recorded in the base year 1990. CO_2 contributed the largest share of emissions, accounting for 85.5% of the total in 2004.

- Total emissions with net CO_2 emissions/removals in 2004 show a decrease of 1.2% 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 LUCF sector (visible over several years due to 3-year averaging of the storm effects). Removals from LUCF have now returned to the levels prevailing in the 1990s.
- A comparison of CO_2 emissions with the number of heating degree days in the period 1990–2004 (see Figure 13 below) indicates a strong correlation between CO_2 emissions and winter climatic conditions.
- Between 1990 and 2004, CH_4 decreased by 18.7%, 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 8.6% in 1990 to 6.9% in 2004.
- In parallel to the reduction of CH_4 due to decreases in livestock populations, N_2O emissions from enteric fermentation and from manure management declined by 10.9% between 1990 and 2004.
- HFC emissions increased significantly due to their application as substitutes for CFCs. SF_6 emissions have shown relatively large fluctuations (ratio max. value / min. value = 2) since 1990. In 2004, SF_6 emissions increased by 22.8% compared to 1990, while PFC emissions declined by 32.9%. The share of all synthetic gases combined rose from 0.5% in 1990 to 1.6% in 2004.

Greenhouse Gas Emissions	1990		1995		2000		2004	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
Gross CO_2 emissions (without LUCF)	44'513	84.3%	43'335	84.9%	43'918	85.0%	45'317	85.5%
CH_4	4'529	8.6%	4'080	8.0%	3'769	7.3%	3'683	6.9%
N_2O	3'541	6.7%	3'349	6.6%	3'264	6.3%	3'156	6.0%
HFCs	0	0.0%	152	0.3%	418	0.8%	618	1.2%
PFCs	100	0.2%	15	0.0%	93	0.2%	67	0.1%
SF_6	143	0.3%	98	0.2%	193	0.4%	176	0.3%
Total (without CO_2 from LUCF)	**52'826**	**100%**	**51'029**	**100%**	**51'655**	**100%**	**53'019**	**100%**

Table 15 Switzerland’s total gross GHG emissions (without LUCF) in CO_2 equivalent (Gg), selected years.

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

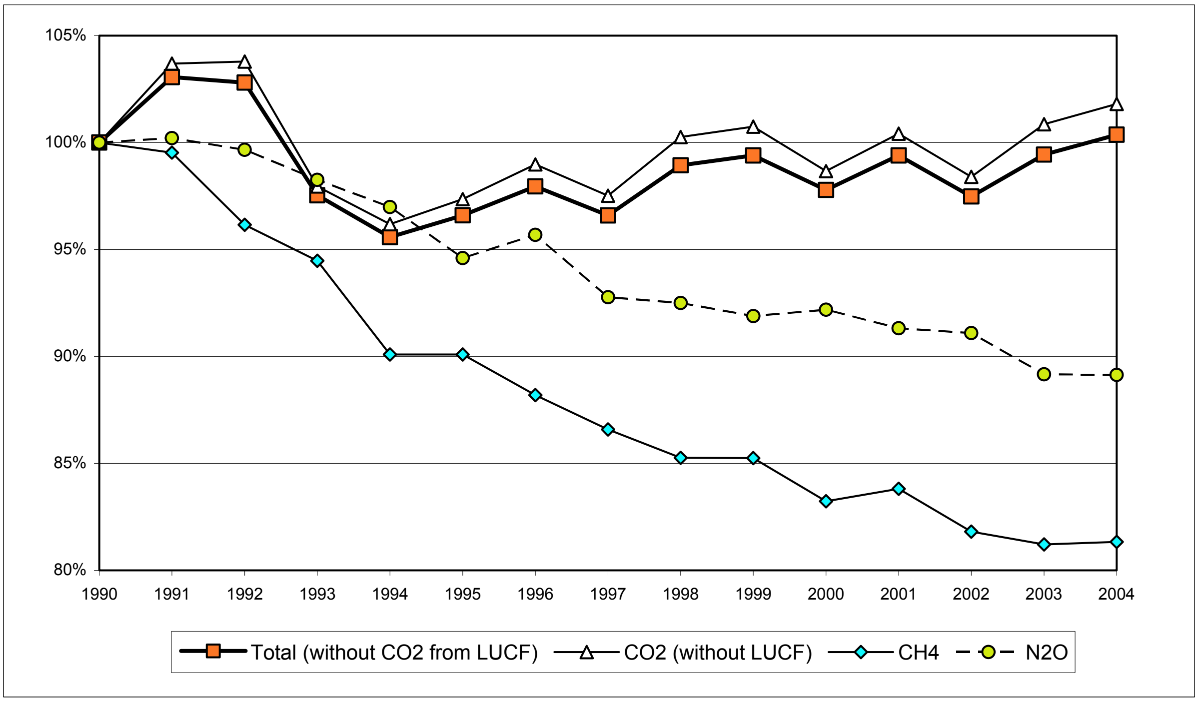

Figure 8 Relative trend of Switzerland’s GHG emissions by gas, 1990–2004 (base year 1990 = 100%). The increase of the synthetic gases is not shown (354% in 2004, compared to 1990).

2.3. Emission Trends by Sources and Sinks

Table 16 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.

Source and Sink Categories	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)														
1 Energy	**42'045**	**44'044**	**44'212**	**41'844**	**40'927**	**41'624**	**42'541**	**42'076**	**43'294**	**43'493**	**42'419**	**43'173**	**42'303**	**43'414**	**43'745**
1A1 Energy Industries	2'544	2'826	2'912	2'562	2'589	2'619	2'829	2'794	3'116	2'967	2'884	3'010	3'084	3'062	3'372
1A2 Manufacturing Industries and Construction	6'062	5'956	5'808	5'603	5'626	5'542	5'462	5'549	5'717	5'784	5'856	5'960	5'786	5'822	5'819
1A3 Transport	14'599	15'078	15'393	14'312	14'486	14'151	14'193	14'757	14'957	15'542	15'774	15'465	15'340	15'505	15'608
1A4 Other Sectors	17'811	19'162	19'095	18'372	17'214	18'308	19'056	17'982	18'506	18'183	16'901	17'726	17'106	18'068	17'981
1A5 Other (Offroad)	519	538	557	575	594	613	624	635	646	657	668	670	672	674	676
1B Fugitive emissions from oil and natural gas	509	484	448	420	417	392	377	358	352	360	336	343	316	283	287
2 Industrial Processes	**3'183**	**2'825**	**2'664**	**2'350**	**2'491**	**2'407**	**2'251**	**2'182**	**2'288**	**2'380**	**2'673**	**2'786**	**2'721**	**2'727**	**2'886**
3 Solvent and Other Product Use	**466**	**444**	**424**	**400**	**385**	**367**	**346**	**324**	**302**	**292**	**281**	**270**	**257**	**247**	**233**
4 Agriculture	**6'090**	**6'098**	**5'980**	**5'965**	**5'809**	**5'761**	**5'750**	**5'593**	**5'557**	**5'544**	**5'506**	**5'528**	**5'472**	**5'380**	**5'413**
6 Waste	**1'041**	**1'031**	**1'025**	**965**	**876**	**869**	**855**	**853**	**822**	**797**	**776**	**749**	**740**	**760**	**743**
Total (without CO_2 from LUCF)	**52'826**	**54'442**	**54'305**	**51'524**	**50'488**	**51'029**	**51'743**	**51'027**	**52'263**	**52'505**	**51'655**	**52'506**	**51'493**	**52'529**	**53'019**
5 Land-Use Change and Forestry	-1'273	-1'339	-1'424	-2'388	-2'392	-2'355	-2'507	-2'674	-2'602	-2'256	149	450	305	-1'766	-2'069
Total (with net CO_2 emissions/removals)	51'552	53'103	52'881	49'136	48'096	48'674	49'236	48'353	49'661	50'249	51'805	52'956	51'798	50'762	50'950

Table 16 Switzerland’s GHG emissions in CO_2 equivalent (Gg) by sources and sinks, 1990–2004.

The percentage shares of source categories are shown for selected years in Table 17. Figure 9 through Figure 12 are graphical representations of Table 16 data. For the development of the sub-sectors of source 1 Energy see Chapter 3.

Source and Sink Categories	1990		1995		2000		2004	
	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%	Gg CO_2 eq	%
1 Energy	42'045	79.6%	41'624	81.6%	42'419	82.1%	43'745	82.5%
1A1 Energy Industries	2'544	4.8%	2'619	5.1%	2'884	5.6%	3'372	6.4%
1A2 Manufacturing Industries and Construction	6'062	11.5%	5'542	10.9%	5'856	11.3%	5'819	11.0%
1A3 Transport	14'599	27.6%	14'151	27.7%	15'774	30.5%	15'608	29.4%
1A4 Other Sectors	17'811	33.7%	18'308	35.9%	16'901	32.7%	17'981	33.9%
1A5 Other (Offroad)	519	1.0%	613	1.2%	668	1.3%	676	1.3%
1B Fugitive emissions from oil and natural gas	509	1.0%	392	0.8%	336	0.7%	287	0.5%
2 Industrial Processes	3'183	6.0%	2'407	4.7%	2'673	5.2%	2'886	5.4%
3 Solvent and Other Product Use	466	0.9%	367	0.7%	281	0.5%	233	0.4%
4 Agriculture	6'090	11.5%	5'761	11.3%	5'506	10.7%	5'413	10.2%
6 Waste	1'041	2.0%	869	1.7%	776	1.5%	743	1.4%
Total (without CO_2 from LUCF)	**52'826**	**100.0%**	**51'029**	**100.0%**	**51'655**	**100.0%**	**53'019**	**100.0%**

Table 17 Contribution of individual source categories to total gross emissions (excluding LUCF) in CO_2 equivalent (Gg), selected years.

A considerable change in the share of sector 6 Waste compared to the previous submission (2005) is due to a reallocation: all emissions from waste-to-energy activities (combustion of municipal solid waste, construction and special waste) have been removed from 6C and transferred to 1A1, in line with IPCC 1997.

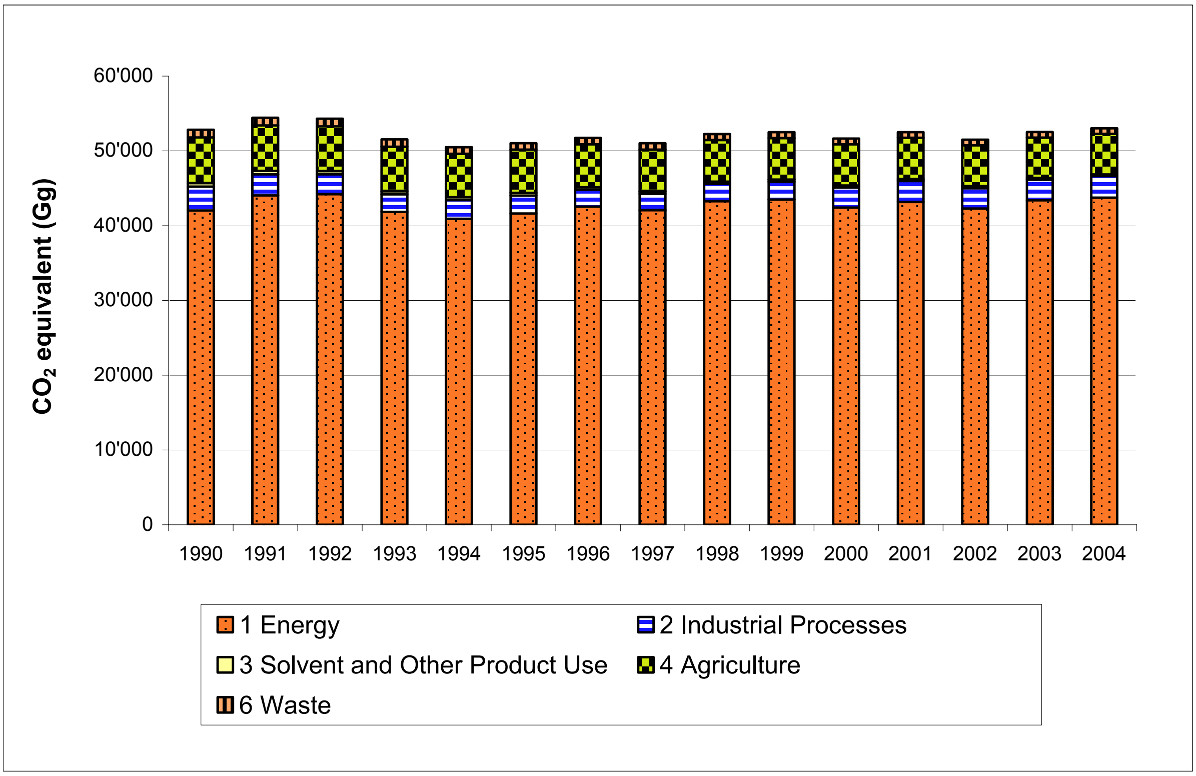

Figure 9 Switzerland's greenhouse gas emissions in CO_2 equivalent (Gg) by main source categories, 1990–2004 (without CO_2 from LUCF).

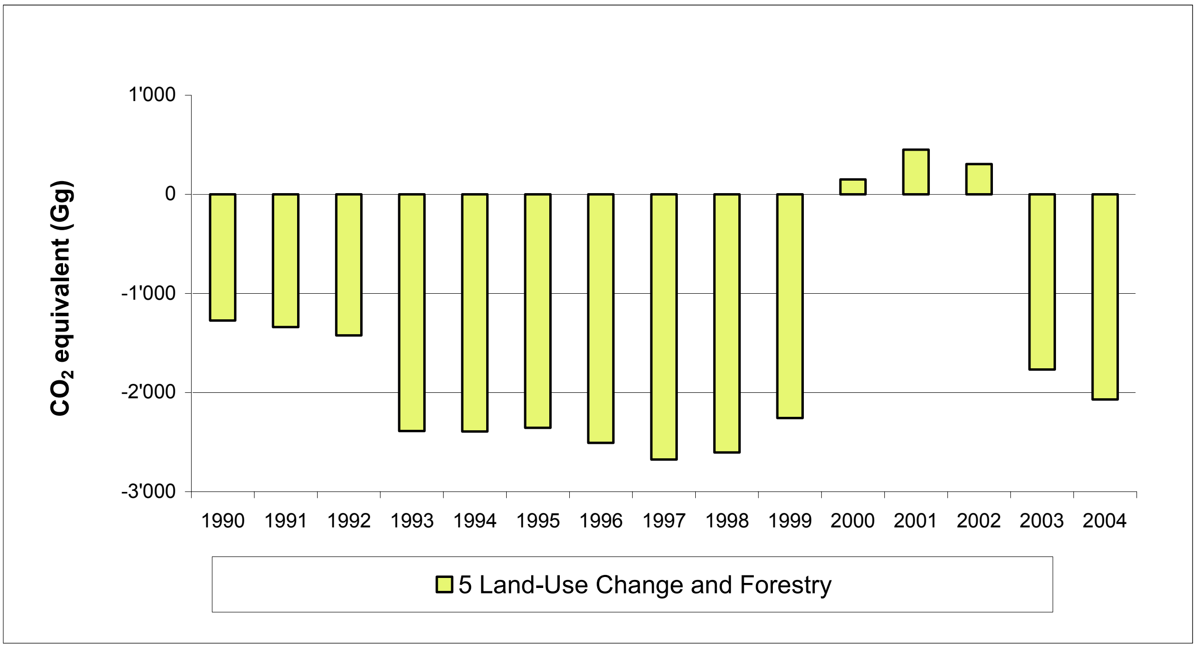

Figure 10 Switzerland's net GHG removals (negative emissions) by sinks from LUCF, 1990–2004.

Figure 10 shows the net removals (negative emissions) by sinks from LUCF in Switzerland. In 1990 and in 1999, two storms led to significant loss in biomass (in 1999, the amount of biomass destroyed was nearly three times higher than average annual net growth of Swiss forests). Without the influence of these storms, the net removals show only slight variations between, approximately, -1'800 and -2'600 Gg CO_2 equivalent.

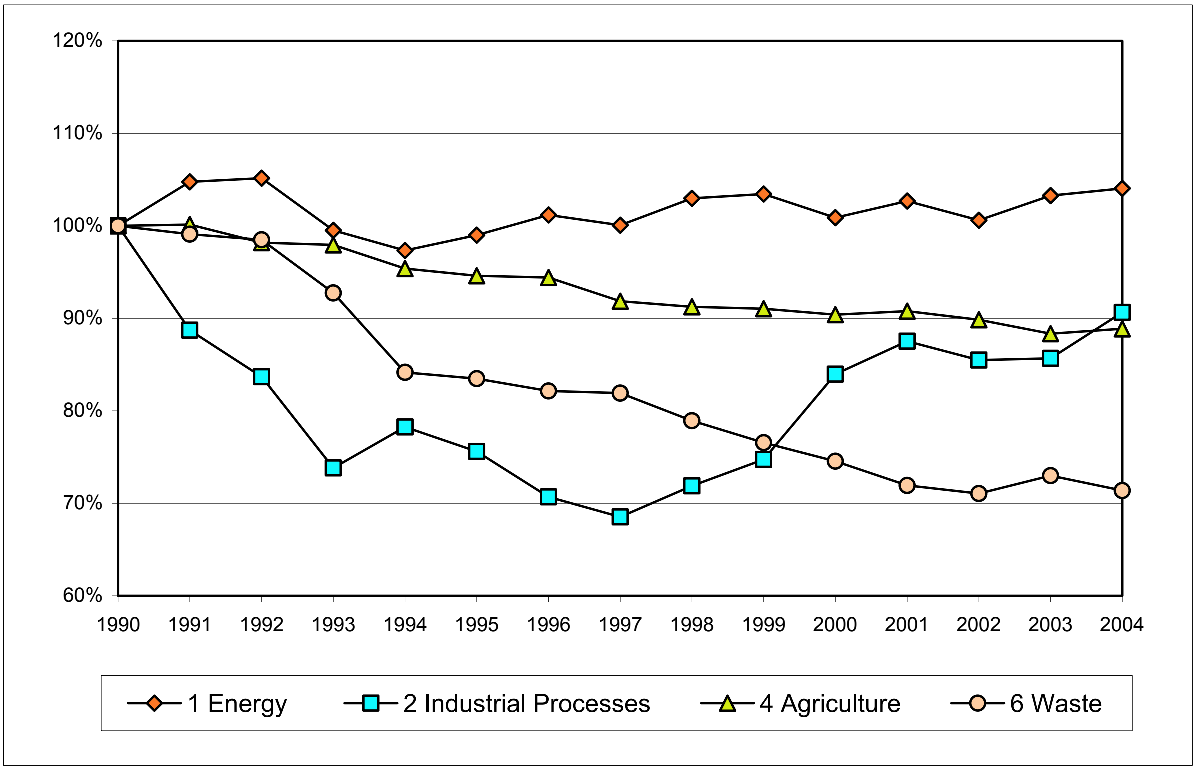

Figure 11 Relative emission trends by main source categories (base year 1990 = 100%).

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 slight rebound towards the end of the period under review.
- 4 Agriculture: Declining populations of cattle and swine and reduced fertilizer use have led to a decrease in CO_2-equivalent emissions.
- 6 Waste: Total emissions from the source category Waste decreased steadily throughout this period. 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 Box 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.

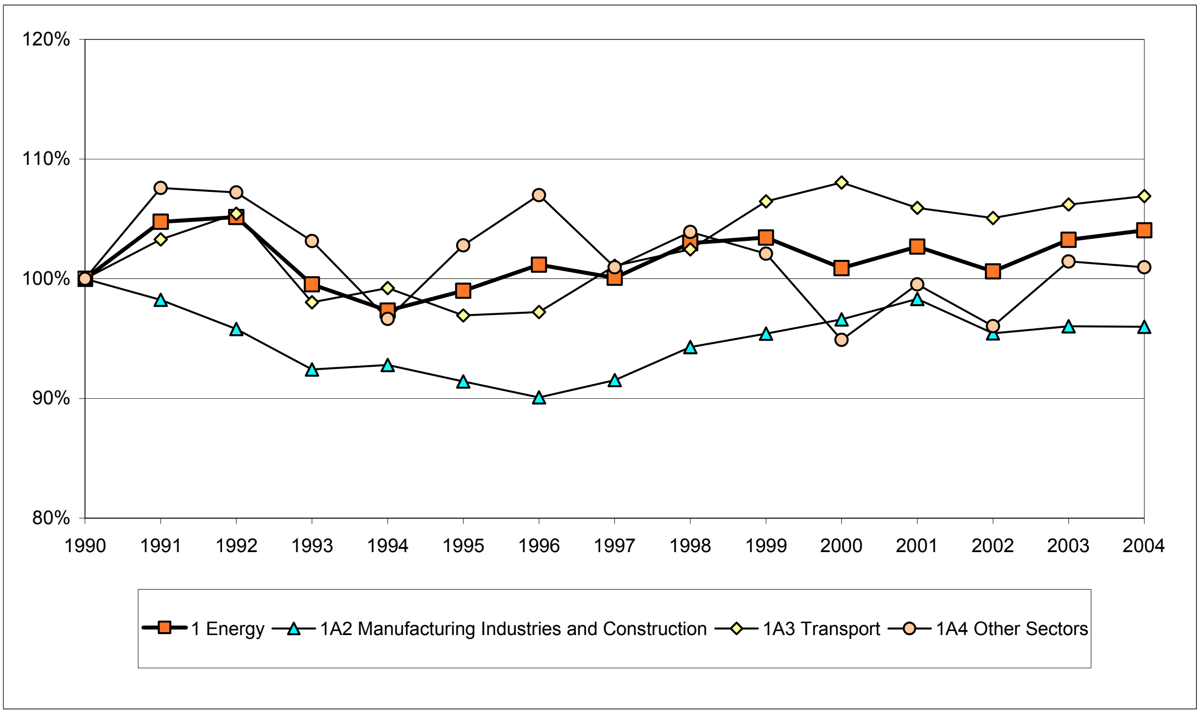

Figure 12 Emission trends for the three main sub-categories in the Energy sector, accounting for 90% of emissions in this source category (not shown are the sub-categories of minor importance: 1A1 Energy Industries, 1A5 Other/Off-road and 1B Fugitive Emissions). The trend for the sector as a whole (“1 Energy”) is shown in bold.

It is noteworthy that, because of Switzerland’s electricity production structure (about 95.3% generated by hydroelectric and nuclear power plants in 2004; SFOE 2005, 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 the 1A3 Transport sector showed a slight increase over the period 1990–2004, but with significant fluctuations indicating a fairly strong correlation between this sector and economic development – periods of stagnation 1993–1996 and 2001–2004, and growth (gross value-added) 1996–2000.
- 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” – 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 1990–2004, 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.

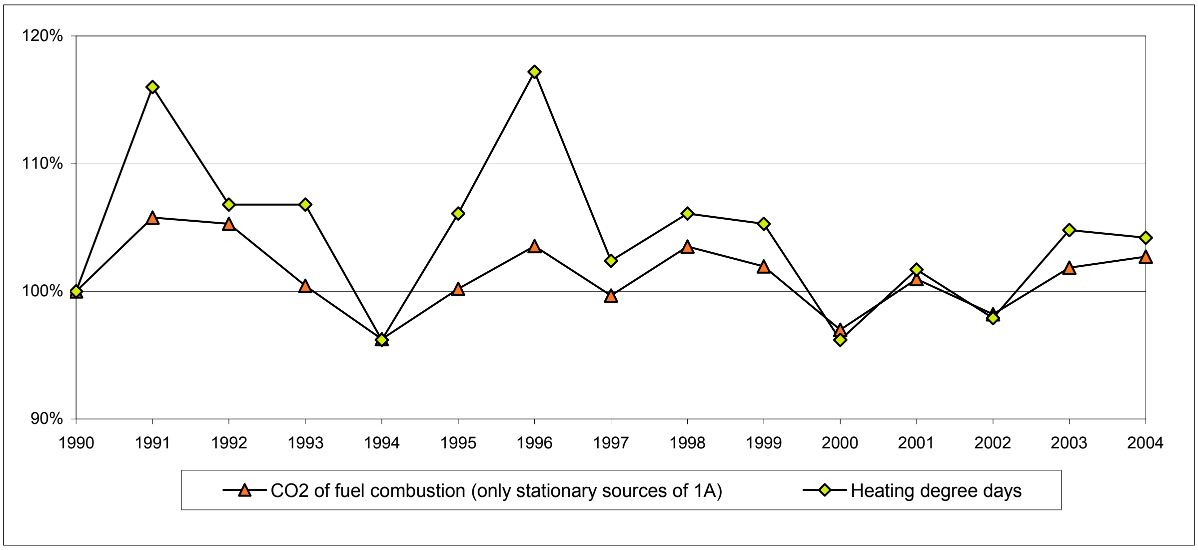

Figure 13 Relative trend for CO_2 emissions from fuel combustion (excluding transport and off-road activities) compared with the number of heating degree days (see text above).

2.4. Emission Trends for Indirect Greenhouse Gases and SO_2

Emission trends for indirect greenhouse gases show a very pronounced decline. From 1990 to 2004, 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.

Indirect Greenhouse	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gases and SO_2	Gg														
NO_x	159	154	144	129	125	117	111	106	104	103	99	95	90	87	86
CO	690	663	625	552	517	481	469	458	445	441	428	406	382	370	354
NMVOC	287	269	250	223	207	190	177	166	152	147	140	131	122	113	105
SO_2	42	38	35	28	30	27	27	26	24	19	18	20	18	17	17

Table 18 Switzerland's indirect GHG and SO_2 emissions in Gg, 1990–2004.

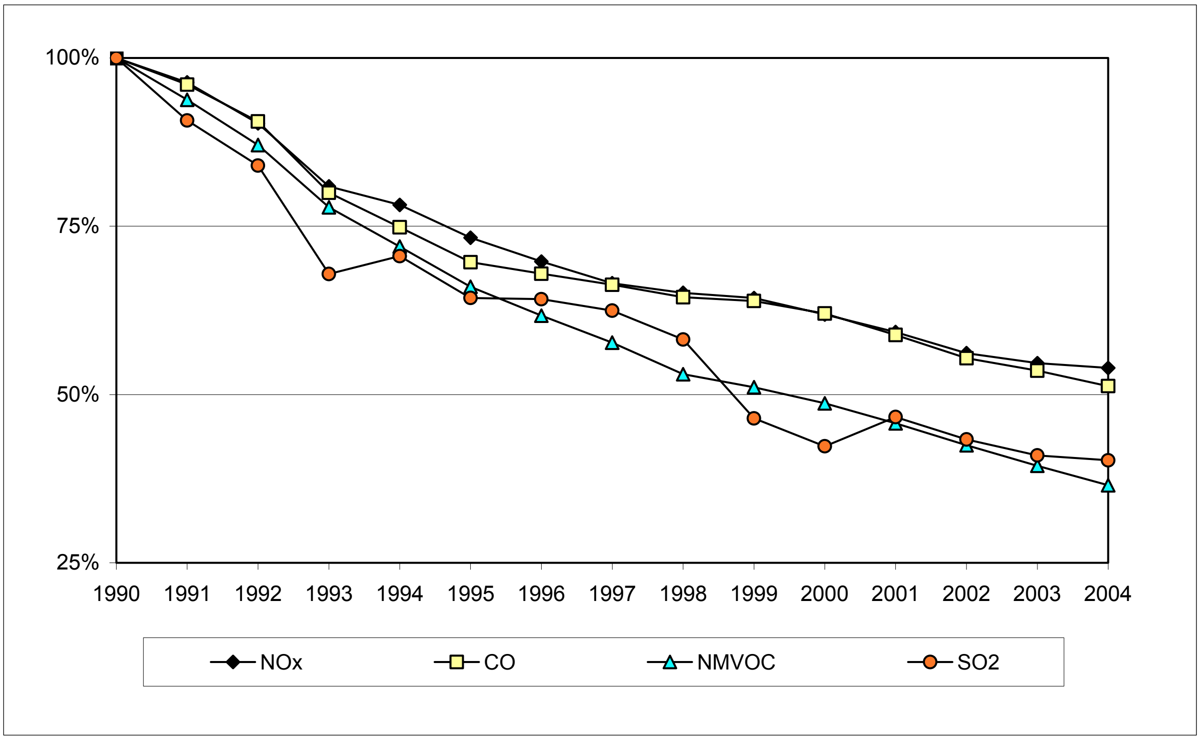

Figure 14 Relative trends for indirect GHG and SO_2 emissions, 1990–2004 (base year 1990 = 100%).

Sector 1 Energy was by far the largest source of indirect greenhouse gas emissions (see Table 19), with the only exception being NMVOCs, where category 3 Solvent and Other Product Use accounted for 48% of the total.

Sources	**NO_x**	**CO**	**NMVOC**	**SO_2**
	Emissions 2004 (Gg)			
1 Energy	80.8	334.8	39.7	13.1
2 Industrial Processes	0.29	9.73	8.37	2.31
3 Solvent and Other Product Use	0.01	0.02	50.14	0.01
4 Agriculture	4.48	7.28	4.64	0.05
6 Waste	0.48	2.08	1.99	1.34
Total	**86.0**	**353.9**	**104.9**	**16.8**

Table 19 Indirect GHG and SO_2 emissions in Gg by source, 2004.

Figure 15 shows the relative contributions of the various sectors for each individual gas (data from Table 19). Sector 1 Energy is clearly visible as the main source of NO_x, CO and SO_2.

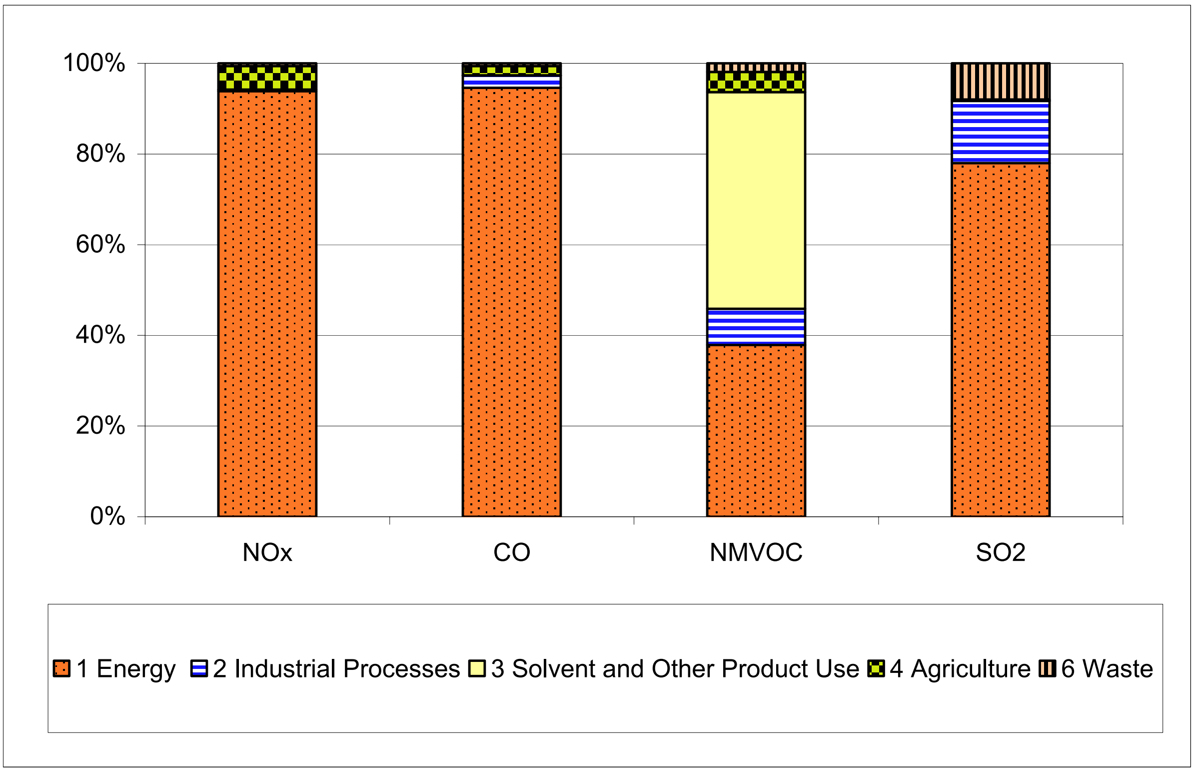

Figure 15 Relative contributions of individual sectors to indirect GHG and SO_2 emissions, 2004.

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 2004, it emitted 43’745 Gg CO_2 equivalent which correspond to 82.5% of total emissions (53’019 Gg, without CO_2 from LUCF). The emissions of the period 1990–2004 are depicted in Figure 16.

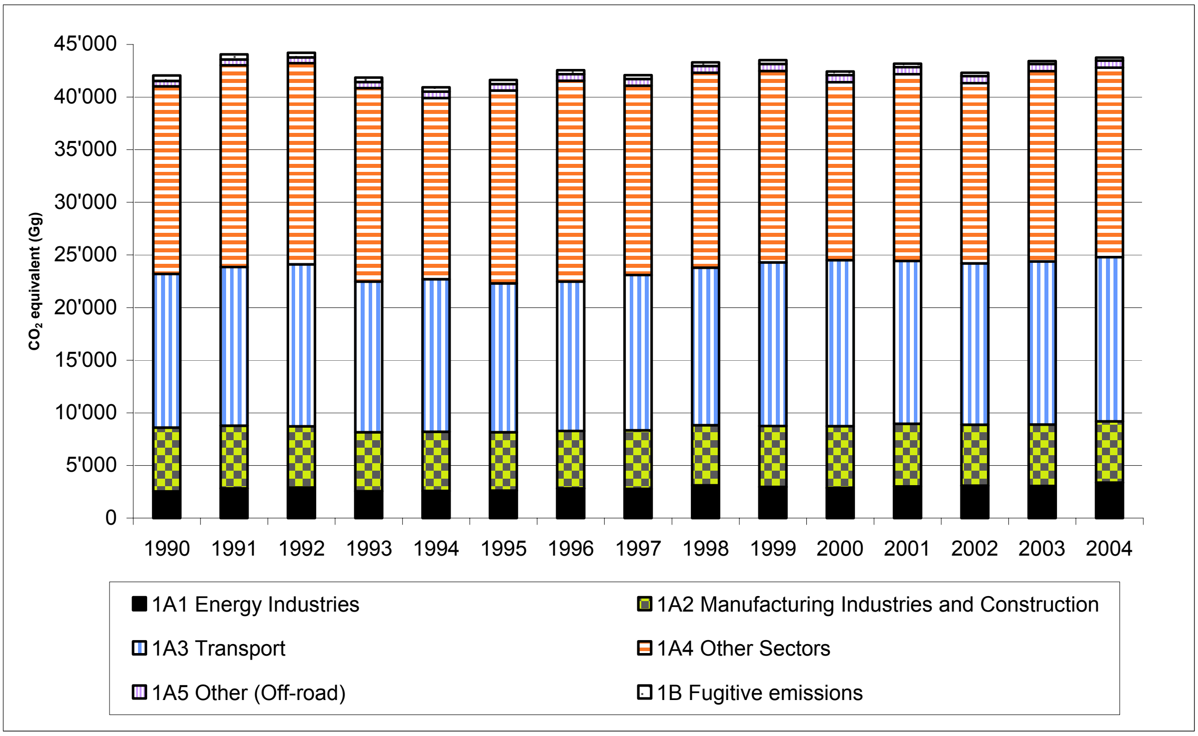

Figure 16 Switzerland’s GHG emissions of source category 1 Energy 1990–2004 in CO_2 equivalent (Gg).

For the total emissions of the energy sector, a very slight increasing but statistically not significant trend may be observed in the period 1994–2004. Three sub-categories dominate the emissions:

- 1A3 Transport and 1A4 Other Sectors are the main sources that cover 35.6% and 41.1%, respectively, of total emissions.
- 1A2 Manufacturing Industries and Construction are of minor importance. They contribute 13.4% to the total emissions.
- 1A1 Energy Industries, 1A5 Other (Off-road) and 1B Fugitive Emissions only play a minor role. In 2004, they cover 7.8%, 1.5% and 0.6%, respectively, of the total emissions of 1 Energy.

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

- The far most important gas emitted from source category 1 “Energy” is CO_2. It accounts for 98.57% of the category. Its fluctuations reflect climatic variability in Switzerland (see Figure 13 and related comments).
- In 2004, CH_4 emissions contributed 0.62% to the total emissions of the energy sector. The decreasing trend since 1990 is the result of reduced emissions from gasoline passenger cars due to catalytic converters.
- N_2O contributed 0.81% to the total emissions of the energy sector. 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 1999. With new converter materials being used, the emission factors are decreasing since 2000.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)														
CO_2	41'251	43'244	43'430	41'102	40'189	40'904	41'827	41'375	42'593	42'777	41'724	42'477	41'642	42'779	43'119
CH_4	535	515	472	431	412	386	364	342	335	339	316	319	290	272	270
N_2O	259	285	309	310	326	335	351	359	367	377	379	378	371	364	356
Sum	42'045	44'044	44'212	41'844	40'927	41'624	42'541	42'076	43'294	43'493	42'419	43'173	42'303	43'414	43'745

Table 20 GHG emissions of source category 1 “Energy” by gas in CO_2 equivalent (Gg), 1990–2004.

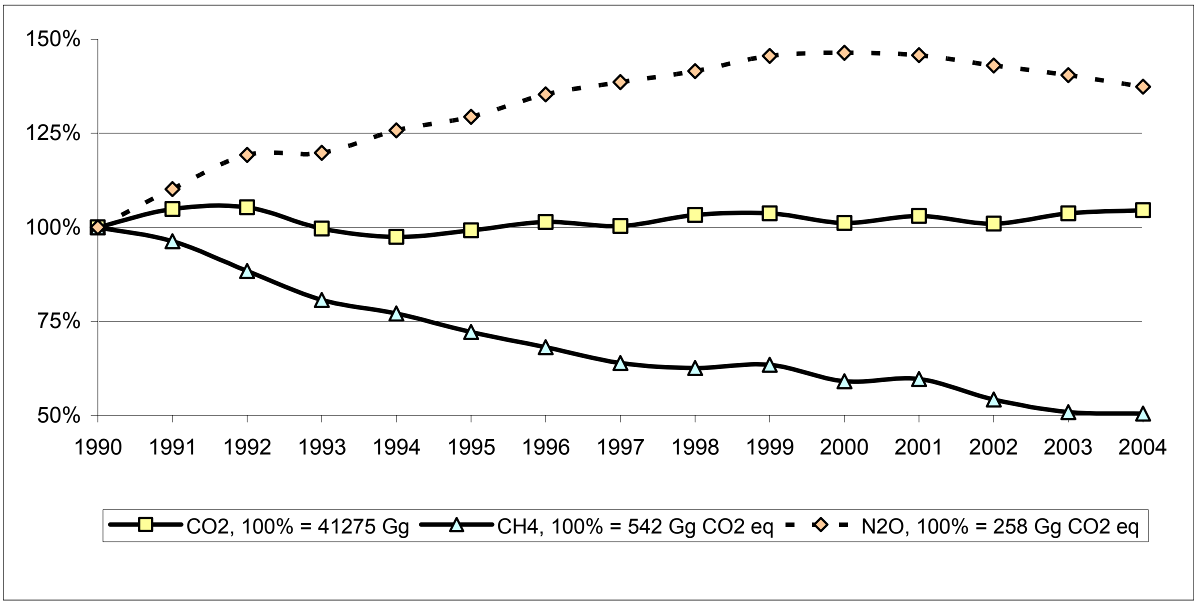

Figure 17 Relative trends of the greenhouse gases of source category 1 “Energy” in the period 1990–2004. The base year 1990 represents 100%.

The following table summarises the emissions of source category 1 “Energy” in 2004. The table includes emissions from international bunkers (aviation) as well as biomass which are both not accounted for in the Kyoto Protocol but are contained in the CRF tables.

Emissions 2004	**CO_2**	**CH_4**	**N_2O**	***Total***
	CO_2 equivalent (Gg)			
1 Energy	**43'119**	**270**	**356**	***43'745***
1A Fuel Combustion	**43'009**	**91.7**	**356.0**	***43'457***
1A1 Energy Industries	3'255	1.7	116.2	***3'372***
1A2 Manufacturing Industries and Construction	5'768	9.0	42.0	***5'819***
1A3 Transport	15'442	24.5	141.4	***15'608***
1A4 Other Sectors	17'876	55.3	50.4	***17'981***
1A5 Other	669	1.3	5.9	***676***
1B Fugitive Emissions from Fuels	**109**	**177.9**	**0.0**	***287***

International Bunkers	3'433	1	33	***3'468***
CO_2 Emissions from Biomass	2'273	0	0	***2'273***

Table 21 Summary of source category 1 “Energy”, emissions[3] in 2004 in Gg CO_2 equivalent (rounded values).

The Swiss greenhouse gas inventory identifies 38 key sources (see Chapter 1.5), 19 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).

[3] 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.

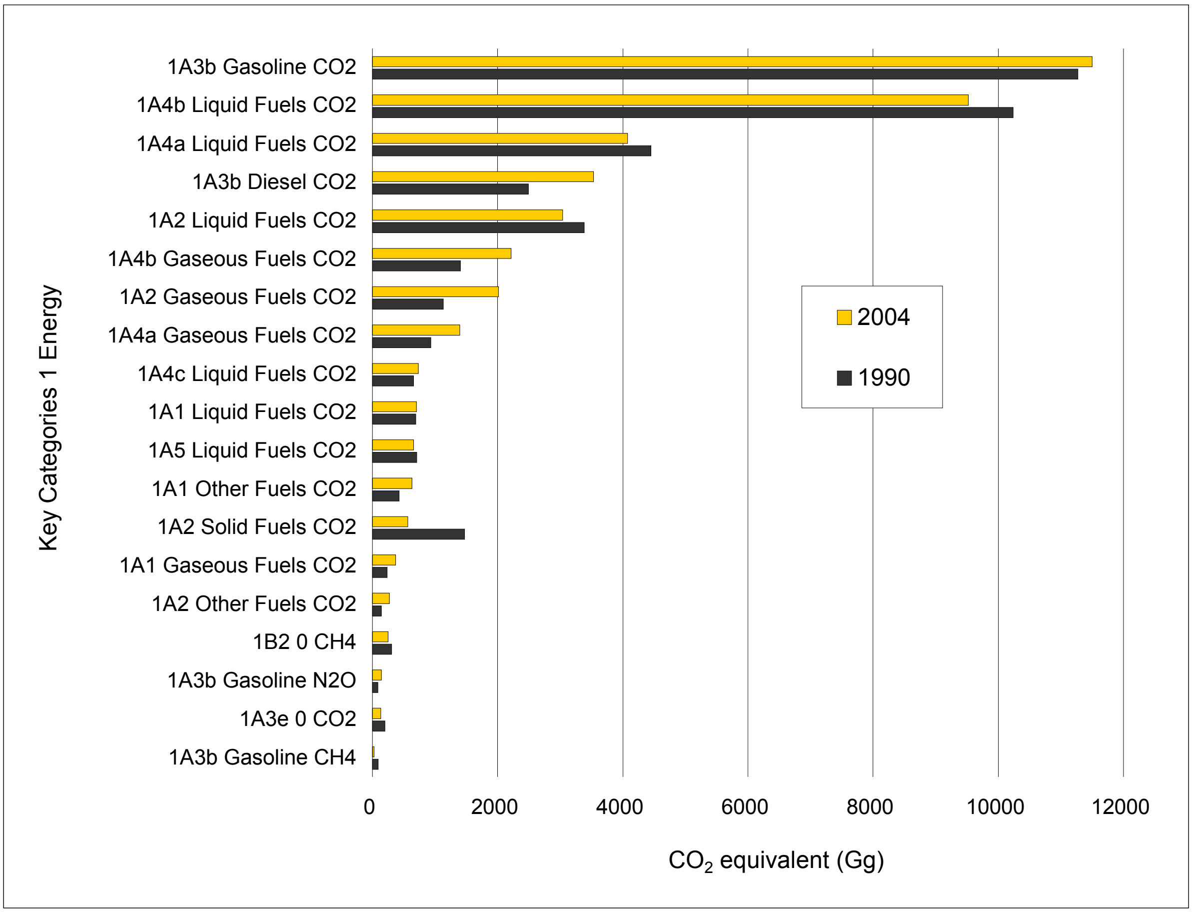

Figure 18 Key sources in the Swiss GHG inventory pertaining to the energy sector.

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 22. Further details are given in Annex A2.2, Methodology for Estimating CO_2 Emissions.

CO_2 Emission Factors 1990-2004	
Fuel	t CO_2 / TJ
Hard Coal	94.0
Gas Oil	73.7
Residual Fuel Oil	77.0
Natural Gas	55.0
Gasoline	73.9
Diesel Oil	73.6
Propane/Butane (LPG)	65.5
Jet Kerosene	73.2

Table 22 CO_2 emission factors for fuels. The values are assumed to be constant over the period 1990-2004. The value for natural gas also holds for CNG (compressed natural gas).

3.1.3. Feedstocks

Energy data are taken from the Swiss overall energy statistics (SFOE 2005). Exceptions are coal and residual fuel oil, which are taken from Basics 2006. 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 2005) contains the fossil fuel consumption of the Principality of Liechtenstein (about 34'600 inhabitants, 29100 employees in industrial and service sector), since the two countries form a customs and monetary union governed by a customs treaty. Until now, Switzerland therefore had included Liechtenstein's energy related emission in its GHG inventory. For the present submission of 31 May 2006, Switzerland for the first time corrected the emissions by subtracting the Liechtenstein's fuel consumption from the consumption provided in the Swiss overall energy statistics.

Liechtenstein's activity data (energy consumption) for Gas oil, LPG and natural gas were taken from the two available CRFs for the years 1990 and 2004 of Liechtenstein and were subtracted from the corresponding figures of the Swiss overall energy statistics. The Swiss emissions were then modelled using the reduced activity data. For the other years 1991–2003, no CRF tables for Liechtenstein are available yet. FOEN interpolated (linearly) Liechtenstein's consumption data between 1990 and 2004. This procedure may seem rough but it should be noted that Liechtenstein's fuel consumption, 3700 TJ in 2004, amounts only up to 0.56% of the Swiss consumption. That means that deviations between interpolated and true consumption are not of great influence for the Swiss inventory.

3.1.5. Leakage from Natural Gas Distribution

Under Source Category 1B2 b the amount of methane leaked from the Natural Gas distribution system is reported. In order to avoid double counting, these emissions are subtracted from the consumption of natural gas in the present submission. This was not the case in the previous submissions. For reasons of simplicity, the entire amount of leaking natural gas was subtracted from the category with the largest leakages (1A4b Residential).

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, Liquid Fuels and Other Fuels in Energy Industries (1A1) are key categories regarding level; CO_2 from the combustion of Gaseous Fuels and Other Fuels are also key categories regarding trend; N2O from the combustion of Other Fuels in 1A1 is a key category regarding 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”. An exception is auto-production in heat and power generation in waste incineration plants, which is included in 1A1.

In Switzerland, electricity production is dominated by hydroelectric power plants (55.3%) and nuclear power stations (40.0%). Other sources such as (fossil fueled) combined heat and power generation, and power generation from solar, wind and bio gas account only for about 4.7% of the electricity generated in Switzerland (SFOE 2005; table 24; data for the year 2004).

1A1	Source	Specification	Data Source
1A1 a	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: SAEFL 2005c, EMIS EF: CO_2 Fahrni 1999, EMIS Other sources: AD: SFOE 2005: EMIS EF: SAEFL 2000a; SFOE 2001; EMIS
1A1 b	Petroleum Refining	Combustion activities supporting the refining of petroleum products, excluding evaporative emissions.	AD: Annual report EV 2005, SFOE 2005; EMIS EF: Industry data; EMIS
1A1 c	Manufacture of Solid Fuels and Other Energy Industries	Not occurring in Switzerland	-

Table 23 Specification of source category 1A1 “Energy Industries”

b) Manufacturing Industries and Construction (1A2)

Key categories 1A2
CO_2 from the combustion of Gaseous Fuels, Liquid Fuels, Solid Fuels and Other Fuels in Manufacturing Industries and Construction (1A2) is a key category regarding both 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.

1A2	Source	Specification	Data Source
1A2 a	Iron and Steel	Iron and Steel industry	AD: SFOE 2005, Basics 2006 and industry data; EMIS EF: EMIS, SAEFL 2000a
1A2 b	Non-ferrous Metals	Non-ferrous Metals industry	Same as in 1A2a.
1A2 c	Chemicals	Chemical industry	Same as in 1A2a.
1A2 d	Pulp, Paper and Print	Pulp, Paper and Print industry	Same as in 1A2a.
1A2 e	Food Processing, Beverages and Tobacco	Food Processing, Beverages and Tobacco industry	Same as in 1A2a.
1A2 f	Other (Combustion Installations in Industries)	Category 1A2 f contains Cement, Lime, Brick and tile, Fine ceramics, Asphalt concrete plants, Container glass, Glass, Glass wool and Mineral wool.	Same as in 1A2a and EKV 1991

Table 24 Specification of source category 1A2 “Manufacturing Industries and Construction”

c) Transport (1A3)

Key categories 1A3b
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of gasoline and of diesel (level)
CH_4 from the combustion of gasoline (trend)

Key source 1A3e
CO_2 from 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.

1A3	Transport	Specification	Data Source
1A3 a	Civil Aviation (National)	Large (jet, turboprop) and small (piston) aircrafts, helicopters	SFOE 2005, FOCA 2006a, FOCA 2006b
1A3 b	Road Transportation	Light and heavy motor vehicles, coaches, two-wheelers	AC: SFOE 2005, EF: SAEFL 2004a-d, RWTÜV 2003 TUG 2002
1A3 c	Railways	Diesel locomotives	SAEFL 2005a
1A3 d	Navigation (National)	Passenger ships, motor and sailing boats on the Swiss lakes	SAEFL 2005a
1A3 e	Military Aviation		VTG 2006

Table 25 Specification of Swiss source category 1A3 “Transport”.

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

Key categories 1A4a, 1A4b
CO_2 from the combustion of gaseous and liquid fuels in the Commercial/Institutional Sector (1A4a) and in the Residential Sector (1A4b) are key categories regarding both level and trend.

Key categories 1A4c
CO_2 from the combustion of Liquid Fuels in Agriculture/Forestry (1A4c) is a key category regarding level.

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

1A4	Source	Specification	Data Source
1A4 a	Commercial/ Institutional	Emission from fuel combustion in commercial and institutional buildings	AD: SFOE 2005, CEPE 2005 EF: EMIS, SAEFL 2000a; SFOE 2001
1A4 b	Residential	Emissions from fuel combustion in households	AD: SFOE 2005 EF: EMIS, SAEFL 2000a; SFOE 2001
1A4 c	Agriculture/ Forestry/ Fishing	Comprises fuel combustion for grass drying and off-road machinery in agriculture	AD: EMIS and SAEFL 2005a EF: EMIS, SAEFL 2000a; SFOE 2001; SAEFL 2005a

Table 26 Specification of source category 1A4 “Other sectors”.

e) Other – Off-road: Construction, Hobby, Industry and Military (1A5)

Key sources 1A5
CO_2 from the combustion of liquid fuels in 1A5 Other – Off-road is a key category regarding both level and trend.

In Switzerland, the sub-sources are defined according to the next table. The IPCC category structure distinguishes mobile and stationary sources. Most of the Swiss sub-categories refer to mobile sources. For CO_2 emissions, the fraction of mobile sources has been estimated for the emissions in 2000. For that year they account for 96% to 97% of the category total. For later years, no significant change may be expected.

1A5	Off-road	Specification	Data Source
	Construction	Construction vehicles and machinery	Emission, EF, AD: SAEFL 2005a
	Hobby	Household and gardening machinery and motorised equipment	
	Industry	Industrial off-road vehicles and machinery	
	Military (without military aviation)	Tanks and similar off-road vehicles. (emissions from military road vehicles are included in 1A3b Road Transportation)	

Table 27 Specification of Swiss source category 1A5 "Other" (off-road).

3.2.2. Methodological Issues

General Issues

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 etc.) and stock changes are published in the Swiss overall energy statistics (SFOE 2005) and the yearly reports of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2005). Exceptions are coal and residual fuel oil, which are taken from Basics 2006. 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 liquid fuels stagnated (1990 to 2004: -0.02% to 465'635 TJ) and gaseous fuels strongly increased (1990 to 2004: +66.5% to 112'474 TJ), overestimating of oxidation factors tends to overestimate emission increase and is therefore conservative.

For coal, IPCC 1996 provides a global average oxidation factor of 98.0%. However, most 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)[4].

[4] 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

The consumption of coal plays a minor role in Switzerland. It decreased over the considered period (1990 to 2004: -62% to 6'018 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 79% of total Swiss coal consumption in 2004. With the main share of coal used in cement production, and under the assumption of high efficiency coal boilers, the overestimation of emission decrease may become minor.

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

a) Energy Industries (1A1)

Key categories 1A1
CO_2 from the combustion of Gaseous Fuels, Liquid Fuels and Other Fuels in Energy Industries (1A1) are key categories regarding level; CO_2 from the combustion of Gaseous Fuels and Other Fuels are also key categories regarding trend; N_2O from the combustion of Other Fuels in 1A1 is a key category regarding 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, 100% of the emissions related to municipal solid waste and special waste incineration are reported under 1A1 for the first time (and not under 6C anymore).

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 ("Other fuels")
Emission factors for CO_2, N_2O, 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. 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

residual carbon found in clinker. Carbon in all kiln fuels shall therefore be accounted for as fully oxidized (oxidation factor = 1.0)."

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 and SO_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 (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 2005). 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, N_2O, NO_x, CO and NMVOC are country specific based on comprehensive life cycle analysis of industrial boilers, documented in SAEFL 2000a (pp. 14-27). For NO_x emission factors, expert judgement has been used to estimate the fraction of low-NO_x burners.
All emission factors for biomass are based on SAEFL 2000a (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 (see also Section 3.2.6 on planned improvements).

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

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	73.51		1	0.6	34	11	2	33
Natural gas	55		6	0.1	15	14	2	0.5
Biomass		92	21	1.6	160	500	7	20
	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)	0.510	0.760		113.8	0.400	0.116	0.018	0.060
Other fuels (special waste)	1.450			38.5	0.776	0.116	0.057	0.397

Table 28 Emission Factors for 1A1a Public Electricity and Heat Production in Energy Industries in 2004. Emission factors for waste incineration are provided per ton of waste incinerated for both municipal solid waste incineration and special waste incineration.

In the table above, the CO_2 emission factor of light fuel oil (73.51 t/TJ) is a weighted average[5] emission factor including both LFO (73.7 t/TJ) and LPG (65.5 t/TJ) emissions.

The emission factor for N_2O has almost doubled from 60 g N_2O per ton of waste in 1990 to 113.8 g/t in 2004. 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

[5] Calculation: 73.51 t/TJ = (213'597 TJ * 73.7 t/TJ + 5'198 TJ * 65.5 t/TJ) / (213'597 TJ + 5'198 TJ) for the year 2004.

14g/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. The emissions from heat and/or power generation in municipal solid waste incineration plants are therefore reported under category 1A1a[6]. 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.

Source/fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1A1a Other fuels																
Total Other fuels in 1A1a	Gg	2'603	2'477	2'467	2'441	2'411	2'433	2'471	2'538	2'657	2'828	3'039	3'147	3'263	3'221	3'351
Municipal solid waste	Gg	2'470	2'340	2'310	2'310	2'250	2'270	2'290	2'340	2'420	2'590	2'800	2'920	3'031	2'990	3'120
Special waste	Gg	133	137	157	131	161	163	181	198	237	238	239	227	232	231	231

Table 29 Activity data for 1A1a "Other fuels": municipal solid waste and special waste incinerated with heat and/or power generation 1990 to 2004.

The table above documents the increase of municipal solid waste incinerated by 26% from 1990 to 2004. This is due to the fact that since 1.1.2000, 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 incineration) in category 1A1 being a key category regarding trend.

(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 2004 correspond to the consumption of LFO, natural gas and biomass in public district heating systems (SFOE 2005; tables 21, 26, and 28). Other fuels is calculated from annual amount of municipal solid waste incinerated with heat and/or electricity (see Table 29).

Source/fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1A1a Public Electricity/Heat Fuel Consumption																
Total	TJ	39'752	41'013	42'776	37'735	37'093	38'025	40'790	41'812	47'094	45'130	45'731	47'629	48'200	48'866	50'139
Light fuel oil	TJ	980	1'790	1'917	1'662	810	554	810	1'065	852	725	512	554	512	682	554
Heavy fuel oil	TJ	3'195	5'006	6'336	1'748	1'541	1'791	2'420	1'063	4'093	815	0	0	0	0	0
Natural gas	TJ	4'270	4'705	4'664	4'627	4'724	5'313	6'580	6'941	6'785	6'695	5'793	6'286	6'036	6'784	6'804
Coal	TJ	499	105	105	52	79	52	0	0	0	0	0	0	0	0	0
Other (waste-to-energy)	TJ	30'768	29'369	29'684	29'595	29'880	30'264	30'911	32'692	35'303	36'835	39'356	40'719	41'523	41'240	42'601
Biomass	TJ	40	40	70	50	60	50	70	50	60	60	70	70	130	160	180

Table 30 Activity data in 1A1a Public Electricity/Heat.

The table above documents the increase of Gaseous Fuel consumption by 60% from 1990 to 2004. This increase is the first reason for category 1A1 Gaseous Fuels being a key category regarding trend.

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

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 (see Section 1.4.3) and in SAEFL 2000a.

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

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	2.50	0.6	110	15	2.5	490
Gas (refinery LPG)	59.3	2.30	0.6	55	15	2.3	25
P-Coke	94.1	2.50	1.6	200	100	10.0	500

Table 31 Emission Factors for 1A1b Petroleum Refining in 2004.

Activity Data

Activity data on fuel combustion (TJ) for Petroleum Refining (1A1b) is extracted from the Annual Reports of the Swiss Petroleum Association (EV 2005, p. 82).

Source/fuel	**Unit**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
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	10'091	10'909	11'447	10'525	14'360
Heavy fuel oil	TJ	1'296	1'216	998	1'054	1'426	1'834	1'618	1'780	1'428	1'698	1'952	1'936	1'518	1'769	1'339
Gas (refinery LPG)	TJ	4'610	7'454	7'139	8'237	9'253	8'483	9'474	8'913	9'594	9'655	8'139	8'973	9'929	8'756	11'901
Petroleum coke	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	1'120

Table 32 Activity data in 1A1b Petroleum Refining (NO: not occurring).

The table above documents the increase of gas (refinery LPG) consumption for Petroleum refining by over 150% from 1990 to 2004. This is explained by the fact that in 1990 one of the Swiss refineries operated at reduced capacity and in later years resumed full production, leading to higher fuel consumption. This increase is the second 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, Liquid Fuels, Solid Fuels and Other Fuels in Manufacturing Industries and Construction (1A2) is a key category regarding both 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 CO_2 emissions of 1A2a to 1A2f (with the exception of waste derived fuels in cement industry). The top-down method is also used to estimate non-CO_2 emissions from most of the sources in 1A2 (see "methods" in Table 33 below). These sources are characterised by rather similar industrial combustion processes and assumingly homogenous emission factors, where a top-down approach is feasible. Identical emission factors for each fuel type are applied throughout these sources. The unit of emission factors refers to fuel consumption (in TJ).
- A *bottom-up* (Tier2/Tier3) method is used to calculate the non-CO_2 emissions from the remaining group of sources characterised by heterogeneous emission factors. This group comprises Iron and Steel industries (1A2a) as well as the sources in 1A2f: Cement, Lime, Brick and tile, Fine ceramics, Asphalt concrete plants, Container glass, Glass, Glass wool and Mineral wool. 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").

Source/	Method applied to calculate **CO_2 emissions**	Method applied to calculate ***non*-CO_2 emissions**
1A2 a Iron and Steel	Top-down	
Iron and Steel		Bottom-up (EMIS)
Other sources in 1A2a		Top-down
1A2b Non-Ferrous Metals	Top-down	Top-down
1A2c Chemicals	Top-down	Top-down
1A2d Pulp, Paper and Print		
Biomass (waste derived fuels from paper and pulp)	Bottom-up (Industry data)	Bottom-up (Industry data)
All other fuels	Top-down	Top-down
1A2e Food Processing, Beverages, and Tobacco	Top-down	Top-down
1A2 f Other		
Cement/Lime/Glass/… industry (without "Other fuels")	Top-down	Bottom-up (Industry data and EMIS)
Cement "Other fuels"	Bottom-up	Bottom-up (Industry data and EMIS)
Other sources in 1A2f	Top-down	Top-down

Table 33 Overview on methods applied to calculate GHG emissions in 1A2.

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).

For the present submission, the emissions related to the use of waste derived fuel in paper and pulp industries are fully reported under 1A2 for the first time (and not under 6C anymore).

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 and SO_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 (carbon emission factor documented in SFOE 2001, Table 45, p. 51; net calorific values on p. 61. See also Annex 2).

The activity data on LFO use from the Swiss overall energy statistics (SFOE 2005) 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 a mixed emission factor that results as a weighted average of the hard coal and lignite emission factors (see remark following the table below). The net calorific value of hard coal has been revised for the current submission (see Annex A2.2.1).

Emission factors for CH_4, N_2O, NO_x, CO and NMVOC are country specific based on comprehensive life cycle analysis of industrial boilers, documented in SAEFL 2000a (pp. 14-27). For NO_x emission factors, expert judgement has been used to estimate the fraction of low-NO_x burners.

All emission factors for biomass are based on SAEFL 2000a (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 (see also Section 3.2.6 on planned improvements).

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

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								
1A2 a Iron and Steel (Total)								
LFO	73.51		1.0	0.6	34	11	2	33
HFO	77.00		4.0	0.8	125	15	4	369
Coal	94.11		10.0	1.6	41	2007	9	344
Gas	55.00		6.0	0.1	38	6	2	0.5
Biomass								
Other Fuels								
1A2 b Non-Ferrous Metals								
LFO	73.51		1.0	0.6	34	11	2	33
HFO	77.00		4.0	0.8	125	15	4	369
Coal	94.11		10.0	1.6	200	100	10	500
Gas	55.00		6.0	0.1	15	14	2	0.5
Biomass		92.0	21.0	1.6	160	500	7	20
Other Fuels								
1A2 c Chemicals								
LFO	73.51		1.0	0.6	34	11	2	33
HFO	77.00		4.0	0.8	125	15	4	369
Coal	94.11		10.0	1.6	200	100	10	500
Gas	55.00		6.0	0.1	15	14	2	0.5
Biomass		92.0	21.0	1.6	160	500	7	20
Other Fuels								
1A2 d Pulp, Paper and Print								
LFO	73.51		1.0	0.6	34	11	2	33
HFO	77.00		4.0	0.8	125	15	4	369
Coal	94.11		10.0	1.6	200	100	10	500
Gas	55.00		6.0	0.1	15	14	2	0.5
Biomass (Black liquor)		81.34			78	148		332
Other Fuels								
1A2 e Food Processing, Beverages and Tobacco								
LFO	73.51		1.0	0.6	34	11	2	33
HFO	77.00		4.0	0.8	125	15	4	369
Coal	94.11		10.0	1.6	200	100	10	500
Gas	55.00		6.0	0.1	15	14	2	0.5
Biomass		92.0	21.0	1.6	160	500	7	20
Other Fuels								
1A2 f Other								
LFO	73.51		1.0	0.6	34	11	2	33
HFO	77.00		4.0	0.8	125	15	4	369
Coal	94.11		10.0	1.6	200	100	10	500
Gas	55.00		6.0	0.1	15	14	2	0.5
Biomass		92.0	21.0	1.6	160	500	7	20
Other Fuels	69.93	11.06	1.2	6.0	280	380	13	44

Table 34 Emission factors for sources in 1A2a-f for 2004. For sources that are calculated bottom-up (see Table 33 further above), the table shows implied emission factors.

Remark: In the table above, the CO_2 emission factor of light fuel oil of 73.51 t/TJ (2004) 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 (94.11 t/TJ in 2004) is a weighted average emission factor including hard coal (94 t/TJ), petroleum coke (94 t/TJ) and lignite (104 t/TJ) emissions[7].

Bottom-up approach

Following IPCC Tier 3, bottom-up non-CO_2 emission factors are based on production data (e.g. tons of cement or steel produced) or on fuel consumption in the cement, lime, glass, iron and steel industries.

The emission factors for CO_2 and SO_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 (carbon emission factor documented in SFOE 2001, Table 45, p. 51; net calorific values on p. 61). The net calorific value of hard coal has been revised for the current submission (see Annex A2.2.1).

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 (see Section 1.4.3). They have been updated for the recent years by expert judgement. An overview of key processes that are documented in the old EMIS database and their relation to CRF categories is provided in Annex A3.1.2.

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.

1A2 a 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	94.13	9.0	1.6	67	11	40	1.5
	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 35 Emission factors for sources in Iron and Steel 1A2a in 2004.

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	0.024	0.91	0.7	0.004	0.037

Table 36 Emission factors for cement industry in 2004 (NO: not occurring). Source: EMIS data base. Emission factors for CO_2 are fuel specific; they are the same as in the top-down approach (see Table 34).

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

[7] Calculation:
94.13t/TJ = (5'616TJ * 94t/TJ + 80TJ * 104t/TJ + (321TJ + 1'120TJ) * 94t/TJ) / (5'616TJ + 80TJ + 321TJ + 1'120TJ) for 2004.

other characteristics of waste derived fuels are from Hackl, A / G. Mauschitz 2003[8]. These emission factors are preliminary and may be revised for future submissions.

	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 meal	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

Table 37 Emission factors and other characteristics of waste derived fuels ("Other fuels") used in the cement industry.

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 33 above) are based on aggregated fuel consumption data from the Swiss overall energy statistics (SFOE 2005) 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 2004 is provided in the table below.

[8] As cited in the EMIS data base.

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1A2 Manufacturing Industries and Constr. (Total)	*TJ*	87'424	87'595	86'889	85'214	86'047	86'014	86'773	87'821	90'193	92'157	93'465	95'603	94'331	95'901	96'701
Light fuel oil	*TJ*	26'477	29'307	29'456	28'734	27'907	28'097	29'927	31'840	34'203	34'803	33'652	34'774	34'198	34'658	33'622
Heavy fuel oil	*TJ*	18'770	17'238	16'690	14'349	14'603	11'576	11'245	10'561	10'225	9'701	7'301	7'167	6'279	5'554	5'713
Coal	*TJ*	14'774	11'486	8'980	7'638	7'956	8'210	5'533	5'014	4'386	4'392	6'388	6'502	6'002	6'074	5'753
Natural gas	*TJ*	19'348	21'388	23'547	25'807	27'143	28'636	29'468	30'564	31'374	32'837	35'024	35'441	34'540	35'481	36'892
Biomass	*TJ*	3'923	4'196	4'388	4'563	4'673	5'163	5'818	5'214	5'313	5'308	5'484	5'540	6'268	6'700	6'906
Other Fuels	*TJ*	2'047	2'082	2'118	2'598	2'324	2'974	3'509	3'439	3'586	3'420	3'922	4'732	5'301	5'549	5'786
1A2a Iron and Steel	TJ	3'036	3'158	3'381	3'355	3'393	2'895	3'003	3'142	3'355	3'379	3'750	3'850	3'830	3'830	3'755
Light fuel oil	TJ	782	806	811	803	804	652	657	701	761	785	815	811	821	806	808
Heavy fuel oil	TJ	340	339	341	338	338	96	94	99	108	109	123	123	117	119	122
Coal	TJ	469	512	544	435	429	353	290	287	314	284	279	363	385	366	234
Natural gas	TJ	1'445	1'501	1'684	1'779	1'822	1'794	1'963	2'056	2'172	2'202	2'534	2'553	2'506	2'539	2'592
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other Fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2b Non-Ferrous Metals	TJ	517	606	460	469	458	646	687	888	974	1'112	1'100	1'014	1'097	1'181	1'206
Light fuel oil	TJ	240	241	225	201	206	215	213	251	268	270	272	259	279	283	273
Heavy fuel oil	TJ	2.0	1.7	1.5	1.2	1.3	1.9	1.1	1.4	1.3	1.3	1.1	1.0	1.0	1.0	1.1
Coal	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	275	363	233	267	250	429	472	636	705	840	827	754	817	897	931
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other Fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2c Chemicals	TJ	15'427	14'698	14'560	13'955	14'401	15'504	15'838	15'409	15'270	14'433	14'968	15'912	15'348	14'969	15'225
Light fuel oil	TJ	3'117	3'197	2'753	2'874	2'731	3'750	3'737	3'409	2'982	2'722	3'030	3'202	3'109	3'049	3'094
Heavy fuel oil	TJ	1'741	1'172	896	1'146	893	465	486	459	360	265	261	332	180	120	147
Coal	TJ	226	214	198	184	188	179	155	136	124	118	111	95	86	79	74
Natural gas	TJ	10'343	10'116	10'712	9'751	10'590	11'109	11'460	11'405	11'804	11'329	11'566	12'282	11'972	11'721	11'909
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other Fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2d Pulp, Paper and Print	TJ	11'659	11'278	12'698	12'475	13'302	11'787	10'792	10'939	10'610	10'875	11'120	11'189	11'706	11'591	11'429
Light fuel oil	TJ	536	777	986	926	861	954	1'051	993	1'034	1'122	1'090	1'041	1'078	1'028	996
Heavy fuel oil	TJ	5'225	4'715	4'307	3'671	3'337	3'119	2'972	3'179	3'149	2'998	2'528	2'622	2'471	2'374	2'268
Coal	TJ	1'014	619	112	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Natural gas	TJ	2'798	3'269	5'582	6'354	7'662	6'357	5'495	5'579	5'321	5'061	5'809	6'080	6'415	6'305	6'135
Biomass	TJ	2'085	1'898	1'711	1'524	1'441	1'358	1'273	1'189	1'105	1'694	1'694	1'447	1'741	1'885	2'029
Other Fuels	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1A2e Food Processing, Beverages and Tobacco	TJ	7'326	7'697	7'153	7'536	7'260	8'059	8'989	8'889	9'118	9'667	9'497	8'834	9'179	8'986	8'938
Light fuel oil	TJ	4'634	4'808	4'743	4'853	4'837	4'860	5'090	5'005	5'249	5'247	5'172	5'042	4'997	4'945	4'744
Heavy fuel oil	TJ	1'163	1'029	917	826	761	739	655	519	486	484	450	434	392	368	383
Coal	TJ	447	367	443	381	283	340	470	430	256	294	233	135	381	243	141
Natural gas	TJ	1'082	1'494	1'050	1'476	1'380	2'119	2'773	2'935	3'128	3'643	3'641	3'223	3'409	3'430	3'670
Biomass	TJ	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other Fuels	TJ	NO	NO	NO	NO	NO	NO	0	NO	NO	NO	NO	NO	NO	NO	NO
1A2f Other	TJ	49'459	50'158	48'637	47'423	47'232	47'123	47'464	48'553	50'866	52'690	53'029	54'804	53'171	55'343	56'150
Light fuel oil	TJ	17'168	19'478	19'937	19'077	18'466	17'665	19'179	21'481	23'910	24'657	23'274	24'419	23'914	24'547	23'707
Heavy fuel oil	TJ	10'300	9'982	10'227	8'366	9'273	7'154	7'036	6'304	6'121	5'845	3'938	3'655	3'117	2'573	2'793
Coal	TJ	12'617	9'774	7'682	6'638	7'057	7'338	4'618	4'161	3'692	3'697	5'765	5'909	5'150	5'386	5'304
Natural gas	TJ	3'404	4'645	4'287	6'181	5'440	6'828	7'304	7'954	8'244	9'763	10'647	10'548	9'421	10'589	11'654
Biomass	TJ	3'923	4'196	4'388	4'563	4'673	5'163	5'818	5'214	5'313	5'308	5'484	5'540	6'268	6'700	6'906
Other Fuels (Waste fuels in Cement)	TJ	2'047	2'082	2'118	2'598	2'324	2'974	3'509	3'439	3'586	3'420	3'922	4'732	5'301	5'549	5'786

Table 38 Activity data fuel consumption in 1A2 Manufacturing Industries and Construction 1990 to 2004; fuel consumption Other Fuels (Waste fuels in Cement) in TJ has been calculated bottom-up from the amount (in tons) of waste derived fuels used.

The table above documents the increase of Natural Gas consumption for manufacturing industries by 90% from 1990 to 2004 as well as the net decrease of liquid fuel consumption by -13% and the decrease of coal consumption by -61% over the 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 non-CO_2 emissions from cupola ovens in iron foundries and reheating furnaces in steel plants is based on data from EMIS.

Source/production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1A2a Iron and Steel																
Iron foundries: cupol ovens	Gg	90	72	68	54	55	60	51	53	57	56	55	49	37	34	40
Steel plants: reheating furnaces	Gg	1'108	1'155	1'245	1'276	1'230	716	738	789	880	918	1'022	1'048	1'125	1'110	1'094

Table 39 Activity data: Production in Iron and Steel that is used to calculate bottom-up non-CO_2 emissions from sources in 1A2a (EMIS database).

Activity data on cement production used for the calculation of non-CO_2 emissions from fuel use in cement industry is provided by the association of Swiss cement producers (Cemsuisse 2004) (See Table 68 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[9]: Estimates by FOEN experts, SAEFL 2003a and Cemsuisse 2004. The activity data is used to calculate CO_2 emissions from "Other fuels" in 1A2.

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	47'807	42'827	0	32'618	22'409	21'662	66'232	15'687	248'994

Table 40 Activity data: Amount of waste derived fuels ("Other fuels") in cement industry. Sources: Estimates by SAEFL experts (in *italics*), EKV 1991, SAEFL 2003a and Cemsuisse 2004.

The table above documents the increase of the use of waste derived fuels ("Other fuels") in cement industry by more than 300% from 1990 to 2004 (in tons; and by 283% 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

[9] As cited in the EMIS data base.

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):

Source	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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	10'872	11'361	11'046	10'982	11'302
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	6'951	6'629	5'746	5'433	5'516
HFO	TJ	1'907	2'957	4'377	3'263	4'589	2'825	3'507	3'206	3'168	3'260	1'530	1'194	1'079	621	769
Coal	TJ	12'119	9'214	6'950	6'164	6'539	6'811	4'123	3'687	3'353	3'260	5'399	5'424	4'656	4'812	4'736
Gas	TJ	362	14	67	48	27	168	34	10	62	121	22	11	11	0	11
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	3'922	4'732	5'301	5'549	5'786
Cement waste biomass	TJ	122	105	88	191	429	680	973	988	693	753	850	1'698	1'835	2'098	2'190
Cement waste fossil	TJ	1'925	1'977	2'030	2'408	1'895	2'295	2'535	2'450	2'893	2'668	3'071	3'033	3'466	3'452	3'596

Table 41 Activity data: Overview on fuel use in cement industry.

c) Transport (1A3)

Key categories 1A3b
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of gasoline and of diesel (level)
CH_4 from the combustion of gasoline (trend)

Key source 1A3e
CO_2 from military aviation (trend)

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

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

Aviation (1A3a)

Methodology

The methodology used so far for modelling the emissions of civil aviation has been changed, the emissions have been completely revised and improved. The new method is described in the following paragraphs, a comparison between the previous and the present activity data is shown in Chapter 9.1.

Swiss FOCA now uses a Tier 3a method that replace the formerly used tier 2 method in order to estimate both LTO and Cruise emissions for domestic and international flights for 1990, 1995, 2000, 2002 and 2004. 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. Both methods are described below.

To separate emissions reported under 1A3a Civil Aviation and international bunker emissions (memo items), domestic flights and international flights are distinguished. (Dodmestic: All flights between any two points in Switzerland. LTO: All flights which take place between Switzerland and another country; arriving traffic from abroad is also counted in the LTO; Cruise: All flights which start in Switzerland and end in another country).

Details of emission factors and activity data see below. Further tables containing more detailed information are also given in Annex A2.5.

The output of the emission modelling consists of tables with the following structure:

Airport	Distance	Type Traffic	Move-ments	Type	Aircraft ICAO	Engine Name	Fuel (LTO) tons	Emissions (LTO) in tons					
	Km		No.					CO2	H2O	SO2	NOx	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

Table 42 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.

The bottom-up approach in this inventory is considered complete and therefore the result for the calculated fuel consumption should be not more than a few percent below the effective tanked fuel quantity. The calculated domestic fuel consumption is considered complete. In order to match the reported fuel quantity sold with the bottom up calculation, any occurring difference between total fuel sold and total fuel calculated is attributed to “International” (bunker). The factor between calculated international fuel and adjusted international fuel is used to linearly scale the bunker emissions. For 1990, the bunker fuel consumption and the emissions had to be expanded by the factor 1.045.

The results of the emission modelling have been transmitted from FOCA to FOEN in a aggregated form. The FOEN CRF coordinator calculated the implied emission factors 1990, 1995 and 2000. Using linearly interpolated implied emission factors and the annual fuel sold (Swiss overall energy statistics, SFOE 2005), the missing emissions of the years 1991-1994, 1996-1999 could be determined.

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 22). Small yearly variations have been neglected so far.

- CH_4, NMVOC: 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)[10]. For CH_4, the emission factor varies between 3.4 kg/TJ in 1990, minimum value 3.2 kg/TJ in 1995 and maximum value 5.3 kg/TJ in 2004.
- N_2O: The IPCC default value 2.3 kg/TJ is used for the whole period 1990-2004 (IPCC 1997b).

SO_2:
The emission factor is 23.3 kg/TJ (1990–2004).

Precursors:

Assignment of emission factors for the 1990 and 1995: The fleet that was 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 450 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 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 1991b). 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. Actual fuel burn of hundreds of flights has been analysed. FOCA is now able to compute realistic mean fuel burn (and emissions) of the Airbus fleet very accurately. From FOCA statistics, the great circle distance for every flight is known. To estimate the effective flight distance, the great circle distance is multiplied by a mean factor of 1.05 [FOCA 2005]. Multiplication of cruise emission factors by flight distance directly produces cruise emissions per aircraft (see Table 149 in Annex A2.5).

Some of the old or missing aircraft cruise factors had to be modelled on the basis of the ICAO engine emissions databank. Vast knowledge of aircraft types and engine technology was necessary to perform this task. For piston engine aircraft, Swiss FOCA has produced its own data, which were taken under real flight conditions (2005 data, publication envisaged in 2006).

LTO-Times in Mode

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

[10] for the previous submissions, a split of split of 0.53 : 0.47 has been used.

helicopters, the times in mode shown in the Appendix are used, based on ICAO, US EPA and Swiss FOCA data.

Activity Data

The basic source for the 1990 and 1995 inventories 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. For 2004, the statistics contains up to 800'000 records with individual tailnumbers. All annual aircraft movements recorded are split into domestic and international flights (2004: 718’673 movements total). Data are then sorted and accumulated by aircraft registration, airport/airfield, company, type of flight, domestic/international (65’000 records). The data sets are connected to FOCA aircraft-engine-combinations database. This database links aircraft registration to engine codes, number of engines, aircraft cruise codes, and LTO-Time codes. Missing aircraft (aircraft that were not yet flying in Switzerland the year before) are listed out. In 2004, a total of nearly 3’000 new aircraft had to be added to this database, each with assignment of aircraft, engine and cruise codes. The codes are linked to corresponding codes in FOCA engine-data, LTO-cycle and aircraft-cruise-factors database for emission calculation.

Procedure for 1990 and 1995 inventories: The aircraft registration number, which is normally the key variable, is missing in the 1990 and 1995 airport data. Therefore FOCA merged the two files with the variables “Airline” and “Seats”. Since 1990 many airlines do not exist anymore. Missing airlines were replaced with airlines of the same nationality operating on the same flight stage.

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, helicopter and small jet emission data are still sparse, so aggregation of aircraft is necessary. Procedure for 1990 and 1995 inventories: For 1990 and 1995 data, the emissions data for non-scheduled, non-charter, General Aviation (helicopters etc.) could not be calculated with a Tier 3 method. The portion of fuel consumption of this traffic is estimated to 10% of the domestic consumption. Data were taken from two FOCA studies (FOCA 1990, FOCA 1991)

The Swiss FOCA statistical database 2004 contains records of the number of all movements per airport, including all movements from airfields. Movements from airfields are dominated by small piston engine aircraft. In those cases where destination or local flight information were missing, the track distances have been estimated by mean flight times. In Switzerland, the mean cruising time for small aircraft has been estimated 20 minutes, corresponding to a mean total flight time of 30 to 40 minutes (LTO included). With this information and the FOCA emissions data base (2004), cruise emissions of small aircraft have been calculated. Procedure for 1990 and 1995 inventories: For some airfields there was no information available about actual aircraft that have been flying and no information was recorded about their destination, however, from the fleet register, the most frequent (generic small) aircraft have been derived.

Helicopter movements: Helicopters can contribute quite significantly to domestic emissions, basically through a huge number of “rotations” (from loading to unloading, mostly without landing). For the inventory, the number of helicopter rotations was taken from "Unternehmensstatistik der Schweizer Helikopterunternehmen” (FOCA 2004). The number of rotations has been converted to movements by multiplying with a factor of two. Further corrections have been made in order to avoid double counting with LTO at airports. From fleet composition, a split between 87% single engine helicopters and 13% twin engine helicopter has been made, applying two corresponding FOCA emission factor data sets and special times in mode (no take-off and taxi) for the actual emission calculation. For the IPCC inventory, Helicopter rotations emissions are considered 100% domestic. (There is a helicopter base in the Principality of Liechtenstein consuming a certain amount of fuel contained in the Swiss statistics. Its consumption actually leads to international bunker emissions. The Liechtenstein Office of Environmental Protection estimated its domestic emission due to the helicopter activities in the order of magnitude of 0.1 Gg CO_2. FOCA and FOEN decided to report these emissions as Swiss-domestic since it is a small amount and the effort for a separation would be considerable.)

Table 43 summarises the activity data for domestic (1A3a) and international aviation (reported under Memo items, international bunkers/aviation). A comparison of the activity data due to the current modelling results with the former results is shown in Chapter 9.1.

Civil Aviation	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
	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	2'539	2'296	2'028	1'951	1'963
Total international	41'891	40'879	43'506	45'349	46'847	49'925	51'982	53'990	56'606	60'813	63'694	60'105	55'475	49'771	46'900
Sum	45'341	44'074	46'724	48'515	49'924	52'999	54'954	56'840	59'348	63'497	66'233	62'401	57'503	51'722	48'863
1990 = 100%	100%	97%	103%	107%	110%	117%	121%	125%	131%	140%	146%	138%	127%	114%	108%

Table 43 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.

Road Transportation (1A3b)

Key categories 1A3b
CO_2 from the combustion of diesel (level and trend)
CO_2 from the combustion of gasoline and of diesel (level)
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 using country-specific emission factors. The emission factors are derived from the carbon content of fuels (see Table 22). The activity data corresponds to the amounts of gasoline and diesel fuel sold in Switzerland (sales principle). These numbers are taken from the national fuel statistics which is part of the Swiss overall energy statistics (SFOE 2005).

Other gases

The other gases are modelled with a well-documented national method (SAEFL 1995a, 2004a-c, INFRAS 2004, RWTÜV 2003, TUG 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 1995a, 2004a-c). 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, ASTRA 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/BFS 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[11], number of starts, trip length distributions and parking time distributions. The fleet composition also accounts for foreign vehicles (SAEFL 2004a, SAEFL 2004f). Further details of emission modelling are given in Annex 2.6.

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 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.

Emission Factors

The emission factors for CO_2 are country-specific and based on measurements and analyses of fuel samples (see Table 22). Emission factors for the further gases are 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, SAEFL 2004c (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, TUG 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 2004b). 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 2.6.

The following table gives a selection of mean emission factors. The CO_2 factors are constant over the whole period 1990–2004. 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

[11] 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.

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 (TNO 2002a-b, TNO 2003). Emission factors per emission concept are given in Annex A3.2.1. A separate table shows the details of the N_2O emission factors.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
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	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	73.6	73.6	73.6	73.6	73.6
CH4															
gasoline	0.024	0.021	0.018	0.016	0.014	0.013	0.011	0.010	0.009	0.008	0.007	0.007	0.006	0.005	0.005
Diesel	0.0012	0.0012	0.0011	0.0009	0.0009	0.0008	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0005
N2O															
gasoline	0.0020	0.0024	0.0028	0.0031	0.0034	0.0036	0.0038	0.0038	0.0037	0.0036	0.0034	0.0032	0.0030	0.0027	0.0025
Diesel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.002	0.002
NOx															
gasoline	0.452	0.398	0.345	0.307	0.279	0.255	0.233	0.213	0.194	0.177	0.156	0.142	0.129	0.120	0.110
Diesel	0.227	0.230	0.221	0.216	0.219	0.214	0.213	0.213	0.215	0.218	0.221	0.221	0.215	0.211	0.204
CO															
gasoline	3.133	2.816	2.501	2.291	2.113	1.963	1.835	1.734	1.648	1.576	1.518	1.453	1.372	1.312	1.252
Diesel	0.218	0.223	0.198	0.181	0.177	0.161	0.155	0.149	0.145	0.141	0.133	0.128	0.123	0.118	0.108
NMVOC															
gasoline	0.539	0.472	0.405	0.356	0.309	0.269	0.233	0.205	0.181	0.162	0.142	0.127	0.111	0.100	0.090
Diesel	0.049	0.051	0.043	0.038	0.037	0.032	0.030	0.029	0.028	0.027	0.026	0.025	0.024	0.023	0.021
SO2															
gasoline	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.007	0.006	0.005	0.004	0.0004
Diesel	0.065	0.061	0.056	0.047	0.020	0.016	0.017	0.016	0.019	0.021	0.013	0.012	0.011	0.009	0.0005
Heavy duty vehicles								**t/TJ (= kg/GJ = g/MJ)**							
CO2	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6	73.6
CH4	0.0020	0.0020	0.0019	0.0019	0.0018	0.0018	0.0018	0.0017	0.0016	0.0016	0.0014	0.0013	0.0012	0.0011	0.0010
N2O	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012	0.0011	0.0010	0.0010	0.0009
NOx	1.027	1.028	1.028	1.022	0.994	0.961	0.938	0.924	0.926	0.928	0.911	0.893	0.859	0.827	0.786
CO	0.220	0.218	0.217	0.213	0.205	0.201	0.197	0.192	0.186	0.179	0.172	0.160	0.157	0.155	0.151
NMVOC	0.081	0.080	0.079	0.077	0.073	0.072	0.071	0.070	0.066	0.063	0.059	0.051	0.048	0.046	0.042
SO2	0.065	0.061	0.056	0.047	0.020	0.016	0.017	0.016	0.019	0.021	0.013	0.012	0.011	0.009	0.0005

Table 44 Mean emission factors for road transport for passenger cars and heavy duty vehicles. For more details see Annex 3.

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 157’590 TJ of gasoline and 67’110 TJ of diesel oil (2004). 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.

Activity data 2004	**source category**	**Gasoline**	**Diesel**	**Total**
			1000 TJ	
on-road consumption (model)	1A3b	138.9	57.8	196.6
"tank tourism"	1A3b	15.7	-8.5	7.2
off-road consumption (models)	1A3a,c,d;e; 1A4c; 1A5	3.0	17.9	20.9
Gasoline and Diesel sold in Switzerland (CRF)	1A3; 1A4c; 1A5	157.6	67.1	224.7

Table 45 Activity data for calculating the CO_2 emissions of Road Transportation.

Further activity data needed for modelling the non-CO_2 emissions are the mileages (vehicle kilometres) per vehicle category in Table 46.

Veh. cat.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	million vehicle-km														
PC	42'648	43'744	43'176	42'260	43'278	44'638	45'564	46'136	47'053	48'163	49'552	50'713	51'697	52'423	53'082
LDV	2'758	2'742	2'867	2'923	3'048	3'025	3'112	3'258	3'421	3'577	3'792	3'971	4'128	4'207	4'276
HDV	2'044	1'997	2'046	2'038	2'069	1'996	2'014	2'048	2'110	2'224	2'385	2'291	2'228	2'213	2'291
Coaches	110	110	111	111	112	112	111	110	103	100	101	97	98	96	95
UBus	175	187	188	191	190	193	189	189	190	193	197	205	208	208	209
2W	2'025	1'946	1'866	1'793	1'717	1'744	1'756	1'823	1'872	1'941	1'998	2'061	2'123	2'179	2'233
Sum	49'759	50'726	50'254	49'314	50'413	51'708	52'745	53'564	54'749	56'198	58'024	59'337	60'481	61'327	62'185
	100%	102%	101%	99%	101%	104%	106%	108%	110%	113%	117%	119%	122%	123%	125%

Table 46 Mileages in millions of vehicle kilometres. PC passenger cars, LDV light duty vehicles, HDV heavy duty vehicles, UBus urban buses, 2W Two-wheelers.

In 2004, 85.4% of total vehicle kilometres are driven by passenger cars, 6.9% and 3.7% by light and heavy duty vehicles, respectively. The mileages increased for all vehicle categories (except coaches), totalling 25% in the period 1990–2004 or 1.6% per year. In the same period, fuel consumption increased less strongly, by 12%, indicating improved fuel efficiency. The effect is shown in the next table indicating the specific fuel consumption per vehicle-km. For most vehicle categories, the specific consumption has decreased in the period 1990-2004 (between -7% and -20%); only two-wheelers have enhanced their consumption (4%). On an average over the whole car fleet, a decrease of 10% has been reached.

Veh. Categ.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	specific fuel consumption (MJ/veh-km)														
PC G	3.17	3.15	3.13	3.13	3.11	3.09	3.08	3.05	3.03	3.00	2.97	2.94	2.92	2.90	2.87
PC D	3.06	3.07	3.05	3.11	3.04	3.03	3.02	3.02	2.99	2.94	2.88	2.78	2.70	2.65	2.61
LDV G	4.14	4.05	3.97	3.91	3.86	3.83	3.79	3.74	3.68	3.63	3.58	3.52	3.46	3.42	3.36
LDV D	4.93	4.86	4.78	4.71	4.60	4.53	4.47	4.41	4.36	4.31	4.24	4.14	4.06	4.01	3.96
HDV D	10.85	10.85	10.85	10.74	10.75	10.61	10.47	10.34	10.20	10.10	10.00	10.19	10.17	10.15	10.13
Coach D	12.24	12.21	12.16	12.06	11.96	11.86	11.75	11.64	11.52	11.41	11.26	11.09	10.99	10.91	10.86
UBus D	16.17	16.18	16.15	16.10	16.04	15.97	15.86	15.74	15.65	15.53	15.42	15.33	15.20	15.11	15.03
2W G	1.21	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.28	1.28	1.28	1.28	1.27	1.27	1.26
Average	3.53	3.50	3.50	3.50	3.48	3.44	3.42	3.39	3.36	3.33	3.31	3.27	3.22	3.19	3.16
	100%	99%	99%	99%	99%	98%	97%	96%	95%	94%	94%	93%	91%	90%	90%

Table 47 Fuel consumption of road transport, not including "tank tourism"(abbreviations: compare with Table 45; G gasoline, D diesel fuel.

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/BFS 2000.)

Veh. cat.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	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	3'545	3'630	3'701	3'754	3'801
LDV	221	228	229	228	232	238	241	243	247	254	260	268	274	275	277
2W	764	747	729	720	708	704	699	709	718	728	731	740	741	746	749
	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	2.75	2.74	2.72	2.71	2.69
LDV	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.97	1.96	1.96	1.96	1.96	1.96
2W	1.59	1.58	1.57	1.56	1.55	1.54	1.54	1.53	1.52	1.51	1.50	1.51	1.52	1.52	1.53

Table 48 Vehicle stock numbers and average number of starts per vehicle per day.

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. Railways, navigation etc. are all modelled by the same approach. The emissions are calculated with a Tier 2 method. 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 (SAEFL 2005a). More details of the emission modelling are described in Annex A2.7 Off-road Vehicles.

Emission Factors (SAEFL 2005a)

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

- The emission factor for CO_2 is assumed to be constant in the period 1990-2004 with value 73.6 t/TJ (Diesel oil, see Table 22).
- For SO_2 the emission factors are given in Table 144 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 0.5 kg/TJ in 2004.
- The emission factors for all other gases are shown in Table 154 in Annex A2.7.2, row diesel oil. 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 155 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 between 283 and 300 g/kWh is used (see Table 154). The operating hours depend on the number of vehicles per age and size class. In 2000 e.g., 1255 vehicles were operating 0.773 million hours per year with an average number of 616 operating hours per year per vehicle (SAEFL 2005a.) The resulting fuel consumption is shown in Table 49.

Railways	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Diesel (TJ)	1'132	1'162	1'192	1'222	1'253	1'283	1'276	1'270	1'263	1'256	1'250	1'259	1'269	1'278	1'288
	100%	103%	105%	108%	110%	113%	112%	112%	111%	111%	110%	111%	112%	113%	114%

Table 49 Activity data (diesel oil consumption) for railways.

Navigation (1A3d)

Methodology

The emissions of the whole off-road sector including navigation have undergone a complete revision as mentioned above (railways). The emissions are calculated with a Tier 2 method. Activity data and emission factors were updated and the emission calculation was carried out in a new database that is structured in analogy to the on-road database (SAEFL 2005a). More details of the emission modelling are described in Annex A2.7 Off-road Vehicles.

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 with a Tier 2 approach for the years 1990, 1995, 2000, 2005 etc. up to 2020. For the other years, 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 has not been estimated so far. However, it is assumed to be small compared to the domestic consumption of navigation. The emissions of navigation reported in the CRF under 1A3c include, therefore, the bunker emissions.

Emission Factors (SAEFL 2005a)

- The emission factor for CO_2 is assumed to be constant in the period 1990-2004 with value 73.6 t/TJ for diesel oil, 73.9 t/TJ for gasoline and 73.7 t/TJ for gas oil (Table 22).
- For SO_2 the emission factors are given in Table 144 in Annex 2 (diesel oil, gasoline, gas oil).
- The emission factors for all other gases are shown in Table 154 in Annex A2.7.1. 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. Table 50 shows the fuel consumption. In 2004, the fuel-split was 51%, 35% and 14% for diesel, gasoline and gas oil.

Navigation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Diesel (TJ)	928	914	900	885	871	857	858	859	860	861	863	861	860	859	858
Gasoline (TJ)	531	524	517	510	502	495	503	510	518	525	533	546	560	573	586
Gas oil (TJ)	223	227	231	235	239	243	244	244	244	244	245	245	245	245	245
Sum (TJ)	1'682	1'665	1'648	1'630	1'613	1'595	1'604	1'613	1'622	1'631	1'640	1'652	1'664	1'677	1'689
	100%	99%	98%	97%	96%	95%	95%	96%	96%	97%	97%	98%	99%	100%	100%

Table 50 Fuel consumption of navigation.

Military Aviation (Other Transportation 1A3e)

Key source 1A3e
CO_2 from military aviation (trend)

Methodology

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

The fuel consumption 1990–2004 is known yearly since it is being copied from the logbooks of the military aircrafts (VTG 2006). 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 BABLW) for 1990 and 1995. From these inputs, SAEFL determined average emission factors 1990 and 1995. For 1991-1994 the emission factors are linearly interpolated between 1990 and 1995. For 1996-2004, 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 22).
- NO_x, VOC, CO: Engine producer information is used (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 1996-2004, 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 1996-2003, the values 1995 are used. The division of VOC into CH_4 and NMVOC is carried out by a constant split of 53% : 47%.
- N_2O: The IPCC default value 23 kg/TJ is used (IPCC 1997b) over the whole period 1990–2004.
- SO_2: The emission factor is 23.3 kg/TJ (1990–2004).

Activity data

The fuel consumption is copied from the logbooks of the military aircrafts and summed up yearly (see Table 51).

Military aviation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
fuel cons. (TJ)	2'733	2'495	2'382	2'268	2'192	1'955	1'806	1'941	1'927	1'734	1'793	1'755	1'837	1'641	1'490
	100%	91%	87%	83%	80%	72%	66%	71%	71%	63%	66%	64%	67%	60%	55%

Table 51 Activity data for military aviation (VTG 2006). The net calorific value is 34.4 MJ/ litre.

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

Key categories 1A4a, 1A4b
CO_2 from the combustion of gaseous and liquid fuels in the Commercial/Institutional Sector (1A4a) and in the Residential Sector (1A4b) are key categories regarding both level and trend.

Key categories 1A4c
CO_2 from the combustion of Liquid Fuels in Agriculture/Forestry (1A4c) is a key category regarding 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. These sources are characterised by rather similar combustion processes and the same emission factors are assumed throughout these sources. 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 and SO_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 (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 2005). 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, N_2O, NO_x, CO and NMVOC are country specific based on comprehensive life cycle analysis of combustion boilers in the residential, commercial institutional and agricultural sectors, documented in SAEFL 2000a (pp. 42-56). For NO_x

emission factors, expert judgement has been used to estimate the fraction of low-NO_x burners.

The coal emission factor for CO_2 (see table below) is a mixed emission factor that results as a weighted average of the hard coal and lignite emission factors. The net calorific value of hard coal has been revised for the current submission (see Annex A2.2.1).

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

Since the fraction of stationary engines in total fuel consumption is rather small, emission factors for combustion boilers are used for all sources and fuels considered (see also Section 3.2.6 on planned improvements).

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

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+b Other Sectors: Commercial/Institutional and Residential								
LFO	73.51		1	0.6	34	12	6	33
Gas	55.00		6	0.1	15	16	2	0.5
Coal	94.11		300	1.6	65	3'600	100	350
Biomass		92	120	1.6	150	2'100	40	20

Table 52 Emission Factors for 1A4a and 1A4b: Commercial/Institutional and Residential in “Other Sectors” for 2004.

Remark: In the table above, the CO_2 emission factor of light fuel oil (73.51 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 (94.11 t/TJ) is a weighted average emission factor including hard coal (94 t/TJ), petroleum coke (94 t/TJ) and lignite (104 t/TJ) emissions, the same emission factor as for 1A2 "top-down" sources (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 2005; Table 17).

The consumption of natural gas in 1A4b Residential has been modified to account for (the entire) leakages in the distribution system (see Section 3.1.5).

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A4a Commercial/Institutional	TJ	81'344	91'491	90'109	89'504	81'788	85'789	91'495	86'933	88'779	87'708
Light fuel oil	TJ	59'498	66'478	64'865	62'710	56'548	57'870	61'825	59'188	60'265	59'108
Natural gas	TJ	17'108	19'599	19'871	21'128	19'952	21'952	23'178	21'779	22'317	22'447
Coal	TJ	0	0	0	0	0	0	0	0	0	0
Biomass	TJ	4'737	5'414	5'372	5'667	5'287	5'967	6'492	5'966	6'197	6'152
1A4b Residential	TJ	172'769	184'408	184'980	176'547	167'074	180'672	188'023	175'274	181'499	178'446
Light fuel oil	TJ	138'916	145'507	145'174	136'252	128'901	137'597	139'992	131'915	136'509	131'838
Natural gas	TJ	24'816	28'460	29'940	30'389	28'844	33'225	37'348	33'913	35'440	37'346
Coal	TJ	607	701	486	495	449	430	243	206	131	131
Biomass	TJ	8'430	9'740	9'380	9'410	8'880	9'420	10'440	9'240	9'420	9'130

Source/Fuel	Unit	2000	2001	2002	2003	2004
1A4a Commercial/Institutional	TJ	82'437	86'186	83'427	88'587	87'400
Light fuel oil	TJ	54'173	56'194	53'520	56'224	54'415
Natural gas	TJ	22'338	23'782	23'204	25'143	25'731
Coal	TJ	0	0	0	0	0
Biomass	TJ	5'926	6'210	6'702	7'220	7'254
1A4b Residential	TJ	165'071	173'993	167'693	177'555	178'041
Light fuel oil	TJ	120'784	127'553	122'470	129'328	128'194
Natural gas	TJ	35'606	37'259	37'072	39'605	40'903
Coal	TJ	121	121	121	121	374
Biomass	TJ	8'560	9'060	8'030	8'500	8'570

Table 53 Activity data in 1A4a Commercial/Institutional and 1A4b Residential.

The table above documents the increase of Natural Gas consumption by 52% (1A4a) and 63% (1A4b) from 1990 to 2004 as well as the net decrease of liquid fuel consumption by -8.7% (1A4a) and -7.7% (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 3 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. Agriculture and forestry machinery are part of the off-road sector. They were modelled with the same approach as railways, navigation etc. The emissions are calculated with a tier 2 method. An explanation of the method applied for off-road emissions is given in Annex A2.7 including emission factors and activity data.

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 and SO_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 (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 (see Section 1.4.3). Some of the emission factors have been updated based on expert judgement.

Emission Factors (SAEFL 2005a)

- The emission factor for CO_2 is assumed to be constant in the period 1990-2004 with value 73.6 t/TJ for diesel oil and 73.9 t/TJ for gasoline (Table 22).
- For SO_2 the emission factors are given in Table 144 in Annex 2 (diesel oil, gasoline).
- The emission factors for all other gases are shown in Table 154 in Annex A2.7.1. 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.

Off-road machinery: Activity data is shown in Annex A2.7.3.

Source/Fuel	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1A4c Agriculture/Forestry	TJ	10'420	10'411	10'403	10'396	10'391	10'386	10'372	10'358	10'346	10'335	10'324	10'323	10'330	10'337	10'344
Drying of Grass	TJ	1'895	1'823	1'752	1'682	1'614	1'546	1'480	1'415	1'351	1'288	1'226	1'211	1'205	1'199	1'193
of which light fuel oil	TJ	1'162	1'118	1'074	1'032	990	948	908	868	828	790	752	743	739	735	731
of which natural gas	TJ	733	705	677	650	624	598	572	547	522	498	474	468	466	463	461
Machinery	TJ	8'526	8'588	8'651	8'714	8'777	8'840	8'892	8'943	8'995	9'047	9'099	9'112	9'125	9'138	9'152

Table 54 Activity data in 1A4c Agriculture/Forestry.

e) Other – Off-road: Construction, Hobby, Industry and Military (1A5)

Key sources 1A5
CO_2 from the combustion of liquid fuels in 1A5 Other – Off-road is a key source regarding both level and trend.

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 were updated and the emission calculation was carried out in a new database that is structured in analogy to the on-road database (SAEFL 2005a).

The revision also affected the sections construction, hobby, industry, and military, which are summarised in 1A5 Other (Off-road).

1A5 emissions have been modelled in the same manner as those of railways and navigation (see sections above). They were all calculated in the same database and are documented in the same reports (SAEFL 2005a). 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. For more details see Annex A2.7.

Emission Factors (SAEFL 2005a)

- The emission factor for CO_2 is assumed to be constant in the period 1990-2004 with value 73.6 t/TJ for diesel oil and 73.9 t/TJ for gasoline (Table 22).
- For SO_2 the emission factors are given in Table 144 in Annex 2.

- The emission factors for all other gases are shown in Table 154 in Annex A2.7.1. 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 155 in the Annex A2.7.2.

Activity Data

The numbers of vehicles and operating hours are given in Annex A2.7.3. Fuel consumption data is shown in Table 55.

Off-road cat.	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1A5	fuel consumption in TJ														
Construction	5'288	5'454	5'620	5'786	5'951	6'117	6'181	6'244	6'308	6'371	6'435	6'473	6'511	6'550	6'588
Hobby	602	616	629	643	656	670	683	696	709	722	735	728	722	716	709
Industry	898	961	1'023	1'086	1'149	1'211	1'271	1'330	1'389	1'449	1'508	1'507	1'506	1'505	1'504
Military offroad	53	53	54	54	54	54	55	55	55	56	56	55	55	54	54

Table 55 Activity data (fuel consumption) and CO_2 emissions for off-road activities Construction, Hobby, Industry and Military (without Military Aviation, see 1A3e).

3.2.3. Uncertainties and Time-Series Consistency

Note that all results of this section 3.2.3 refer to the emission data according to the former submission April 2006 and not to the emission of the current submission (May 2006). The deviations are very small. For further details see 1.7.

A quantitative **Tier 1** analysis (following Good Practice Guidance; IPCC 2000, p. 6.13ff) is used to estimate uncertainties of key categories in the NIR. First, uncertainties of activity data and emission factors are estimated separately. The combined uncertainty for each source is then calculated using a Rule B approximation (IPCC 2000 p. 6.12). Further, the Rule A approximation is 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 is performed, too. It starts 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 are prepared on a disaggregated level. For each key category within 1A the uncertainty of the corresponding activity data and emission factor are determined (see Annex +1.2.2). In addition, correlation coefficients are implemented and adequate probability distributions are adopted: normal distributions are chosen in general except for 1A1/other fuels/CO_2 and for 1A2/other fuels/CO_2, where lognormal distributions were chosen for the uncertainty of the emission factor (large uncertainties with implied normal distributions may generate negative 2.5 percentile values for the emissions). See Table 137 and Table 138 for details.

a) Uncertainties

Uncertainties of activity data and emission factors are derived from a mixture of empirical data and expert judgment. With the submission 2006, uncertainties are consistently defined as half the 95% confidence interval divided by the mean and expressed as a percentage. (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 halve the value of non-default-uncertainties with the present definition.)

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).

A	B	C	D	E	F	G	H	I
Fuel type (IPCC 2000)	Corresponding fuel type in SFOE 2005	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	511'940	1.0	26'740	20	538'680	1.4	1
Gaseous fuels	Gas	113'490	5	0	0	113'490	5.0	2
Solid fuels	Kohle	5'630	5	1'000	100	5'650	18.4	3
Other fuels	Müll- und Industrieabfälle	44'670	10	0	0	44'670	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. E and F: Data from SFOE 2005 seems to underestimate stock changes. Here a rough conservative expert estimate is given of actual stock changes.

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.

Table 56 Details of uncertainty analysis of fuels in 1A (Import, production, stock changes and consumption numbers according to submission April 2006).

Data on stock changes is taken from the Swiss overall energy statistics (SFOE 2005; Table 4), except for solid fuels (coal), where the SFOE data seems to underestimate stock changes in coal considerably. New governmental policy that was introduced from 1999 reduced significantly or stopped altogether state subsidies for fuel stocks and reduced the amount of mandatory stocks that companies have to maintain ("Pflichtlager"; see DEA 2003). Experts within the Swiss cement industry confirmed that this resulted in a significant reduction of coal and heavy fuel oil stocks (and additional consumption) during the last few years that has not yet been accounted for in current data on stock changes from SFOE. Therefore, own expert estimates on stock changes in solid fuels are used, rather than data from SFOE, based on information provided by experts from the cement industry. Uncertainties of these (coal-)stock estimates are very high (100%).

Uncertainty in CO_2 emission factors in fuel combustion (1A)

Liquid fuels: The net calorific values for liquid fuels 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.

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 2004 (approx.)
Heavy fuel oil	41.2	0.85	2.06	4.13	0.000132	6	1%
Light fuel oil	42.6	0.13	0.31	0.61	0.004521	10	52%
Diesel	42.8	0.10	0.23	0.47	0.000187	10	14%
Gasoline	42.5	0.29	0.68	1.36	0.009073	30	33%
Jet kerosene	43.0	0.25	0.58	1.16	0.000001	10	0.3%
Sum	42.6				0.013914	66	100%
Combined STD/Unc		0.118 =SQR(sum(E))	0.28	0.55			

Table 57 Results from the 1998 analysis of the low calorific values of liquid fuels in Switzerland (EMPA 1998).

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. SGWIA 2005 provides a range of -2.9% and +1.7%, or an average of 2.3%. Interpreting this range as one standard deviation, a 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[12].

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

Table 58 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.

A		B	C	D	E	F	G	H	I	J	K	L	M
IPCC Source category		Gas	Base year emissions 1990	Year 2004 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	3'714.50	6'186.06	5.0	4.6	6.8	0.975	0.0558	0.1501	0.26	1.06	1.09
1A	Liquid fuels	CO2	34'319.03	34'143.58	1.4	0.55	1.48	1.174	-0.0425	0.8287	-0.02	1.61	1.61
1A	Solid fuels	CO2	1'490.48	566.35	18.4	5.0	19.1	0.250	-0.0241	0.0137	-0.12	0.36	0.38
1A	Other fuels	CO2	1'676.11	2'211.82	10.0	30.0	31.6	1.623	0.0111	0.0537	0.33	0.76	0.83
Total CO2 Emissions Fuel			41'200.11	43'107.80									
Overall uncertainty CO2 combustion emissions in the year (%):								2.24	CO2 combustion emissions trend uncertainty (%):				2.15

Table 58 Results from Tier 1 uncertainty calculation and reporting for CO_2 emissions in 1A Fuel Combustion (Emissions according to submission April 2006).

The analysis results in an overall uncertainty of the CO_2 emissions from 1A Fuel Combustion of 2.24% for the year 2004 and in a trend uncertainty for the period 1990 to 2004 of 2.15%.

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12 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 is estimated to be medium[13].

Other source categories
Uncertainty: No estimates of the uncertainties have been performed.

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

At the level of total energy-related CO_2 emissions, a first quality control consists in the comparison of emissions modelled using the Sectoral Approach and stored in the internal greenhouse gas files of SAEFL 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 1990–2004 are negligible which marks an excellent agreement.

FOEN-internally, a comprehensive cross-check of CRF tables with the internal GHG files (CRF-independent spreadsheets and calculations) is carried out for every year. This allows a

[13] For details regarding the classification of data quality as high, medium and low, see Section 1.7

comparison on a very disaggregated level of source categories and gases, including checks for summations and links made across the CRF tables.

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.

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 very good agreement between the two approaches is found.

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)

Comparison with total aviation fuel sold in Switzerland in 1990: FOCA bottom-up calculated total fuel adds up to 1’012’060 Tons. Due to Swiss overall energy statistics, total aviation fuel sold is 1’054’395 Tons (SFOE 2005). The modelling result was obtained by direct application of activity data and predefined emission factors. The difference of 4% between bottom up calculation and reported fuel sold is considered to be acceptable. Even in the case, where actual flight paths together with sophisticated fuel flow modelling are used, differences of 10% can easily result from fuelling strategies of airlines and other operational effects. FOCA investigation showed that airlines are calculating whether it is economically beneficial to refuel at a place with lower fuel prize. In some cases it can be economically beneficial for the airline to carry much more fuel than necessary to fly a certain operation. For the year 2004 FOCA investigation showed that for short and medium haul flights, airlines have the tendency to buy fuel abroad. The difference of +6% for the calculation can therefore easily be explained.

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/100pkm is in line with expectations for 1990 passenger fleets. For freighters the calculated numbers are not representative, because they carry only a few pax besides their freight.

Activity data: 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 Bâle). The published number of movements for scheduled and charter flights in 1990 is: 263’952 (without Bâle). The difference is due to pure cargo, post and rerouted flights, which are not considered as scheduled or charter movements.

Plausibility Check: SAS-Compiler: FOCA used the SAS-Software (Statistical Analysis System) for programming. This software has a compiler system that controls the program flow and indicates all number of records which are read and written. All class variables were checked with the FREQ procedures for controlling the frequencies and the content of each variable. In this manner, FOCA could handle the missing values. The totals of all calculated variables in input-work-files where listed out and the results were checked.

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.

3.2.5. Source-Specific Recalculations

All sources 1A1-1A5 except 1A3b and 1A3e have been recalculated for 1990-2003. See Chapter 9.

The net calorific value of hard coal has been revised for the current submission (see Annex A2.2.1).

3.2.6. Source-Specific Planned Improvements

EMIS database

The revision of the EMIS database is not completed yet. Until the next submission the queries will be implemented to export the emission data in the structure of the CRF Reporter.

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

At present, for stationary fuel combustion activities in Public Electricity and Heat Production (1A1a), Manufacturing Industries and Construction (1A2), the same emission factors for industrial combustion boilers and stationary engines are used for all sources and fuels. This is based on the fact that the fraction of stationary engines in total fuel consumption is rather small. In future inventories, it is planned to estimate the share of engines in total fuel consumption in each of the considered source categories and to use different emission factors for industrial boilers and engines for non-CO_2 emissions.

CO_2 emission factors for the use of waste derived fuels in cement industry are preliminary and may be revised for future submissions.

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 certification is necessary. The results will be used for improving the emission modelling in future years.

Other Sectors (1A4)

In future inventories, it is planned to estimate the share of engines in total fuel consumption in each of the considered source categories and to use different emission factors for heat boilers and engines for non-CO_2 emissions.

Other: Off-road (1A5)

After the revision of the off-road emissions, no more improvements are planned at the moment.

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 are a key category regarding 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)

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

Table 59 Specification of source category 1B2 “Fugitive Emissions from Oil and Natural Gas”.

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 SO2 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 (in this submission for the first time) 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 60; sources: Battelle 1994, Xinmin 2004, SGWIA 2005). 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.

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 a	0.80000	1.20000	0.19200	-
Cast iron b	0.08800	0.13200	0.02112	-
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	-

Table 60 CH_4-Emission Factors for 1B2 “Fugitive Emissions from Oil and Natural Gas” (Battelle 1994, Xinmin 2004, SGWIA 2005)

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 2005).

The activity data for methane of Natural Gas (source 1B2b) are provided by the Swiss gas association (SFOE 2005, SGWIA 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 2005; 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 error of 50% is estimated for Switzerland.

Qualitative estimate of uncertainties of non-key category emissions in 1B Fugitive Emissions from Fuels
A preliminary uncertainty assessment of all other sources in source category 1B2 based on expert judgement results in medium confidence in the emissions estimate.

The time series is consistent.

3.3.4. Source-Specific QA/QC and Verification

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

3.3.5. Source-Specific Recalculations

For source 1B2b Natural Gas, the emissions of CH_4 leakages from gas pipelines have been recalculated from 1990 until 2003. Also the emissions from 1B2c emissions from venting and flaring were recalculated. See Chapter 9.

3.3.6. Source-Specific Planned Improvements

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

It is planned to include the CO_2-emissions stemming from oil refinery fugitive emissions of NMVOC.

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.

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

Table 61 Specification of Swiss source category International Bunkers for civil aviation.

3.4.2. Methodological Issues

The methodologies used are described in chapter 3.2.2 for system boundaries. The emissions from civil aviation (domestic and international) are calculated with a Tier 3a. The activity data of the bunker is summarised in Table 62 (see also Table 43).

Civil Aviation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
(bunker)	Fuel consumption in TJ														
Total international	41'891	40'879	43'506	45'349	46'847	49'925	51'982	53'990	56'606	60'813	63'694	60'105	55'475	49'771	46'900
1990 = 100%	100%	98%	104%	108%	112%	119%	124%	129%	135%	145%	152%	143%	132%	119%	112%

Table 62 International bunker fuels. Consumption of kerosene in TJ.

3.4.3. Uncertainties and Time-Series Consistency

See remarks in chapter 3.2.2., Aviation (1A3a).

3.4.4. Source-Specific QA/QC and Verification

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

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).

In the present submission, energy related emissions from municipal solid waste (MSW) incineration plants have been reported for the first time 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 2G (Industrial Processes, Other), from 4F (Burning of Agricultural Residues), from 6A (Solid Waste Disposal on Land) and from 6B (Wastewater Handling) are not foreseen for reporting in the CRF.

Therefore, the CO_2 emissions from the combustion of biomass in the CRF are incomplete. The following table provides an overview of effective biomass combustion CO_2 emissions in Switzerland 2003 and their reporting in the CRF. Data stems from the CRF and the SAEFL internal GHG files.

Biomass combustion CO_2 emissions do not count for the national total emissions and are a memo item only.

Biomass combustion CO_2 emissions	**Unit**	**Value 2004**	**Note**
1A1 Energy Industries (without MSW incineration)	Gg	17	Included in CRF Source 1A1
1A1 Energy generation from MSW Incineration	Gg	2'371	Not included in CRF
1A2 Manufacturing Ind. and Constr. (excluding waste fuels in cement prod.)	Gg	800	Included in CRF Source 1A2
1A2 Use of waste derived fuels in cement production	Gg	179	Not included in CRF
1A3 Transport	Gg	NO	
1A4 Other Sectors (Commercial/Institutional, Residential)	Gg	1'456	Included in CRF Source 1A4
2G Industrial Processes, Other	Gg	14	Not included in CRF
4F Agriculture, Burning of Residues	Gg	116	Not included in CRF
6A Solid Waste Disposal on Land	Gg	67	Not included in CRF
6B Wastewater Handling	Gg	294	Not included in CRF
6C Waste Incineration (without MSW incineration)	Gg	108	Included in CRF Source 6C
Total biomass combustion CO_2 emissions included in CRF	Gg	2'381	
Total energy related biomass combustion CO_2 emissions included in CRF 1A	Gg	2'273	See table "Summary 2" in CRF
Total biomass combustion CO_2 emissions in Switzerland 2004	Gg	5'422	

Table 63 Effective biomass combustion CO_2 emissions in Switzerland and their representation in the CRF.

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 2005) and from the yearly report of the Swiss Petroleum Association [Erdöl-Vereinigung/Union pétrolière] (EV 2005). Exceptions are coal and residual fuel oil, which are taken from Basics 2006. These statistics account for production, imports, exports, transformation and stock changes. The results are exported from the internal GHG files of SAEFL into the UNFCCC GHG Inventory.

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 1990–2004. The CO_2 emissions agree very well, for all years the differences are between 0.53% and 1.47%. For energy consumption the differences are somewhat larger – between 1.42% and 2.63% – due to 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 (r^2 = 0.89).

Difference between Reference and Sectoral Approach															
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	%														
Energy Consumption	2.00	2.29	2.20	2.06	2.46	2.63	1.93	1.74	2.25	1.57	1.88	1.81	1.42	1.70	2.02
CO_2 Emissions	0.86	1.11	1.18	1.09	1.41	1.63	0.94	0.80	1.47	0.64	0.87	0.92	0.53	0.70	1.24

Table 64 Differences in energy consumption and CO_2 emissions between the Reference and the Sectoral (National) Approach. The difference is calculated according to [(RA-NA)/NA] 100% with RA = Reference Approach, NA = National Approach.

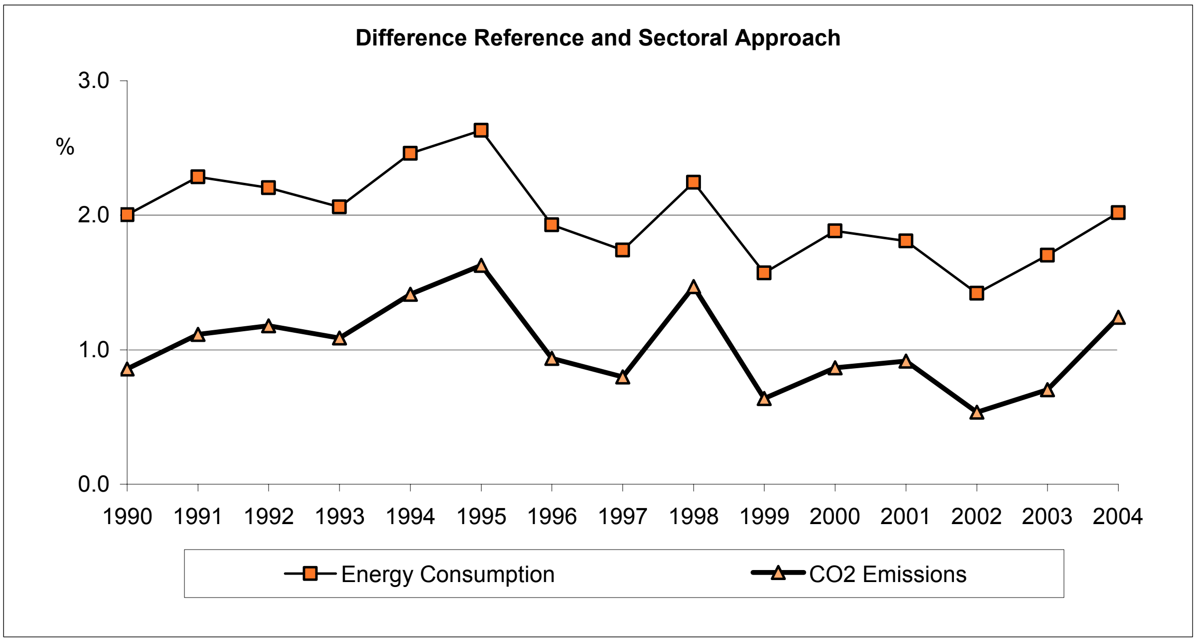

Figure 19 Time series for the differences between Reference and Sectoral Approach. Numbers are taken from the table above.

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 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 a oxidation factor of 1.0 was chosen (cf. Chapter 3.2.2.)

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.

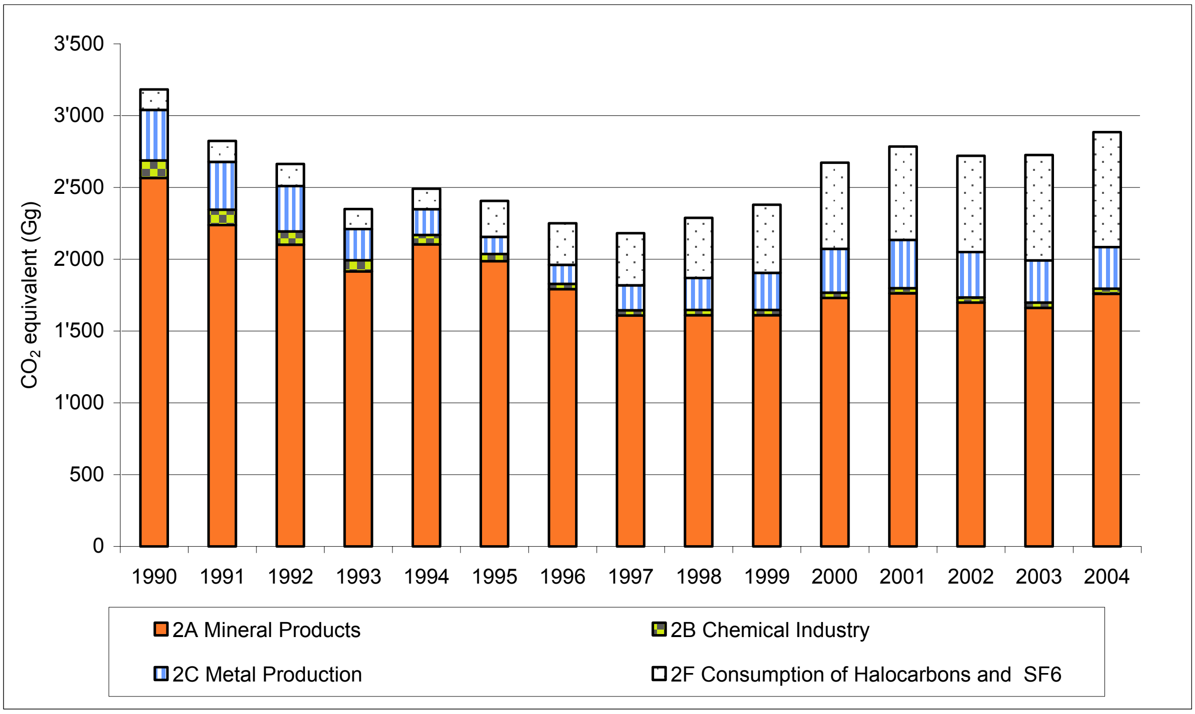

Figure 20 Switzerland's GHG emissions of source category 2 "Industrial Processes" 1990–2004. The emissions of the source category 2G "Other" are very small (about 0.3 Gg) and are not shown in the figure.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)														
CO_2	2'830	2'499	2'360	2'115	2'280	2'105	1'923	1'745	1'765	1'809	1'946	1'982	1'934	1'904	2'000
CH_4	9.1	8.7	8.3	8.0	7.7	7.3	7.3	7.2	7.2	7.2	7.2	7.2	7.2	7.1	7.1
N_2O	100.8	86.6	72.5	58.4	44.3	30.2	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.1
Synthetic gases	244	231	223	169	160	264	305	413	500	547	704	781	764	800	862
Sum	3'183	2'825	2'664	2'350	2'491	2'407	2'251	2'182	2'288	2'380	2'673	2'786	2'721	2'727	2'886

Table 65 GHG emissions of source category 2 "Industrial Processes" 1990-2004 by gases in CO_2 equivalent (Gg).

Although its emissions have decreased by over -30% in the period 1990-2004, Mineral Products (sub-category 2A) remain the dominant source amongst the Industrial Processes. Consumption of Halocarbons and SF_6 (sub-category 2F) are of increasing importance. The emissions of synthetic gases have grown by a factor of 3.54 in the same period, primarily because of the change from CFC to HFC in a lot of technical applications.

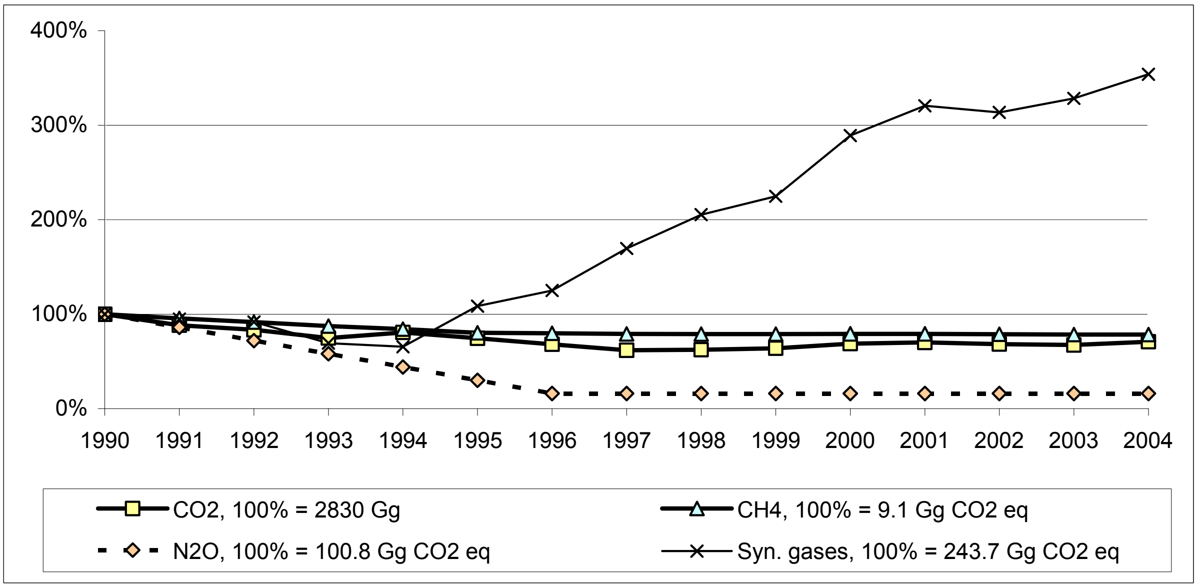

Figure 21 Relative trends of the greenhouse gases of source category 2 "Industrial Processes" in the period 1990-2004. The base year 1990 represents 100%.

The CO_2 emissions have declined to 70% whereas the synthetic gases have increased up to 354% in the period 1990-2004.

4.2. Source Category 2A – Mineral Products

4.2.1. Source Category Description

Key category 2A1
The non-energy CO_2 emissions in Cement Production (2A1) are a key category regarding 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.

2A	Source	Specification	Data Source
2A1	Cement Production	Emissions from calcination process in cement production and emissions from blasting operations.	AD: Cemsuisse 2004 EMIS EF: calcination-CO_2: WBCSD 2001; EF Other gases: EMIS
2A2	Lime Production	Emissions from calcination process in lime production.	AD: EMIS 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	Included in 2G	
2A6	Road Paving with Asphalt	Emissions from road paving	AD: EMIS EF: EMIS
2A7	Other	Not occurring in Switzerland	

Table 66 Specification of source category 2A "Mineral Products".

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 (see Section 1.4.3).

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

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

Table 67 Emission Factors for 2A1 Cement Production for 2004 (cem.: cement).

Activity Data

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

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
2A1 Cement Production						
Cement production	Gg	3'754	3'891	3'771	3'592	3'957
Clinker production	Gg	3'214	3'275	3'150	3'081	3'265

Table 68 Activity data in 2A1 Cement Production.

The table above documents the decrease of Swiss cement production by -22% from 1990 to 2004. 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 has been reviewed for the present submission of the inventory. 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 (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 (see Section 1.4.3). Annual lime production is estimated at 79'800 t in 2004.

c) 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 (2004). 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 (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 (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 general QA/QC measures described in Section 1.6 have been carried out.

4.2.5. Source-Specific Recalculations

All emissions have been recalculated for the time series 1990–2003 due to the revision of the EMIS database. See Chapter 9.

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

N_2O Emissions in Chemical Industry (2B) are a key category regarding trend.

Source category 2B "Chemical Industry" comprises non-energy emissions from the Production of Nitric Acid, Carbide and Organic Chemicals. The production of Ammonia and Adipic Acid are not occurring in Switzerland.

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

Table 69 Specification of source category 2B "Chemical Industry".

4.3.2. Methodological Issues

a) Ammonia Production (2B1)

Methodology

For CO_2, NO_x, CO, NMVOC and SO_2 emissions from Nitric Acid Production (2B2), 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 (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. 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 2004:

2B2 Nitric Acid Production	N_2O	NO_x
	kg/t	kg/t
Nitric Acid Production	0.80	0.10

Table 70 Emission Factors for 2B2 Nitric Acid Production in 2004.

The emission factor for N_2O was 5 kg/t in 1990, decreased to 0.8 kg/t in 1996, and remained constant since then. This strong decrease is the main reason for 2B2 N_2O emissions being a key category regarding trend.

Activity Data

Activity data on annual production in 1990 has been provided by industry. As the use of fertilizers in agriculture and therefore the production of nitric acid are likely to decrease, the conservative assumption is made that production has been constant in the period 1990 - 2000, at 65’000 tons of nitric acid produced annually. After 2000, a linear decrease of nitric acid production reaching 50'000 tons in 2020 is assumed, based on expert estimate.

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.

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 (see Section 1.4.3).

Activity Data

Activity data on annual production have been provided by industry as documented in the EMIS database.

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 general QA/QC measures described in Section 1.6 have been carried out.

4.3.5. Source-Specific Recalculations

All emissions have been recalculated for the time series 1990–2003 due to the revision of the EMIS database. See Chapter 9.

4.3.6. Source-Specific Planned Improvements

In 2B1 Ammonia Production is planned to report other emissions (apart from NH_3) for future submissions.

Also, the N_2O emission factor for 2B2 Nitric Acid Production will be revised.

4.4. *Source Category 2C – Metal Production*

4.4.1. Source Category Description

Key category 2C3
The CO_2 emissions and PFC emissions in Aluminium Production (2C3) are key categories regarding 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.

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
2C2	Ferroalloys Production	Included in 1C1.	
2C3	Aluminium Production	Emissions from the production of Aluminium	AD: Industry Data, www.alu.ch EF for PFC: Industry Data EF other gases: EMIS
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: EMIS
2C5	Other	Not occurring in Switzerland	

Table 71 Specification of source category 2C "Metal Production".

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. The emissions are calculated by multiplying the annual production output of steel (level of activity) by emission factors.

In Aluminium Production (2C3) 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 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 2004 without measured emission data the European average emission factor (0.15 kg_{PFC}/t_{AL}) (IAI 2005) with a correction factor of

0.25 is being used. This results to 0.0375 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.

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).

For CO_2 emissions from Iron and Steel Production (2C1), an emission factor of 135 kg CO_2 per ton of steel produced is used (EMIS).

For CO_2 emissions from Aluminium Production (2C3), an emission factor of 1.6 ton CO_2 per ton of aluminium is used (EMIS). 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 coke (for the anode production) per ton of aluminium (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 72 are used.

Year	Emission factor (kg/t)	
	CF_4	C_2F_6
1990	0.1530	0.0170
1991	0.1373	0.0153
1992	0.1215	0.0135
1993	0.1058	0.0118
1994	0.0900	0.0100
1995	0.0833	0.0093
1996	0.0765	0.0085
1997	0.0698	0.0078
1998	0.0630	0.0070
1999	0.0540	0.0060
2000	0.0360	0.0040
2001	0.0360	0.0040
2002	0.0360	0.0040
2003	0.0360	0.0040
2004	0.03375	0.00375

Table 72 PFC emissions factors for aluminium production in Switzerland.

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 (see Section 1.4.3).

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:

Source/production	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
2C Metal Production											
2C1 Iron and Steel	Gg	1'198	1'227	1'313	1'330	1'285	776	790	842	937	975
2C3 Aluminium	Gg	87.0	81.9	75.4	36.4	24.2	20.7	26.6	27.3	32.3	34.4

Source/production	Unit	2000	2001	2002	2003	2004
2C Metal Production						
2C1 Iron and Steel	Gg	1'078	1'097	1'162	1'143	1'134
2C3 Aluminium	Gg	35.5	36.3	40.2	43.9	44.9

Table 73 Activity data for 2C1 and 2C3 in Metal Production.

The table above documents the decrease of aluminium production by almost 50% from 1990 to 2004. This decline results in CO_2 and PFC emissions from category 2C3 being a key category regarding trend (however not regarding level).

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 estimate as 30%. For PFC, an emission uncertainty of 48% (with normal distribution) is assumed, which is a result of the Monte Carlo simulation of the emissions of synthetic gases (Carbotech 2006, see also Table 9).

Qualitative estimate of uncertainties of non-key category emissions in 2C

A preliminary uncertainty assessment of non-key category emissions in 2C based on expert judgment results in medium confidence in emissions estimates.

The time series is consistent.

4.4.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out (checklists see FOEN 2006).

4.4.5. Source-Specific Recalculations

In the previous years SF_6 from Aluminium Foundries in 2C4 had been reported under Solvents in category 2F5. This was due to the structure of the relevant import statistics. On the basis of different discussions this was identified as being incorrect. In 2004 the declaration is corrected and also the activity data in this category for previous years has been changed. This results in higher emissions for this category as compared to the previous reports. However the total overall emissions for the synthetic gases remain and it is only a matter of reallocation to different categories.

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. The available time was too short to obtain detailed information from the industry. It however is foreseen to include detailed information in the 2007 submission.

4.5. Source Category 2D – Other Production

Source category 2D “Other Production” is **not a key category.**

All emissions from Pulp and Paper and Food and Drink production are included under source category 2G - Other.

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 2F
PFC from consumption of halocarbons and SF_6 (2F) is a key category regarding trend (no. 24 in Table 6)

Key category 2F1
HFC from consumption of halocarbons and SF_6; Refrigeration and air conditioning equipment (2F1) is a key category regarding level and trend (no. 26 in Table 6).

Key category 2F_o
Definition: 2F_o (HFC) includes all HFC sources from 2F without 2F1 (no. 25 in Table 6). 2F_o (HFC) is a key category regarding trend.

See also Chapter 1.5 an d Annex 1 on key categories.

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

2F	Source	Specification	Data Source
2F1	Refrigeration and Air Conditioning Equipment	Emissions from Refrigeration and Air Conditioning Equipment	AD: Various national statistics[14] 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	Semiconductor Manufacturing	Emissions from use in semiconductor manufacturing	AD: Import statistics EF: IPCC default values
2F7	Electrical Equipment	Emissions from use in electrical equipment	AD: Industry data EF: Industry data
2F8	Other	Emissions of SF_6 which are not yet accounted under 2F7	AD: Industry data EF: Industry data

Table 74 Specification of source category 2F “Consumption of Halocarbons and SF_6”. Data source “import statistics”: Carbotech 2006.

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 68% of the total emissions in the source category 2F.

[14] e.g. statistics on registration of cars and trucks, import statistics on synthetic gases (Carbotech 2006)

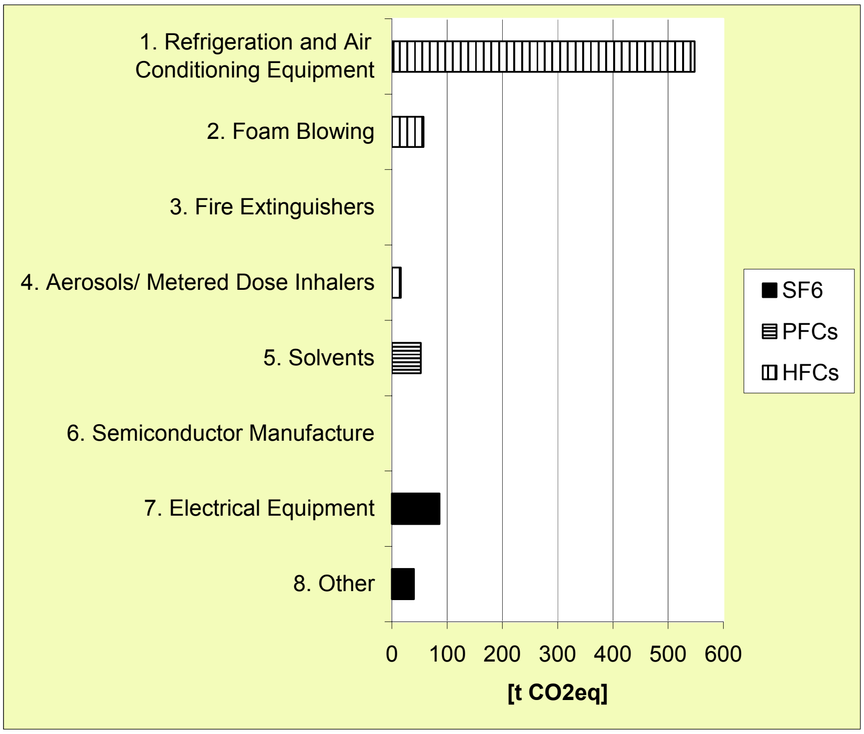

Figure 22 Distribution of emissions under source category 2F "Consumption of Halocarbons and SF_6" (2004 data).

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 3.3 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 75). Detailed documentation of the individual data models is available from Carbotech 2006 and related background documents. This information is SAEFL 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 75 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 Oeko-Recherche 2001.

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	2	0.5	92	37
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)	10 / 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

NA = not available
NR = not relevant as only aggregate data is used
NO = Not occurring (only import of charged units)

Table 75 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.

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 3.3. Car air-conditioning accounts for approx. 29% 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).

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 / 2004

** 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

Table 76 Typical values on life time, charge and emission factors used in model calculations for foam blowing.

Activity Data

The export rate of PU spray from Swiss production is 96.5% of total production volume. For PU and XPS foams the export rate is around 20%. This has been taken into account. From 2000 onwards there is no production of XPS in Switzerland. The imported products have been taken into account.

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.

In the previous years SF_6 from Aluminium Foundries in 2C4 had been reported under Solvents in category 2F5. This was due to the structure of the relevant import statistics. On the basis of different discussions this was identified as being incorrect. For 2004 data the declaration is corrected and also the activity data in this category for previous years has been changed. This results in higher emissions for this category as compared to the previous reports. However, the total overall emissions for the synthetic gases remain and it is only a matter of reallocation to different categories.

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 Semiconductor Manufacturing

Methodology

No HFC, PFC and SF_6 emissions were considered for semiconductor manufacturing in 2004. 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 2F8. A small left over amount which might still be used for semiconductor manufacturing is considered not to be relevant.

2F7 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. The product life emission factor is varying between 0.45%/a (2001) and 0.65%/a (2004).

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.

2F8 Other

Methodology

The emissions reported under 2F8 relate to windows and a small amount of unallocated SF_6 from the SWISSMEM mass balance (see above under 2F7) 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 2008due 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 for 2004. For this purpose, 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 78 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 2006.

In this year for the first time also the uncertainty for the import statistic data has been estimated. Discussions with the persons responsible for data collection in the years 1997–2003 lead to the estimations given in Table 77.

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.

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	-10%	+10%	

Table 77 Estimated uncertainty for the data of the imported substances

The following table summarises the results for the application-specific emission models. The “value 2004” represents the actual emissions in Gg CO_2 equivalent for the specific application as used for calculating the 2004 CRF tables. The average, median, uncertainty, minimum and maximum values are output values of the Monte Carlo Analysis.

Uncertainties with a standard deviation of more than 10% have been calculated for the following applications:

- Foam blowing
- Transport refrigeration
- Domestic refrigeration

These three applications have a contribution to the GHG potential of the synthetic gases of less than 10%. Therefore it seems not a priority issue to make major efforts for reducing these uncertainties.

Medium uncertainties of 7% to 10% have been calculated for the following applications:

- Commercial Refrigeration
- Mobile Air Condition
- Stationary Air Condition

These three applications make a contribution to the total GHG potential of the synthetic gases of about 50%. 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 18% for R134a in Commercial/ Industrial Refrigeration and 17% 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 compared to previous years. 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.

Application	Model parameter	value 2004 Gg CO_2 eq.	Average Gg CO_2 eq.	Median Gg CO_2 eq.	Uncertainty (st. dev.) %	Quality Level -	min. Gg CO_2 eq.	max. Gg CO_2 eq.
Commercial / Industrial Refrigeration	Emissions in Gg CO_2 eq.	293	257	256	8	Medium	184	320
Mobile Air-Conditioning		156	176	174	10	Medium	137	230
Stationary Air-Conditioning		82	97	96	10	Medium	67	133
Foam Blowing		59	62	62	11	Medium	44	89
Transport Refrigeration		15	13	13	15	Medium	9	17
Domestic Refrigeration		0.65	0.65	0.65	12	Medium	0.47	0.92
Others		40	52	40	-		34	196
Metal Production		62	62	62	5		53	71
Total		884	985	980	6		843	1214

Table 78 Summary of results for model parameter “emissions” from Monte Carlo Analysis for 2004 data on selected emission sources.

As a result of the Monte Carlo simulation for the synthetic gases an overall uncertainty of 6% results.

The time series is consistent for all source categories, with exception of the sub-source category “Electrical Equipment” (2F7) 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 (2F7) retroactively.

4.7.4. Source-Specific QA/QC and Verification

No source-specific activities beyond the general QA/QC measures described in Section 1.6 have been carried out. Checklists see FOEN 2006.

4.7.5. Source-Specific Recalculations

Category	Remarks
Foam blowing	PU-Spray 1990 to 2004 The new distribution of the gases 134a and 152a used in PU-sprays evaluated by producer and importer was used also for the years 1990–2000
Transport refrigeration	Number of vehicles corrected 2000 to 2004 Statistic of new registered vehicles till September 2004 projected to the whole year
Domestic refrigeration	The modelling of disposal has been improved. This lead to lower stocks in the following years and by consequence to lower emissions.
Commercial Refrigeration	Improved modelling taking into account better data on emission factors, lifetime and disposal
Air-Conditioning	New emission factors used There was a mistake in the tier 1 calculation

	New modelling of the disposal Rest amount 407C applied for replacement of R22 and assuming more 407c being used in Switzerland.
Heat pumps	Changes for emission factors, amount of cooling agents and disposal according to literature data.
Refrigeration generally	Emission factor disposal and model calculations disposal have been improved
Mobile air condition	New modelling of the disposal, this lead to a difference in the year 2003 of less than 0.4%, but has an influence for the trend calculation up to 8% in the year 2010. There was a wrong link to the trend calculation
Solvents	In the last years SF6 used for the cleaning of aluminium was reported in the category solvents. This was changed now also for the past years (New assignment of imported F-gases from solvent to metal production). No change in the overall emissions. There was a wrong link to the trend calculation.
Windows	New emission factor in production of windows, according to experts interviews found in literature, leading to changes in the period since 1990. Shorter life time leading to another disposal modelling with higher trend in the year 2010.

Table 79 Summary of recalculations in source category 2F.

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 individual review of the GHG inventory submitted in 2005 (UNFCCC 2006) suggested under point 45 that potential emissions by sources should be filled in CRF table 2(I): Sectoral Report for Industrial Processes. Though the data is in general available it was not possible to fulfil the request of the reviewers due to the short available time between receipt of the review report and the submission deadline for the inventory. It however is foreseen to include detailed information in the subsequent submission.

4.8. *Source Category 2G – Other*

4.8.1. Source Category Description

Source category 2G “Other” is **not a key category**.

Source category 2G “Other” comprises non-energy emissions from the production in other industries, including food, drink, pulp, paper industries, and from crematories.

2G	Source	Specification	Data Source
2G	Other	Emissions from the production and application of roofing fabrics, from the production of charcoal, chipboard, fibreboard, cellulose, from the production of beer, wine, alcoholics, bread, smoked meat, sugar and from the use of explosives in the production of gypsum and from Claus-units in refineries. In Switzerland, source category 2G includes the sources pertaining to source category 2D.	AD, EF: EMIS

Table 80 Specification of source category 2G “Other”.

4.8.2. Methodological Issues

Methodology

In Switzerland source category 2G “Other” represents a comprehensive set of industrial processes: production and application of roofing fabrics, the production of charcoal, chipboard, fibreboard, cellulose, the production of beer, wine, alcoholics, bread, smoked meat, sugar and the use of explosives in the production of gypsum as well as the use of Claus-units in refineries (sulphur extraction process). Several processes reported under 2G would be part of CRF category 2D Other Production: Pulp and Paper, Food and Drink. (The present categorisation is due to a former version of EMIS.)

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 (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 (see Section 1.4.3).

4.8.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

The time series is consistent.

4.8.4. Source-Specific QA/QC and Verification

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

4.8.5. Source-Specific Recalculations

All emissions have been recalculated for the time series 1990–2003 due to the revision of the EMIS database. See Chapter 9.

4.8.6. Source-Specific Planned Improvements

Transfer of processes Pulp and Paper, Food and Drink from 2G into 2D.

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 form other types of product use (firework, impregnation of mineral wool) as 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
Emissions of CO_2 and N_2O from source category 3 “Solvent and Other Product Use” are key categories regarding trend.

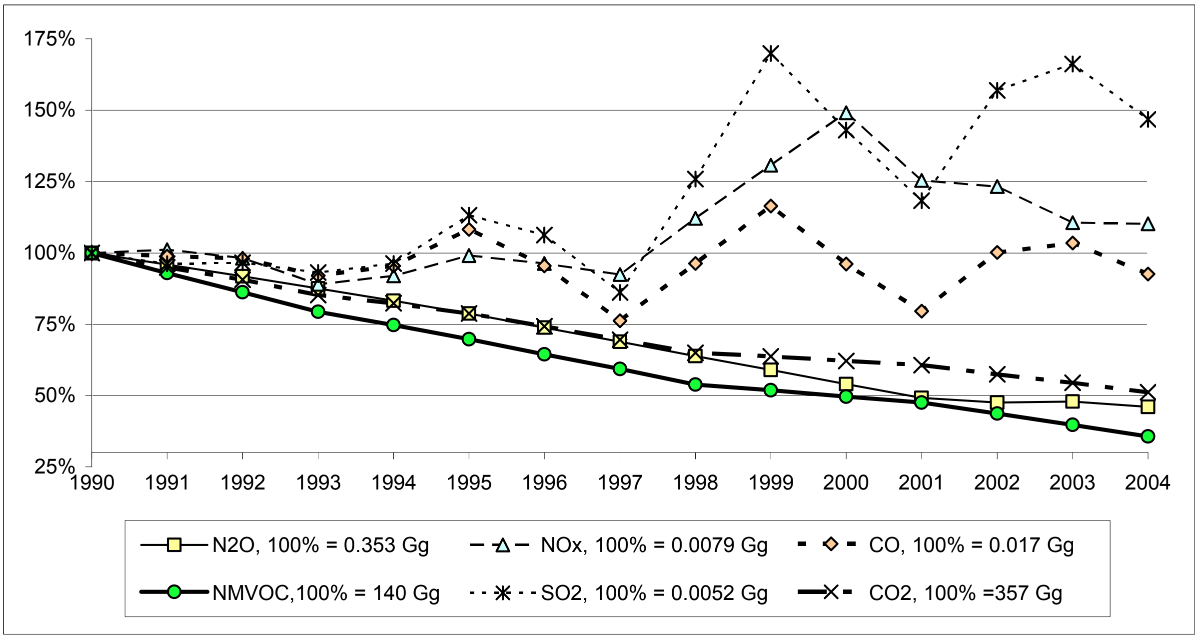

Figure 23 Overview over emissions in category 3 Solvent and Other Product Use in Switzerland. Note that CO_2 and NMVOC emissions evolve highly correlated.

Gas	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
CO_2	Gg	357	339	323	304	294	281	265	248	232	227	222	216	205	195	183
N_2O	t	353	339	324	309	294	278	261	243	225	208	191	173	168	169	162
NO_x	t	7.9	8.0	7.8	7.0	7.3	7.8	7.6	7.3	8.8	10.3	11.8	9.9	9.7	8.7	8.7
CO	t	17	17	17	16	16	18	16	13	16	20	16	13	17	18	16
NMVOC	Gg	140	130	121	111	105	98	90	83	76	73	70	67	61	56	50
SO_2	t	5.2	5.0	5.0	4.8	5.0	5.9	5.5	4.5	6.5	8.8	7.4	6.1	8.1	8.6	7.6

Table 81 Emissions of source category 3 Solvent and Other Product Use.

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 (OAPC 2004) and the introduction of the VOC-tax in 2000 (CH 2003). 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. 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 has been decreasing since 2000.

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.

	Source	Specification	Data Source
3A	Paint Application	Paint application in households, industry and construction	AD, EF: EMIS, SAEFL 2003

Table 82 Specification of source category 3A “Paint Application”.

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 [NIR NL 2005; p. 5-2ff.], assuming that the type and characteristics of solvents used in Switzerland are roughly similar.

Emission Factors

Emission factors for NMVOC are country specific based on data from industry, documented in the EMIS database.

For paint application in households, as the most important source, the emission factor of 200 kg NMVOC/t paint is based on expert estimates.

The emission factor for the indirect CO_2-emissions from NMVOC for 3A is 2.35 Gg CO_2/Gg NMVOC [NIR NL 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 2004.

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 general QA/QC measures described in Section 1.6 have been carried out.

5.2.5. Source-Specific Recalculations

All emissions have been recalculated for the time series 1990–2003 due to the revision of the EMIS database and the inclusion of indirect CO_2 emissions from NMVOC. See Chapter 9.

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.

	Source	Specification	Data Source
3B	Degreasing and Dry Cleaning	Degreasing, Dry Cleaning, Electron. Clean.	AD, EF: industry data, EMIS, SAEFL 2003

Table 83 Specification of source category 3B “Degreasing and Dry Cleaning”.

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 [NIR NL 2005; p. 5-2ff.], assuming that the type and characteristics of solvents used in Switzerland are roughly similar.

Emission Factors

Emission factors for NMVOC are country specific based on data from industry and expert estimates, documented in the EMIS database.

The emission factor for degreasing of metal (350 kg VOC/t solvent), as the most important source, is based on an industry survey.

The emission factor for the indirect CO_2-emissions from NMVOC for 3B is 2.24 Gg CO_2 per Gg NMVOC [NIR NL 2005[15]; 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 (6'000 t solvent in 2004), as the most important source, is based on an industry survey.

5.3.3. 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).

The time series is consistent.

5.3.4. Source-Specific QA/QC and Verification

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

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

5.3.5. Source-Specific Recalculations

All emissions have been recalculated for the time series 1990–2003 due to the revision of the EMIS database and the inclusion of indirect CO_2 emissions from NMVOC. See Chapter 9.

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.

	Source	Specification	Data Source
3C	Chemical Products, Manufacture and Processing	Handling and storage of solvents; fine chemical production; manufacturing of paint, inks, glues, adhesive tape; processing of PVC, polystyrene foam, polyurethane and polyester, as well as production of perfume /aroma and cosmetics.	AD, EF: industry data, EMIS, SAEFL 2003

Table 84 Specification of source category 3C “Chemical Products, Manufacture and Processing”.

5.4.2. Methodological Issues

Methodology

For category 3C country specific methods are used. The emissions of fine chemical 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 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 [NIR NL 2005; p. 5-2ff.], assuming that the type and characteristics of solvents used in Switzerland are roughly similar.

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 vapour pressure.

The emission factor for the indirect CO_2-emissions from NMVOC for 3C is 2.31 Gg CO_2 per Gg NMVOC [NIR NL 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

The activity data for fine chemical production (1'220 t NMVOC in 2004), as the most important source, is based on industry data.

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 general QA/QC measures described in Section 1.6 have been carried out.

5.4.5. Source-Specific Recalculations

All emissions have been recalculated for the time series 1990–2003 due to the revision of the EMIS database and the inclusion of indirect CO_2 emissions from NMVOC. See Chapter 9.

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 is the only direct greenhouse gas emission considered in this category.

	Source	Specification	Data Source
3D	Other	Spray cans: industry, households; domestic solvent use; printing industry; application of glues and adhesives; house cleaning industry/craft/services; hair stylists; scientific laboratories; tank cleaning; textile production; paper and paper board production; clothing production; cosmetic institutions; production of tobacco products; vehicles dewaxing; wood preservation; medical practitioners; other health care institutions; not attributable solvent emissions; N_2O in households, hospitals;	AD, EF: industry data, EMIS, SAEFL 2003

Table 85 Specification of source category 3D "Other".

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 [NIR NL 2005; p. 5-2ff.], assuming that the type and characteristics of solvents used in Switzerland are roughly similar.

Emission Factors

Emission factors for NMVOC are country specific based on data from industry and expert estimates, documented in the EMIS database. 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.

The emission factor for the indirect CO_2-emissions from NMVOC for 3D is 2.53 Gg CO_2/Gg NMVOC [NIR NL 2005; p. 5-2ff.].

The emission factor for house cleaning, the most important source, is 1'200 g/inhabitant based on [UBA 2000].

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 (7'418'000 in 2004).

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 general QA/QC measures described in Section 1.6 have been carried out.

5.5.5. Source-Specific Recalculations

All emissions have been recalculated for the time series 1990–2003 due to the revision of the EMIS database and the inclusion of indirect CO_2 emissions from NMVOC. See Chapter 9.

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 2004 were 5'413 Gg CO_2 equivalents in total which is a contribution of 10.2% to the total of Swiss greenhouse gas emissions. Main agricultural sources of greenhouse gases in 2004 were enteric fermentation emitting 2'516 Gg CO_2 equivalents, followed by agricultural soils with 2'082 Gg CO_2 equivalents. Emissions in all source categories are declining since 1990.

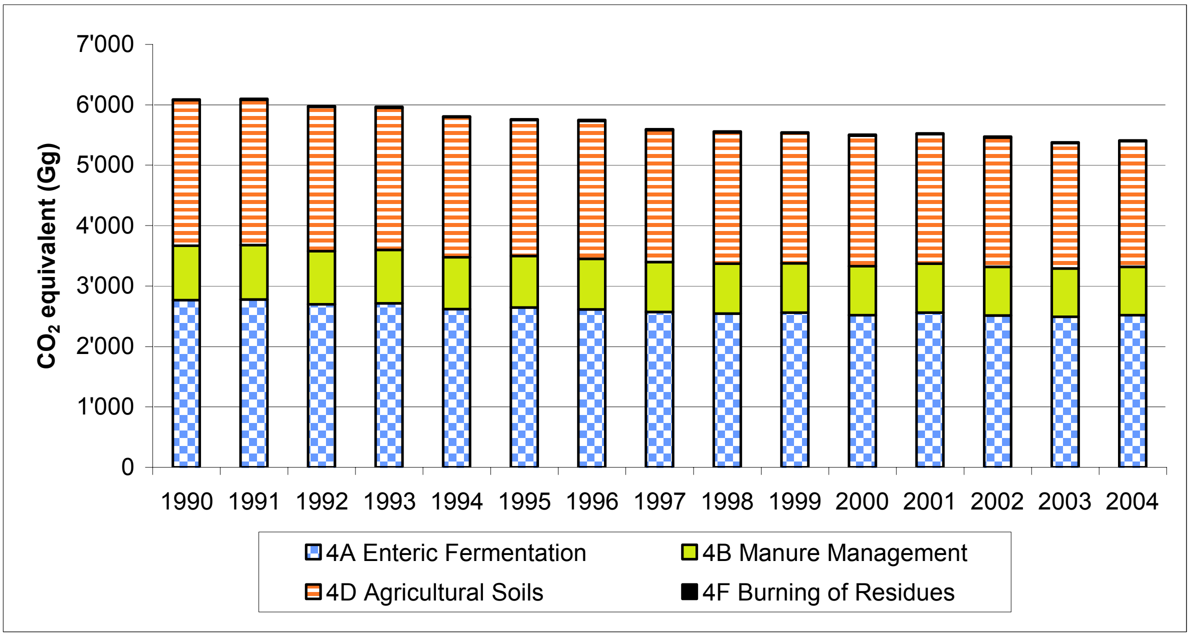

Figure 24 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture1990-2004.

Main greenhouse gases are CH_4 and N_2O. No CO_2 emissions are reported in the agricultural sector. CO_2 emissions from energy use in agriculture are reported under Energy. CO_2 emissions from soils are reported under Land-use Change and Forestry. CO_2 emissions from energy use in agriculture are reported under 1A4 Energy; Others Sectors.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)														
CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
CH_4	3'229	3'239	3'147	3'167	3'053	3'084	3'032	2'985	2'963	2'977	2'930	2'979	2'927	2'902	2'930
N_2O	2'861	2'859	2'833	2'798	2'756	2'677	2'717	2'609	2'595	2'566	2'576	2'549	2'545	2'479	2'483
Sum	6'090	6'098	5'980	5'965	5'809	5'761	5'750	5'593	5'557	5'544	5'506	5'528	5'472	5'380	5'413

Table 86 Greenhouse gas emissions in Gg CO_2 equivalents of agriculture1990-2004.

CH_4 and N_2O emissions are declining since 1990. This trend can be explained by a reduction of the number of cattle and a reduced input of mineral fertilisers. Emission factors did not change significantly.

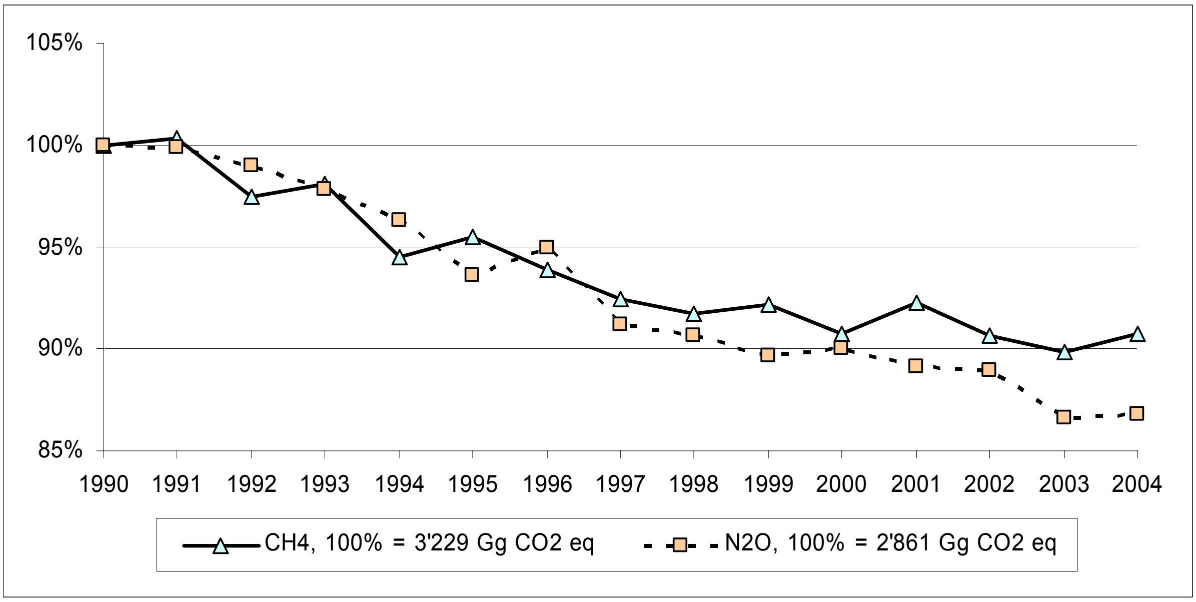

Figure 25 Trend of the greenhouse gases of the agricultural sector 1990-2004. The base year 1990 represents 100%.

Among the key sources of the Swiss inventory, five are out of the agricultural sector: CH_4 emissions from enteric fermentation, CH_4 emissions from manure management, N_2O emissions from manure management, direct N_2O emissions from agricultural soils and indirect N_2O emissions from agricultural soils.

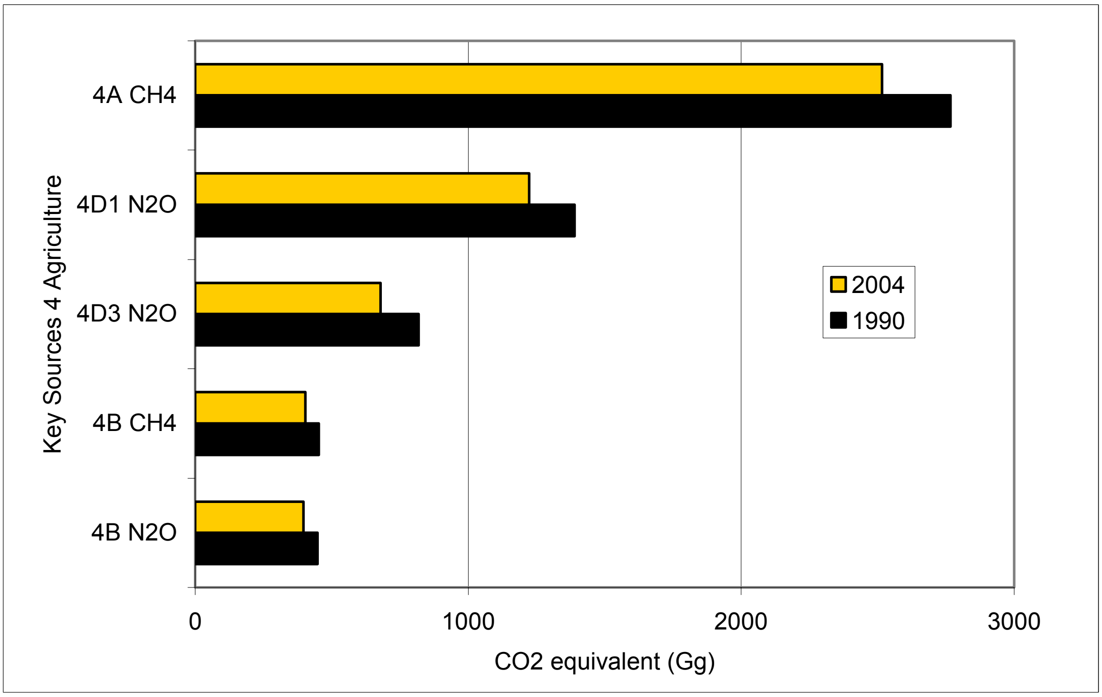

Figure 26 Key sources in Agriculture (emissions in CO_2 equivalents per source category). 4A: Enteric fermentation. 4B: Manure management. 4D: Agricultural soils.

6.2. Source Category 4A – Enteric Fermentation

6.2.1. Source Category Description

Key source 4A The CH_4 emissions from 4A Enteric Fermentation are a key source by level and trend.

The emission source is the domestic livestock population broken down into dairy cattle, non-dairy cattle, swine, sheep, horses and poultry. Emissions from enteric fermentations are declining since 1990, mainly due to a reduction of the number of cattle. Emissions from cattle contribute to more than 94% of the emissions from enteric fermentation.

4A	Source	Specification	Data Source
4A1 4A3 4A4	Cattle Sheep Goats	Emissions from dairy cattle and non-dairy cattle (beef cattle)	AD: Livestock data, net energy and feed intake losses from SBV 2005 EF: SAEFL 1998
4A6 4A8	Horses Swine		AD: Livestock data, digestible energy, feed intake losses from SBV 2005 EF: SAEFL 1998
A47	Mules and asses		AD: Livestock data, digestible energy and feed intake losses from SBV 2005 EF: SAEFL 1998
4A9	Poultry		AD: Livestock data; metabolisable energy and feed intake losses from SBV 2005 EF: SAEFL 1998

Table 87 Specification of source category 4A “Enteric Fermentation”.

6.2.2. Methodological Issues

Methodology

Methodology for the calculation of CH_4 emissions in agriculture is displayed in the following figure.

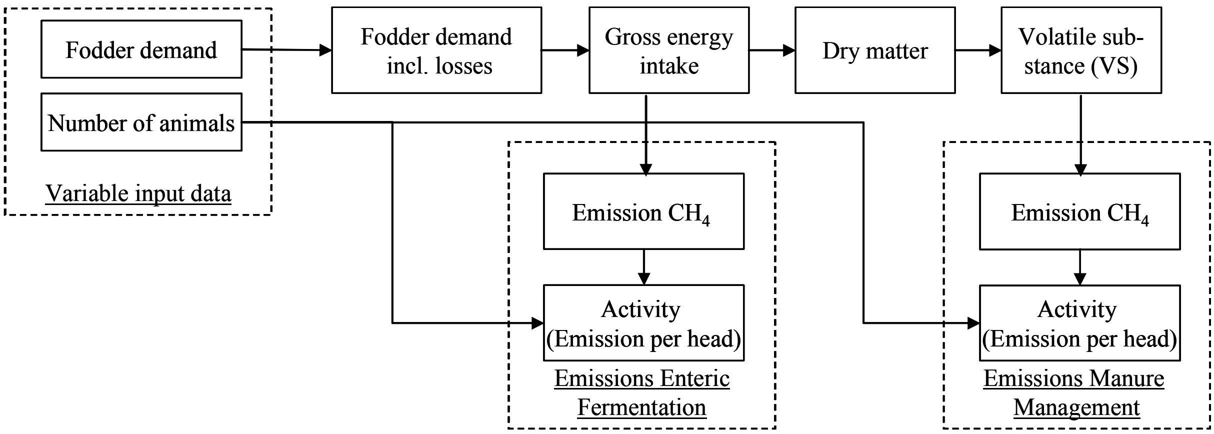

Figure 27 Diagram of the CH_4 Emissions in Agriculture.

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 country specific emission factors are estimated for each animal category. A disaggregation of the livestock category dairy and non dairy cattle into three categories (dairy, non-dairy, young cattle) was not feasible since country specific values for the gross energy intake for young cattle were not available. Equation is based on the parameters gross energy intake and the methane conversion rate.

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 (SAEFL 1998, p. 62f.). The method does not correspond to equation 4.11 of the IPCC Good practice Guidance (IPCC 2000, p.4.20) which distinguishes various forms of net energy (for maintenance, due to weight loss, for activity, for lactation, for work, for pregnancy etc.).

The conversion is based on the following parameters (Daccord 1996):

- Metabolisable energy = Gross energy * 0.53
- Net energy lactation = Metabolisable energy * 0.6
- Net energy growth = Metabolisable energy * 0.58
- Net energy lactation = Gross energy * 0.318
- Net energy growth = Gross energy * 0.307

More details are displayed in the following table.

Livestock Groups	**Calculation of the Gross Energy Intake**
Cattle	
Dairy cattle	Net energy lactation/0.318
Non-Dairy cattle	Net energy lactation/0.318 + Net energy growth/0.307
Sheep	Net energy lactation/0.318 + Net energy growth/0.307
Goats	Net energy lactation/0.318
Horses	Digestible energy*18.45/10.6 (Kirchgessner 1985)
Ponies, Mules and Asses	Digestible energy*18.45/10.6 (Kirchgessner 1985)
Swine	Digestible energy*18.45/14.5 (Buchmann et al. 1994)
Poultry	Digestible energy*18.45/10.3

Table 88 Calculation of the Gross energy intake (SAEFL 1998, p. 122).

For the **methane conversion rate** (%), IPCC default values are used for all animal categories (IPCC 1997b: Reference Manual, p. 4.32–4.35) except for poultry, where national values have been estimated (SAEFL 1998, p. 65ff). The methane conversion rate for poultry is calculated as follows (Hadorn 1994):

CH_4 conversion rate (poultry) = Metabolisable Energy * 0.0016.

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,

Y_m = Methane conversion rate.

The following input data are used:

Gross Energy Intake	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	MJ/head/day														
Cattle															
Dairy cattle	259.2	260.4	255.1	270.5	260.2	261.1	257.7	263.7	262.9	271.1	269.0	274.0	266.9	269.4	277.8
Non-Dairy cattle	106.6	109.5	110.6	108.1	103.9	106.2	106.2	108.2	109.3	110.4	110.1	107.8	109.9	109.9	111.8
Sheep	19.7	20.2	20.6	20.1	21.9	23.0	20.3	18.8	20.6	21.7	21.7	21.7	21.5	21.4	21.9
Goats	28.2	28.5	28.7	28.9	29.5	31.0	28.8	26.1	26.0	25.7	25.7	28.5	27.5	27.9	27.5
Horses	141.6	131.7	130.0	131.4	149.4	172.4	128.6	130.2	130.7	130.7	130.7	135.9	135.7	136.1	136.2
Ponies, Mules and Asses	157.9	154.1	155.6	160.5	156.9	152.1	115.3	111.8	107.5	99.1	98.4	96.4	92.9	89.7	86.9
Swine	30.5	31.2	31.4	31.2	31.9	35.0	32.3	31.6	31.7	31.6	31.6	30.5	30.3	30.3	30.5
Poultry	2.3	2.3	2.4	2.0	2.1	2.2	2.1	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.0

Table 89 Gross energy intake of different livestock groups. Calculation is based on the above mentioned parameters net energy, digestible energy, metabolizable energy according to the method described in SAEFL 1998. Input data on net energy, digestible energy and metabolizable energy is taken from SBV 2005.

The gross energy intake per head for all animal categories revealed some fluctuations, but no trend during the inventory period. Also, the uptake of the main fodder constituents, grass, hey, and silage per cattle showed no significant trend over time (Leifeld/Fuhrer 2005).

The gross energy intake for the horse categories showed major reductions between 1995 and 1996. According to the Swiss Farmers Association data comparison with the years before 1995 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 Association (SBV 2005).

The activity data are grouped into the livestock categories required for emission calculation.[16]

Population Size	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	1'000 head														
Cattle	1'855	1'829	1'783	1'744	1'747	1'748	1'747	1'673	1'641	1'609	1'588	1'611	1'594	1'570	1'545
Dairy cattle	795	795	781	762	763	763	764	744	737	725	714	720	716	703	691
Non-Dairy cattle	1'060	1'034	1'002	982	984	986	983	929	904	884	874	891	878	867	854
Sheep	395	409	415	424	405	387	419	420	422	424	421	420	430	445	441
Goats	68	65	58	57	55	53	57	58	60	62	62	63	66	67	71
Horses	45	49	52	54	48	41	43	46	46	49	50	50	51	53	54
Ponies, Mules and Asses	7	7	8	8	8	8	8	9	10	11	12	12	13	14	15
Swine	1'787	1'723	1'706	1'692	1'569	1'446	1'379	1'395	1'487	1'453	1'498	1'548	1'557	1'529	1'538
Poultry	5'932	5'642	5'499	6'410	6'431	6'241	6'425	6'537	6'724	6'886	6'983	6'939	7'339	7'453	8'061

Table 90 Activity for calculating methane emissions from enteric fermentation (SBV 2005).

The number of cattle was slightly declining during the last 14 years, which is a result of an ongoing process to a less intensive form of animal husbandry due to ecological and economic reasons. The numbers of sheep, goats, horses and poultry 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).

6.2.3. Uncertainties and Time-Series Consistency

No formal uncertainty analysis has been carried out for the actual data. A former minimum-maximum analysis based on 2001 data lead to a 95% confidence interval of 25% (FAL 2003c). Correspondingly, an uncertainty of 13% is set for the emission factor. For the activity

[16] SBV differentiates various sub-categories which are not relevant for calculation of methane emissions (e.g. 9 categories of cattle).

data, an uncertainty of 20% is assumed. These numbers are used as input for the Tier 1 analysis.
For Tier 2 (Monte Carlo), a combined uncertainty of 23% is used for the emissions, which is derived from the error propagation formula for the product EF*AD ($U_E^2 = U_{EF}^2 + U_{AD}^2$). A normal distribution of the uncertainties is assumed. In Table 141 in Annex A1.2.3 the Monte Carlo model uncertainty is given. It may slightly deviate from the input value (23.2% instead of 23.0%), which is the result of a consistency adjustment of the correlations coefficients carried out by Crytal Ball Software automatically.
Note that the CH_4 emissions from enteric fermentation (and manure management) are being recalculated at the moment (see planned improvements). The results will be presented in the inventory which will be submitted together with the initial report in 2006. They will also include ranges for more sophisticated uncertainty estimations.

The time series 1990–2004 is consistent.

6.2.4. Source-Specific QA/QC and Verification

In the literature no published data are available which would allow a second independent approach for estimating the inventory data. Therefore cross checks with parallel independent inventory data is not made. However, verification of the plausibility of the input data used (e.g. net energy) is done regularly by the Swiss Farmers Association (SBV). An internal documentation of the Swiss Federal Research Station for Agroecology and Agriculture (FAL) about the calculation of the greenhouse gas emissions in agriculture assures transparency and traceability of the calculation methods (FAL 2004).

6.2.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

6.2.6. Source-Specific Planned Improvements

For the inventory which will be submitted together with the initial report in 2006, the model for calculating the CH_4 from cattle will be revised. The method will then be closer to the IPCC method. The whole time series will be recalculated. Within the revision, the gross energy intake of young cattle will be estimated. This would allow a further disaggregation of the livestock category dairy and non dairy cattle. Furthermore it is planned to provide more information to explain the fluctuations of the implied emission factors. The study, which shall answer these questions, is currently in process at the Institute of Animal Sciences / Animal Nutrition of the Swiss Federal Institute of Technology Zurich. The study will also include uncertainty estimations on a more sophisticated level than described in the current submission.

6.3. Source Category 4B – Manure Management

6.3.1. Source Category Description

Key source 4B
Source category 4B Manure Management CH_4 is a key source by level and trend. Source category 4B Manure Management N_2O are key sources by level.

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

4B	Source	Specification	Data Source
4B1 4B3 4B4 4B6 4B8	Cattle Sheep Goats Horses Swine	Dairy cattle and non-dairy cattle (beef cattle)	AD: SBV 2005 EF: SAEFL 1998
4B7	Mules and Asses		AD: SBV 2005 EF: SAEFL 1998
4B9	Poultry		AD: SBV 2005 , EF: SAEFL 1998

Table 91 Specification of source category 4B “Manure Management (CH_4)”. (Activity: Activity data; EF: Emission factors).

4B	Source	Specification	Data Source
4B11 4B12	Liquid Systems Solid storage and dry lot		AD: SBV 2005, FAL/RAC 2001; FAL 1997 EF: IPCC 2000

Table 92 Specification of source category 4B “Manure Management (N_2O)”.

6.3.2. Methodological Issues

For calculation of CH_4 and N_2O emissions different livestock groups are used. 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 dairy cattle, non-dairy cattle, swine, sheep, goats, horses and poultry as reported for enteric fermentation.

Calculation of N_2O emissions are based on more detailed livestock population break down with the sub-groups dairy cattle, rearing cattle (1st year, 2nd year, 3rd year), fattening calves, fattening cattle (< ½ year, > ½ year), sheep, fattening pig places, breeding pig places, goats, horses, mules and asses, and poultry. This more detailed calculation is chosen because more detailed data on N excretion for the particular animal categories are available (FAL/RAC 2001).The categories for sheep, pigs and goats as provided by FAL/RAC 2001 do not correspond to the categories of the Swiss Farmers Association (SBV 2005). The conversion from the FAL/RAC 2001 classification to the available livestock categories according to SBV is done as follows (FAL 2000):

- One fattening pig place corresponds to one fattening pig over 25 kg,
- One breeding pig place corresponds to one sow, 1/2 breeding pig place to one boar,
- One sheep place corresponds to one ewe over one year,
- One goat place corresponds to one goat over 1.5 years.

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, the maximum CH_4 producing capacity for manure (B_o) and the CH_4 conversion factors for each manure management system (MCF). For calculation of volatile substance excreted per year (VS) a national method based on the parameters organic substance in the feed intake[17] and its digestibility is applied (SAEFL 1998, p. 71):

VS[g] = Organic Substance (OS) in Feed intake [g]*(1- Digestibility OS [%] / 100)

A comparison between the calculation of VS according to IPCC and the national method described above has been made. IPCC estimates the amount of volatile substances 20-60% higher than the national method which according to SAEFL 1998, p. 72 seems more plausible in the national context. The IPCC method is therefore not taken into consideration.

For the Methane Producing Potential (B_o) and the Methane Conversion Factor (MCF) IPCC default values are used (IPCC 1997b Reference Manual, p. 4.43).

The emission factor for horses (5.13 kg CH_4/head/year in 2002) differs significantly from IPCC default emission factors for developed countries (1.39 kg CH_4/head/year, IPCC 1997b: Reference Manual, p. 4.47). This can be explained by the following parameters (SAEFL 1998, p. 75):

- In Switzerland the dry matter intake is estimated higher than according to IPCC (8.5 kg dry matter intake instead of 6 kg). A value of 6 kg dry matter intake can only be achieved by intake of concentrated feed, which is not the case under national conditions.
- The digestibility of the feed intake is estimated to be lower than according to IPCC.
- It is estimated that the value for VS is 0.45 kg VS per kg DM, which is a lot higher than the IPCC value of 0.29 kg VS per kg DM.

All these factors (higher dry matter intake, lower digestibility, higher VS) lead to a significantly higher emission factor for horses.

Activity data

Activity data on all livestock categories are taken from SBV 2005.

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 FAL 2000.

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[17] For calculation of the feed intake, see chapter 6.2.2 (Methodological issues enteric fermentation).

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 and Solid storage. N_2O emissions from pasture range and paddock appears 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 FAL 1997.

Emission factors

IPCC default emission factors are used for the two animal waste management systems (IPCC 2000, p.4.43).

Source	**Emission factor per animal waste management system (kg N_2O-N / kg N)**
Liquid systems	0.001
Solid storage	0.020

Table 93 Emission factors for calculating N_2O emissions from manure management (IPCC 2000, p. 4.43).

Activity data

Input data on all livestock categories are taken from the Swiss Farmers Association (SBV 2005).These input data are converted into the following livestock categories (Walther et al. 1994, FAL/RAC 2001).

Population Size	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
	1'000 head														
Dairy cattle	795	795	781	762	763	763	764	744	737	725	714	720	716	703	691
Non-Dairy cattle	1'060	1'034	1'002	983	984	986	983	929	904	884	874	891	878	867	854
Rearing cattle 1st year	346	337	324	308	302	295	286	260	254	219	236	238	230	220	215
Rearing cattle 2nd year	253	252	251	239	239	239	243	233	217	188	222	219	219	213	205
Rearing cattle 3rd year	151	148	147	142	141	139	140	139	133	118	130	130	126	124	121
Fattening calves	122	123	123	125	123	120	134	132	137	150	139	155	161	166	168
Fattening cattle <1/2 year	88	79	71	76	79	82	75	68	66	48	43	40	38	39	36
Fattening cattle >1/2 year	100	96	87	92	101	111	105	97	97	162	105	109	104	105	109
Swine	1'195	1'156	1'139	1'110	1'012	914	911	917	983	970	995	1'017	1'022	1'001	1'005
Fattening pig places	1'012	977	960	931	844	757	769	769	827	830	851	868	874	857	859
Breeding pig places	184	179	178	179	168	156	142	148	156	139	145	149	148	144	146
Sheep (Sheep places) [1]	191	201	201	211	201	191	208	208	209	222	217	217	220	229	227
Goats (Goats places) [1]	40	38	34	33	32	31	33	34	35	37	37	35	36	36	38
Horses [2]	45	49	52	54	48	41	43	46	46	49	50	50	51	53	54
Foals (< 1 year)	4	4	5	5	5	5	4	4	4	4	4	4	3	3	3
Foals (1-2 years)	5	6	6	7	7	6	6	6	6	7	6	6	6	6	6
Other horses	36	39	41	43	36	30	32	36	36	38	40	40	42	43	44
Mules and Asses	7	7	8	8	8	8	8	9	10	11	12	12	13	14	15
Poultry	5'932	5'642	5'499	6'410	6'431	6'241	6'425	6'537	6'724	6'886	6'983	6'939	7'339	7'453	8'061
Laying hens	3'083	2'645	2'536	2'518	2'226	2'118	2'226	2'278	2'270	2'223	2'150	2'069	2'154	1'985	2'089
Young hens (< 18 weeks)	719	664	710	719	732	714	732	733	793	761	832	745	754	809	853
Broilers	2'020	2'199	2'096	2'990	3'293	3'231	3'293	3'342	3'502	3'747	3'808	3'993	4'298	4'518	4'971
Other poultry (turkeys)	110	134	158	183	180	177	174	184	158	155	193	132	132	140	148

Table 94 Activity data for calculating N_2O emissions from manure management (SBV 2005).
[1)] For calculation of swine places, sheep places and goat places, see FAL 2000.
[2)] These horse categories are used since 1998. Before 1998 a more detailed classification was used.

Data on nitrogen excretion per animal category (kg N/head/year) is taken from FAL/RAC 2001, p. 48/49 (see Table 183 in Annex A5). 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 to 12 kg N/head/year from 1994 according to the revised standard values of N excretion (FAL 2001).

The split of nitrogen flows into the different animal waste management systems including ammonia emissions are taken from FAL 1997.

c) NO_x Emissions

Methodology

NO_x emissions from manure management are estimated by taking 0.7% of nitrogen excretion from livestock. This factor is based on the CORINAIR Emission Inventory Guidebook 2003 (Corinair 2003). Data on N-excretion (kg N/head/yr) is taken from FAL/RAC 2001.

6.3.3. Uncertainties and Time-Series Consistency

a) CH_4 Emissions

No formal uncertainty analysis has been carried out for the actual data. A former minimum-maximum analysis based on 2001 data (already mentioned above in the Chapter of Enteric Fermentation) lead to a 95% confidence interval of 73% of the emission factor (FAL 2003). Correspondingly, an uncertainty of 36% (half of the confidence interval) is set for the emission factor. For the activity data, an uncertainty of 20% is assumed as in the case of enteric fermentation. These numbers are used as input for the Tier 1 analysis.
For Tier 2 (Monte Carlo), a combined uncertainty of 41% is used for the emissions, which is derived from the error propagation formula for the product EF*AD ($U_E^2 = U_{EF}^2 + U_{AD}^2$). A normal distribution of the uncertainties is assumed. In Table 141 in Annex A1.2.3 the Monte Carlo model uncertainty is given. It slightly deviates from the input value (40.7% instead of 41.0%), which is the result of a consistency adjustment of the correlations coefficients carried out by Crytal Ball Software automatically.
Note that the CH_4 emissions from manure management (and enteric fermentation) are being recalculated at the moment (see planned improvements). The results will be reported in the next submission (September 2006). They will also include ranges for more sophisticated uncertainty estimations.

Time series between 1990 and 2004 is consistent.

c) N_2O Emissions

IPCC gives the following ranges for emission factors (IPCC 1997c).

	Medium	Minimum	Maximum
Emission factor Liquid systems (kg N_2O-N / kg N)	0.001	< 0.001	0.001
Emission factor Solid storage (kg N_2O-N / kg N)	0.02	0.005	0.03

Table 95 Minimum and maximum values for the emission factor for solid storage and the emission factor for liquid systems (IPCC 1997c, p. 4.104).

For the uncertainty analysis, a mean uncertainty of 70% for the emission factors is derived from the values in Table 95. For the uncertainty of activity data, 20% as in the case of CH_4 (manure management) is taken. These numbers are used as input for the Tier 1 analysis. For Tier 2 (Monte Carlo), a combined uncertainty of 73% is used as input for the uncertainty of the emissions. The value of 73% is derived from the error propagation formula for the product EF*AD ($U_E^2 = U_{EF}^2 + U_{AD}^2$). A lognormal distribution is assumed. (With a normal distribution, the 2.5 percentile value would become negative.) In Table 141 in Annex A1.2.3 the Monte Carlo model uncertainty is given. It slightly deviates from the input value (72.7% instead of 73.0%), which is the result of a consistency adjustment of the correlations coefficients carried out by Crytal Ball Software automatically.

Time series 1990-2004 is consistent. Due to a method change in calculating the N-excretion of dairy cattle in 2001 the data between 1990 and 2000 are interpolated in order to get consistency of the time series (FAL/RAC 2001).

6.3.4. Source-Specific QA/QC and Verification

No source-specific activities have been carried out. An internal quality control is done regularly. An internal documentation of the Swiss Federal Research Station for Agroecology and Agriculture (FAL) about the calculation of the greenhouse gas emissions in agriculture assures transparency and traceability of the calculation methods (FAL 2004).

6.3.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

6.3.6. Source-Specific Planned Improvements

For the submission September 2006, the model for calculating the CH_4 from cattle will be revised. The method will then be closer to the IPCC method. The whole time series will be recalculated. The study, which shall answer these questions, is currently in process at the Institute of Animal Sciences / Animal Nutrition of the Swiss Federal Institute of Technology Zurich. The study will also include uncertainty estimations on a more sophisticated level than described in the current submission.

As a component of the quality control process the N_2O calculation method IULIA will be revised. It is however not yet assessable whether this revision will lead to an adjustment of the N_2O calculations as a whole.

6.4. Source Category 4C – Rice Cultivation

Rice Cultivation is of minor importance in Switzerland. There is only some insignificant upland rice cultivation which emissions are assumed to be zero. They are therefore ignored in the emission calculation.

6.5. Source Category 4D – Agricultural Soils

6.5.1. Source Category Description

Key source 4D1, 4D3
Direct (4D1) and indirect (4D3) N_2O emissions from agricultural soils are key sources by 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 from animal production and NMVOC emissions.

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

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 2005, FAL/RAC 2001; FAL 2003° EF: IPCC 1997b (N_2O) and FAL 2000
4D2	Animal production	Only emissions from pasture range and paddock	AD: SBV 2005, FAL/RAC 2001; FAL 1997, EF: IPCC 1997b
4D3	Indirect emissions	Leaching and run-off, N deposition air to soil	AD: SBV 2005; FAL/RAC 2001; FAC 1994a, FAC 1994b. EF: IPCC 1997b
4D4	Other (sewage sludge and compost used for fertilizing)		AD: SBV 2005 EF: IPCC 1997b

Table 96 Specification of source category 4D “Agricultural Soils”.

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 (FAL 2000). According to expert judgement IULIA has been proven to be an adequate method for calculation of N_2O emissions under Swiss circumstances. 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.

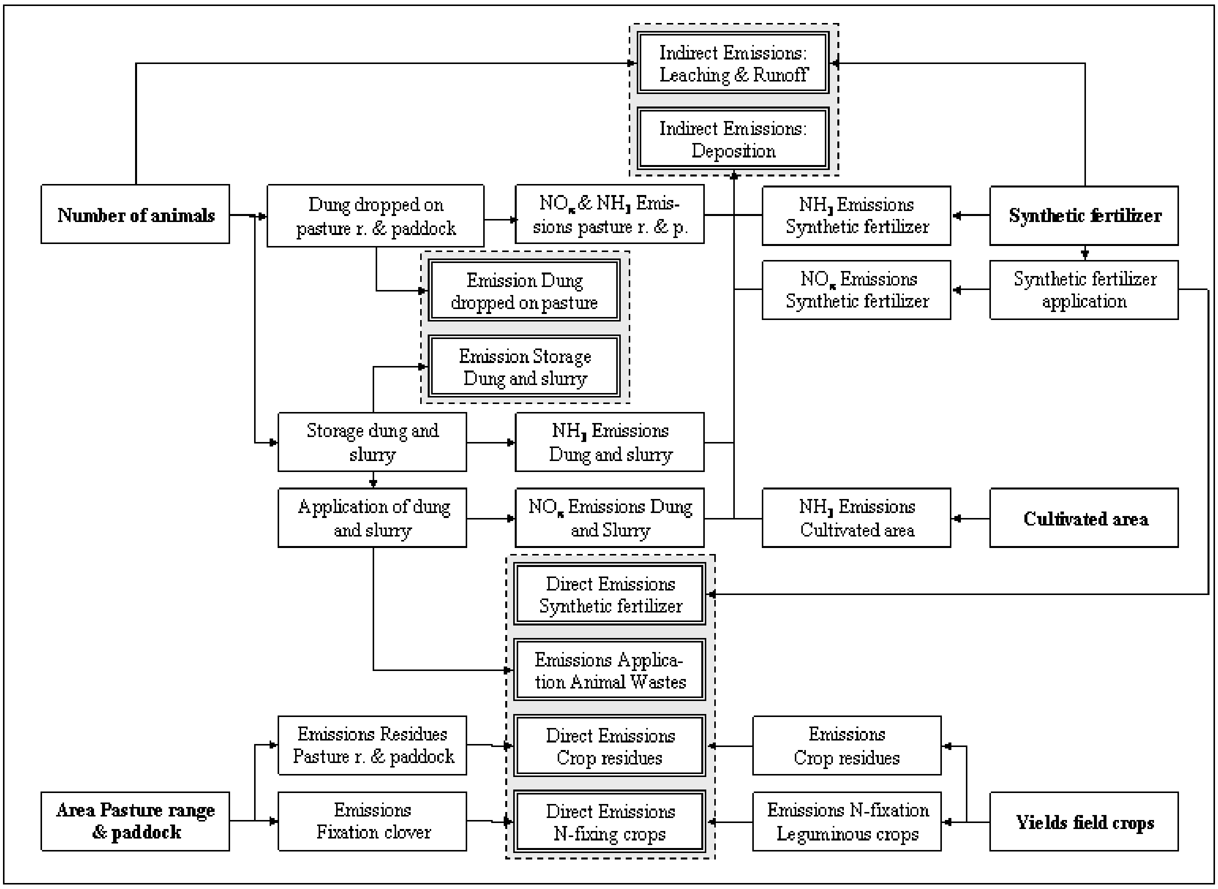

Figure 28 Diagram of the N_2O emissions in Agriculture.

Main differences between the IULIA method and IPCC are (FAL 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 returned to soils on meadows and pastures are considered. This is explained by the fact that the emissions from crop residue 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 (FAL 2000, p. 75).

Direct emissions from soil (4D1)

Calculation of direct N2O emissions from soil is based on IPCC Tier 1b.

- Emissions from **synthetic fertilizer** include mineral fertilizer. The amount of nitrogen in fertilizer is taken from SBV 2005. From the amount of nitrogen in fertilizer losses to the atmosphere in form of NH3 and NOx are subtracted and the rest is multiplied with the corresponding emission factor. According to the method IULIA losses to the atmosphere are set to 6% (NH3) and 0.7% (NOx, according to Corinair 2003) instead of the IPCC value of 10% for NH3 and NOx. (FAL 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 and excretion on pastures. The losses (to the atmosphere) as ammonia are specified for each management category instead of using a fixed ratio of 20% (FAL 2000, p. 66). The loss as NO_x is set to 0.7% of the excreted N (Corinair 2003). For details regarding the volatized N refer to Table 98.

- Emissions from **crop residues** are based on the amount of nitrogen in crop residues returned to soil. In IULIA (FAL 2000, p. 68 and p. 100) this amount is based on data reported on crop yields (SBV 2005), the standard values for arable crop yields (FAL/RAC 2001) and standard amounts of nitrogen in crop residues returned to soils (FAL/RAC 2001). The calculation of the amount of nitrogen in crop residues returned to soil according to IULIA is as follows (FAL 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
  E_{Cr}: Amount of crop yields for culture Cr (kg)
  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

  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 (FAL 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 2005.

- For calculation of emissions from **N-fixing crops**, IULIA assumes that 60% of the nitrogen in crops is caused by biological nitrogen fixation (FAL 2000, p. 70). 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 and the rest from uptake of mineral nitrogen. For the dry matter production of clover on pastures and meadows statistical data were used (FAL 2000, p. 70). The following table gives an overview of the calculation of emissions from N-fixing crops.

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

Table 97 Input values for calculation of emissions from N-fixing crops according to IULIA (FAL 2000, p. 70).

- Emissions from **cultivated organic soils** are based on estimations on the area of cultivated organic soils (FAL 2003a) and the IPCC default emission factor for N_2O emissions from cultivated organic soils (IPCC 1997b).

For estimation of NO_x it is assumed that 0.7% of nitrogen in fertilizer is emitted as NO_x (Corinair 2003).

Estimation of NMVOC emissions of meadows and arable land is based on FAL 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. 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, please 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 (nitrogen excretion in kg N/head/yr) and FAL 1997 (fraction of animal waste management system).

NO_x emissions from animal production are estimated by taking 0.7% of nitrogen excretion from livestock in pasture range and paddock. Data on the amount of N-excretion (kg N/head/yr) is taken from FAL/RAC 2001, the emission factor from Corinair 2003.

Indirect emissions (4D3)

Calculation of the indirect emissions is based on IPCC 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, FAC 1994a and FAC 1994b. $Frac_{Leach}$ is set as 0.2 instead of the IPCC default of 0.3 (FAL 2003b). This value is extrapolated from long-term monitoring and modelling studies from the canton of Berne. According to FAL 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 FAL 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 FAL 1997, p. 41. For NH_3 emissions 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 (FAL 2000, p. 66, Corinair 2003). Details about the amount of volatized N (NH_3 and NO_x) are provided in the following table.

	N excretion (t N) / N content 2004	Losses NH3 (%)	Emissions NH3 (t N) 2004	Losses NOx (%)	Emissions NOx (t N) 2004	Volatized N total (NH3, NOx in t) 2004
Dairy cattle	73'577	32%	23545	0.7%	515	24'060
Non-Dairy cattle						
Rearing cattle 1st year	5'366	22%	1181	0.7%	38	1'218
Rearing cattle 2nd year	8'216	22%	1'807	0.7%	58	1'865
Rearing cattle 3rd year	6'648	22%	1'462	0.7%	47	1'509
Fattening calves	2'183	37%	808	0.7%	15	823
Fattening cattle <1/2 year	287	37%	106	0.7%	2	108
Fattening cattle >1/2 year	3'592	37%	1'329	0.7%	25	1'354
Swine						
Fattening pig places	11'170	46%	5'138	0.7%	78	5'216
Breeding pig places	5'102	46%	2'347	0.7%	36	2'382
Sheep (Sheep places) [1]	2'730	14%	382	0.7%	19	401
Goats (Goats places) 1	606	29%	176	0.7%	4	180
Horses [2]						
Foals (< 1 year)	58	32%	19	0.7%	0	19
Foals (1-2 years)	250.5	32%	80	0.7%	2	82
Other horses	1'950.2	32%	624	0.7%	14	638
Mules and Asses	386	32%	124	0.7%	3	126
Poultry						
Laying hens	1'483	54%	801	0.7%	10	811
Young hens (< 18 weeks)	290	54%	157	0.7%	2	159
Broilers	1'988	48%	954	0.7%	14	968
Other poultry (turkeys)	207	48%	99	0.7%	1	101
Total animals			**41'139**		**883**	**42'021**
Mineral fertilizer, compost and sewage sludge (t N)	57'800	6%	3'468		405	3'873
NH3 emissions from cropland (ha)	1'064'574	1.5%	1'597			1'597
Total			**46'204**		**1'287**	**47'491**

Table 98 Overview of the volatized N (NH_3 and NO_X) from animal wastes and fertilizer for 2004. The total amount of volatized N appears under the indirect emissions (atmospheric deposition) in the CRF, table 4D.

The estimations of the ammonia emissions is based on a Swiss study, which takes into account the specific farming and manure systems (FAL 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.

Emission factors

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

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 pasture, range and paddock	0.0125 kg N_2O -N/kg N
N-fixing pasture, range and paddock	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

Table 99 Emission factors for calculating N_2O emissions from agricultural soils (IPCC 1997c, tables 4.18 (direct emissions) and 4.23 (indirect emissions)).

Activity data

Activity data for calculation of direct soil emissions has been provided by SBV 2005 (use of synthetic fertilizer, crops produced), FAL/RAC 2001, p. 48/49 (nitrogen excretion), SBV 2005 (area of pasture range and paddock) and FAL 2003a (revised area of cultivated organic soils). The relevant activity data for calculating N_2O emissions from soils are displayed in the following table.

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	Related activity data	Value														
Direct emissions																
Fertilizer (t N/yr)		75'200	75'800	75'400	70'200	66'500	63'400	65'900	58'000	58'400	60'100	60'100	64'200	62'800	58'300	57'800
	Mineral fertilizer (t N/yr)	69'700	n.a.	n.a.	n.a.	n.a.	56'300	58'800	50'900	51'100	53'000	53'000	57'100	55'700	53'200	53'600
	Sewage sludge (t N/yr)	4'200	0	0	0	0	4'600	4'400	4'200	4'200	4'000	4'000	4'000	4'000	2'000	1'000
	Compost (t N/yr)	1'300	0	0	0	0	2'500	2'700	2'900	3'100	3'100	3'100	3'100	3'100	3'100	3'200
Animal manure	Nitrogen input from manure applied to soils (t N/yr)	81'387	81'138	79'777	78'839	77'607	76'507	76'518	74'675	74'373	73'479	72'718	71'239	71'065	70'073	69'774
N-fixing crops	Peas, dry beans, soybeans and leguminous vegetables produced (t N/yr)	29'681	29'622	30'585	33'079	34'946	32'404	32'828	33'216	32'908	33'109	32'857	31'846	32'299	32'797	32'952
Crop residue	Dry production of other crops (t N/yr)	35'605	35'490	35'474	37'387	38'443	36'780	38'610	37'999	37'722	36'270	37'869	35'217	36'458	34'581	36'902
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	17'000	17'000	17'000	17'000	17'000
Residues pasture range and paddock	Area of pasture range and paddock (ha)	784'867	788'089	792'338	791'387	785'006	798'550	802'514	803'722	798'295	805'131	806'369	809'441	809'597	812'624	812'370
N-fixing pasture range and paddock	Area of pasture range and paddock (ha)	784'867	788'089	792'338	791'387	785'006	798'550	802'514	803'722	798'295	805'131	806'369	809'441	809'597	812'624	812'370
Indirect emissions																
Leaching and run-off	N excretion of all animals (t N/yr)	149'146	148'535	146'067	144'215	141'766	139'476	139'568	136'101	135'224	132'638	132'275	128'946	128'564	126'738	126'090
	Fertilizer (t N/yr)	75'200	75'800	75'400	70'200	66'500	63'400	65'900	58'000	58'400	60'100	60'100	64'200	62'800	58'300	57'800
	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	40'575	41'094	38'820	38'725	38'548	38'475	38'629	38'273	37'008	36'778
Deposition	Emissions NH3 from fertilizers, animal wastes and cropland	54'358	54'054	53'217	52'418	51'220	50'117	50'277	48'850	48'885	48'510	48'132	47'316	47'183	46'308	46'204
	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	1'349	1'347	1'352	1'340	1'295	1'287
	Sum of volatized N (NH3 and NOx) from fertilizers, animal wastes and cropland (t N/yr)	55'928	55'624	54'767	53'919	52'678	51'538	51'715	50'208	50'240	49'859	49'478	48'668	48'522	47'604	47'491
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	17'515	16'685	16'515	16'262	15'977

Table 100 Activity data for calculating N_2O emissions from agricultural soils. For the sake of completeness, values for mineral fertilizer, sewage sludge and compost are displayed where available. For calculation of the emissions only the total amount of synthetic fertilizer is used.

The following table gives an overview on the different N amounts in 2004 that end up in N_2O emissions in the CRF tables.

Summary of N2O emissions from agricultural soils 2004	N excretion & emission (Kg N a-1)	Emissions (t N)	Emissions (t N2O)	Emissions (Gg N2O)
Direct emissions	**190'028'842**		3'946.09	**3.95**
Synthetic fertilizers	50'384'000	630	989.69	0.99
Animal Wastes applied to Soils	69'773'597	872	1'370.55	1.37
N-fixing crops	32'951'926	412	647.27	0.65
Fixation cropland	1'328'428	17	26.09	0.03
Fixation pasture range and paddock	31'623'498	395	621.18	0.62
Crop residues	36'902'319	461	724.87	0.72
Crop residues cropland	14'567'999	182	286.16	0.29
Crop residues pasture range and paddock	22'334'320	279	438.71	0.44
Cultivation of histosols	17'000	136	213.71	0.21
Animal Production (pasture range and paddock)	**15'976'593**	320	502.12	**0.50**
Indirect emissions	**84'268'902**	0		**2.19**
Deposition	47'490'873	475	746.29	0.75
Leaching and run-off	36'778'028	919	1'444.85	1.44
Other (fertilization with compost and sewage sludge)	**3'948'000**	49	77.55	**0.08**
Total	**294'222'336**	**369**	**4'526**	**6.72**

Table 101 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 99 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 100.

6.5.3. Uncertainties and Time-Series Consistency

Minimum and maximum values for the related emission factors are displayed in Table 102.

	Medium	**Minimum**	**Maximum**
	(kg N_2O – N/kg N)		
Emission factor Synthetic Fertilizer (4D1)	0.0125	0.0025	0.0225
Emission factor Fixation (4D1)	0.0125	0.0025	0.0225
Emission factor crop residues (4D1)	0.0125	0.0025	0.0225
Emission factor organic soils (4D1)	8	2	15
Emission factor pasture range and paddock (4D2)	0.02	0.005	0.03
Emission factor leaching and run-off (4D3)	0.025	0.002	0.12
Emission factor deposition (4D3)	0.01	0.002	0.02

Table 102 Minimum and maximum values for emission factors related to agricultural soils (IPCC 2000).

From the values of Table 102, an emission factor uncertainty of 80% (4D1) and 90-95% (4D3) may be derived. An activity data uncertainty of 10% is assumed for 4D1 and 15% for 4D3. These numbers are used as input for the Tier 1 analysis.
For Tier 2 (Monte Carlo), a combined uncertainty of 80% (4D1) and 95% (4D3) is used as input for the uncertainty of the emissions. The values are derived from the error propagation formula for the product EF*AD ($U_E^2 = U_{EF}^2 + U_{AD}^2$). Lognormal distributions are assumed. (With normal distributions, the 2.5 percentile values would become negative.) In Table 141 in Annex A1.2.3 the Monte Carlo model uncertainty is given. It slightly deviates from the input value (4D1: 78.8% instead of 80.0%; 4D3: 93.2% instead of 95.0%), which is the result of a consistency adjustment of the correlations coefficients carried out by Crytal Ball Software automatically.

The time series 1990-2004 is consistent.

6.5.4. Source-Specific QA/QC and Verification

No source-specific activities have been carried out for N_2O. However, an internal quality control is done regularly. An internal documentation of the Swiss Federal Research Station for Agroecology and Agriculture (FAL) about the calculation of the greenhouse gas emissions in agriculture assures transparency and traceability of the calculation methods (FAL 2004).

6.5.5. Source-Specific Recalculations

No source-specific recalculations have been carried out.

6.5.6. Source-Specific Planned Improvements

As a component of the quality control process the N_2O calculation method IULIA will be revised. It is however not yet assessable whether this revision will lead to an adjustment of the N_2O calculations as a whole.

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 source**.

Emissions from Source Category 4F "Field Burning of Agricultural Residues" occur from open burning of branches in agriculture and forestry. The source category includes CH_4, N_2O, NO_x, CO and NMVOC and SO_2 emissions. Burning of wastes in agriculture and forestry is 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.

Emissions factors

The emission factors are taken from the updated EMIS database.

Emissions from burning of branches in agriculture and forestry	**Emission factor** Gg/Gg wood equivalent
CH_4	0.0068
N_2O	0.00018
NO_x	0.0036
CO	0.1040
NMVOC	0.0095
SO_2	0.0007

Table 103 Emission factors for calculating emissions from burning of branches in agriculture and forestry (EMIS).

Activity data

Activity data is taken from the EMIS database.

Amount of Residues burned	Activity data (in Gg)
Amount of branches burned in agriculture and forestry	70

Table 104 Activity data for calculating emissions from burning of branches in agriculture and forestry (EMIS). Estimations remained unchanged since 1990.

6.7.3. Uncertainties and Time-Series Consistency

No uncertainty assessment has been carried out. Uncertainty is medium or high (especially regarding activity data).

The time series is consistent.

6.7.4. Source-Specific QA/QC and Verification

No source-specific activities have been carried out.

6.7.5. Source-Specific Recalculations

The emissions have been recalculated with updated emission factors (EMEP/CORINAIR 2002) and activity data from EMIS.

6.7.6. Source-Specific Planned Improvements

There are no planned improvements.

7. Land-Use Change and Forestry

This chapter presents the sector LUCF using the approach of the Revised 1996 IPCC Guidelines and the relevant CRF tables. Method and text are unchanged compared to the previous submission. Only emission/removal data of the year 2004 are added.

In addition, the new LULUCF reporting as requested by decision 13/CP.9 has been developed and applied for the base year 1990. Method, input data and new results are described in detail in Annex 4. Until September 2006 the new method will be applied to the time series 1990–2004 and the results will be reported in the initial report.

7.1. Overview

This chapter includes information about the estimation of greenhouse gas emissions and removals of the sector Land-use Change and Forestry (IPCC category 5 in the Common Reporting Format). The following emissions and removals are reported:

- 5A Changes in Forest and Other Woody Biomass Stocks.
- 5B Forest and Grassland Conversion: The emissions of 5B3 Temperate Forests are included in 5A3 Temperate Forests; the emissions of 5B4 Grassland Conversion are not estimated.
- 5C Abandonment of Managed Lands: The emissions of 5C3 Temperate Forests are included in 5A3 Temperate Forests.
- 5D CO_2 Emissions and Removals from Soil (cultivated peat soils under upland crops only).
- 5E Other Emissions are not occurring (NO).

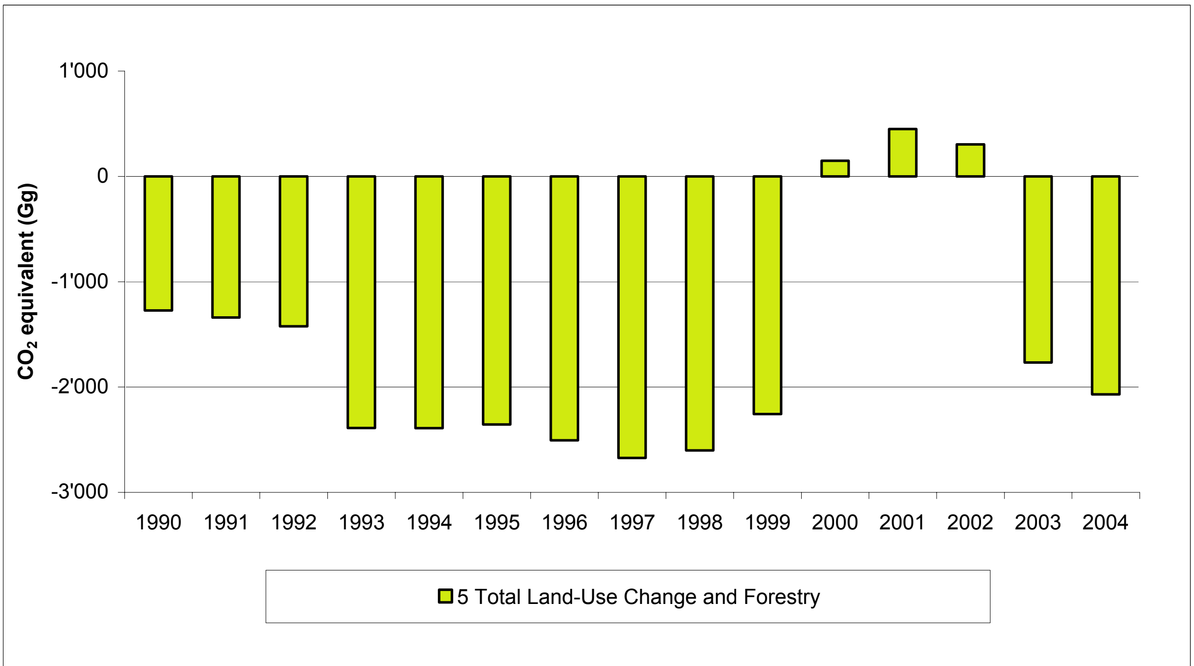

Figure 29 Switzerland's CO_2 emissions/removals of source category 5 "Land-Use Change and Forestry" 1990–2004 in Gg CO_2. Positive values refer to emissions, negative values to removals.

Land-Use Change and Forestry	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO2 (Gg)														
5 Total Land-Use Change and Forestry	-1'273	-1'339	-1'424	-2'388	-2'392	-2'355	-2'507	-2'674	-2'602	-2'256	149	450	305	-1'766	-2'069
5A Changes in Forest and Other Woody Biomass Stocks	-1'887	-1'953	-2'037	-3'001	-3'005	-2'968	-3'120	-3'287	-3'216	-2'869	-464	-163	-308	-2'380	-2'682
5D CO2 Emissions and Removals from Soil	613	613	613	613	613	613	613	613	613	613	613	613	613	613	613

Table 105 CO_2 emissions and removals from Land-Use Change and Forestry (sub-categories and total) in Gg.

Figure 29 illustrates the heavy influence of natural hazards on the net emissions balance of the LUCF sector. In absence of losses of forest stock due to natural hazards, the managed forests remove around 2’000-3'000 Gg CO_2 yearly. In early 1990 and in late 1999, the storms Vivian and Lothar led to significant loss in biomass. In the case of storm Lothar, the amount of destroyed biomass was nearly three times higher than average annual net growth of Swiss forests.

In the inventory, the reduced CO_2 uptake remains visible over several years due to 3-year averaging of the storm effects: the years 1990-1992 contain the reduced removals caused by the storm Vivian, the years 2000-2002 contain the even more reduced removals due to storm Lothar. The years 1993-1999 and 2003-2004 display the situation with normal harvests without such outstanding events. 2003 was affected by the heat wave, which had supported significant bark beetle infestations.

The CO_2 emissions from organic soils remain at a constant value of 613 Gg CO_2.

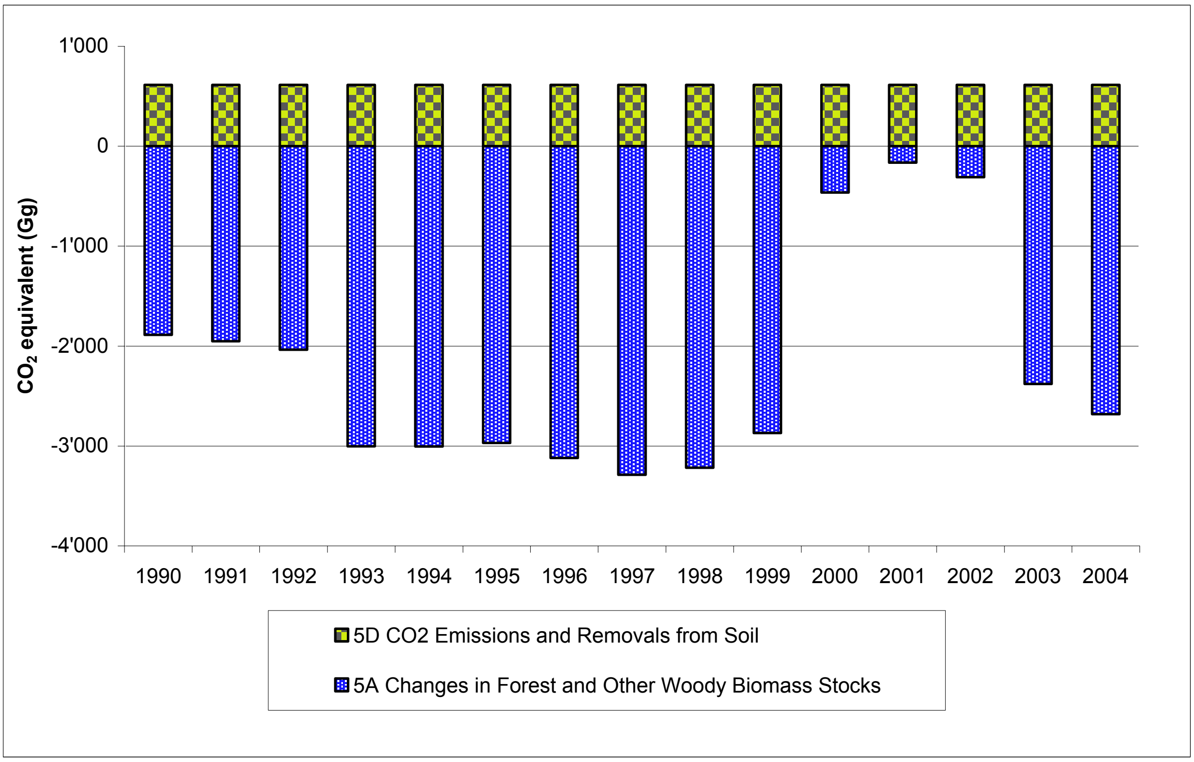

Figure 30 The CO_2 emissions of the sub-categories of Land-Use Change and Forestry 1990–2004.

7.2. Source Category 5A – Changes in Forest and Other Woody Biomass Stocks

7.2.1. Source Category Description

In accordance with IPCC guidelines, the LUCF sector is **not subject to key category analysis**.

Only temperate forests are occurring in Switzerland.

5A2	Source/Sink	Specification	Data Source
	Temperate/ Commercial	Growth rate: as shown in Table 108	Brassel P / U.-B. Brändli 1999 (2nd Swiss National Forest Inventory 1995)
		Harvest of evergreen (coniferous) and deciduous are separated	SAEFL 2005b: Annual forest statistics

Table 106 Specification of source category 5A “Changes in Forest and Woody Biomass Stocks”.

7.2.2. Methodological Issues

Methodology

The carbon uptake increment (CUI) is estimated according to IPCC 1997 revised guidelines, adapted to national data sources (IPCC 1997a-c).

$$CUI_i = A * AGR_i * CEF, \quad AGR_i = G * d_i * f, \quad i = coniferous, deciduous$$

- A (in hectare) is the total managed forest area equivalent to the productive forest/biomass stocks (according to Table 108).
- AGR (in g dry matter/hectare/a) is the average annual growth rate.
- G (= 8.034 m^3/hectare/year)[18] is the gross annual growth rate of timber on managed forest land (under bark, derived from Brassel P. / U.-B. Brändli 1999, 2nd National Forest Inventory). This parameter has been recalculated. The methodology is described below.
- d is the density of coniferous wood (0.384 Mg dry matter/m^3) and deciduous wood (0.556 Mg dry matter/m^3), respectively (Burschel et al. 1993)
- For accounting for the growth of small branches, twigs and roots of non commercial value, the annual growth is increased by the expansion factor f = 1.45 (adapted from IPCC revised 1996 guidelines, Burschel et al.1993).
- CEF (t C/t dry matter) is the carbon emission factor (see below).
- The annual net specific growth rate G has been calculated on basis of the “managed forest area” comparing the two national forest inventories (Table 107 and Table 108):

[18] This value of 8.034 is reported since 2002. A planned improvement is to assess this separately for evergreen and deciduous forests.

Swiss Forest Area	**National forest inventory 1985 (ha)** Mahrer F. 1988	**National forest inventory 1995 (ha)** Brassel P. / U.-B. Brändli 1999	**National forest statistics Increase 1995 to 2004 (ha)** SFSO 1996 SAEFL 2005b
Total forest area NFI *Total forest area national forest statistics*	1’186’300	1’234’000 *1’206’200*[19]	 *+15’800*
Non managed forest area: Tracks (cable cars, high tension lines etc.) and adjoining slopes	 4’700	 5’500	-Assumed to constant
Areas within forests permanently without tree cover (forest roads etc.)	45’700	31’100	- Assumed to constant
Inaccessible forest	33’100	33’400	- Assumed to constant
Scrub forest	55’700	60’800	- Assumed to constant
Total non managed forest area	139’200	130’800	- Assumed to constant
Total managed forest area 1985/1995	1’047’100	1’103’200	- Assumed increasing 1995-2004 as total forest area according to national forest statistics
Increase of managed forest area 1995-2004 (according to national forest statistics SFSO 1996/SAEFL 2005b)			+15’800
Total managed forest area 2004			1’119’000
Evergreen 2004 – 69.9% Deciduous 2004 – 30.1%[20]			782’000 337’000

Table 107 Specification of Swiss forest area in hectares (ha). NFI: National forest inventory.

For the determination of the gross annual growth rate of managed forests, further input data is used:

[19] The national forest statistics are based on land use plans of the municipalities. The increase in forest area is not entered systematically into these land use plans, hence reflects the growth of the total forest area only with delay. The total forest area according to the national forest statistics was in 1995 therefore lower than according to the national forest inventory.

[20] The share of deciduous forest is increasing at a rate of 0.2% per year. The value for 2004 has been extrapolated from 1995 (28.4%) as per Brassel P. / U.B. Brändli 1999

National Forest Inventory	**1985** million m^3	**1995** million m^3
Stem wood total on forest area common to both inventories	359	385
Growth of stem wood on new forest area 1995 (afforestation)		2.5
Stem wood on forest area lost (landslides, deforestation)	3.2	
Total stem wood (over bark)	362.2	387.5
Net stock change stem wood 1995–1985		25.3
Total harvest 1985-1995 (incl. mortality)		72.0
Total growth of stem wood in 10.1 years (harvest plus change in standing stock)		97.3
Total growth of timber wood in 10.1 years (under bark with branches)		89.5
Total growth per annum		8.863
Managed forest area 1995		*1.1032 million ha*
Annual growth rate (AGR)		*8.034 m^3/ha*

Table 108 Calculation of gross annual growth rate based on first (1985) and second (1995) National Forest Inventory (Brassel P. / U.-B. Brändli1999).

Annual growth rates (AGR)
AGR(evergreen) = 8.034 m^3/ha/a * 0.385 Mg dry matter/m^3 * 1.45 = 4.47 Mg dm/ha/a
AGR(deciduous) = 8.034 m^3/ha/a * 0.556 Mg dry matter/m^3 * 1.45 = 6.48 Mg dm/ha/a

5C Abandonment of Managed Lands / 5C2 Temperate Forests is not separately calculated, even though the Swiss forest area has increased by nearly 50% over the last 100 years. The carbon uptake on this surface is included in the carbon uptake increment of forests under 5A2 Temperate Forests. In line with the national forest legislation, the abandoned land has become forest and is now part of the forest statistics.

All reported carbon stock changes refer to living above and below ground biomass of trees and shrubs, but no litter and soil carbon is included. No carbon enrichment in soils is estimated and reported.

Tree cover/biomass stocks on agricultural land (fruit orchards), biomass stocks along railway-lines and roads as well as in settlements/parks are not reported under 5A5 Other Biomass (non forest trees) due to lack of data. There are incentive schemes in agricultural policy to encourage establishment and sustainable management of agricultural woodlots. This data could be included with some extra effort; this improvement is planned within the frame of the new LULUCF reporting.

Emission factors

Source	**Carbon Emission Factor CEF (t C/t dm)**
Total biomass removed in commercial harvest	0.5
Traditional fuel wood consumed	0.5

Table 109 Carbon emission factor (CEF) for calculating CO_2 emissions from changes in forest and other woody biomass stocks.

The implied carbon uptake factor CUF is the product of the average annual growth rate AGR and the carbon emission factor CEF:

$$CUF_i = AGR_i * CEF, \quad i = coniferous, deciduous$$

Source	Implied Carbon Uptake Factor (t C/ha)
Commercial: Evergreen	2.24
Commercial: Deciduous	3.24

Table 110 Implied carbon uptake factor for calculating CO_2 removals from changes in forest and other woody biomass stocks.

Activity data

- The main database for calculations is the 2nd Swiss National Forest Inventory (Brassel P. / U.-B. Brändli 1999) as well as the annual national forest statistics (SAEFL 2005b).
- Area of productive forest / biomass stocks A (ha): The annual forest statistics (SAEFL 2005b, p10) provide yearly data on the annual increase of the total forested area. In 2004, the managed forest area is assumed to have grown proportionately to the total forested area to 1.119 million ha (refer to Table 111). The share of evergreen forests in 2004 was 69.9%, the share of deciduous forest is 30.1%. The deciduous share of forest is gradually increasing; the trend 26.5% in 1985 and 28.4% in 1995 according to Brassel P. / U.-B. Brändli 1999 is extrapolated. In 2004, this corresponds to an evergreen forest area of 0.782 million ha and deciduous forest area of 0.337 million ha.
- Average annual growth rate AGR (t dry matter/ha/a): see above.
- Amount of biomass removed (kt dm)
  The total biomass removed is estimated on the following basis:
  The national forest statistics (SAEFL 2005b, harvest G.4.1 p. 24) provide data for industrial round wood and fuel wood in m^3/a, each for coniferous and deciduous. The annual harvest reported in the CRF is the three year average, total by categories.
- Traditional fuel wood consumed (= deciduous or coniferous fuel wood): figures derived from annual forest statistics (SAEFL 2005b).
- The expansion factor 1.45 (Burschel 1993), accounting for leaves, roots and twigs/small branches of no commercial value, is added to the reported biomass removed.
- These data are disaggregated into evergreen and deciduous as displayed in Table 111. The result is the total amount of biomass removed.

Wood product groups	Type	Harvested volume 2004	Density	Removed biomass [1)]
		1000 m^3	t/m^3	kt dm
Commercial harvest	evergreen	3'403	0.384	1895
(industrial roundwood)	deciduous	462	0.556	372
	sub-total	3'865		2'267
Fuel wood	evergreen	461	0.384	257
	deciduous	620	0.556	500
	sub-total	1'082		757
Total		4'946		3'024

Table 111 Commercial harvest and fuel wood consumed (3 yearly averages).
[1)] Removed harvest incl. expansion factor for above and belowground biomass.

In addition to this reported stock decrease of 3’024 kt dry matter (Table 111), a loss factor of 0.396[21] is added to the amount of biomass removed and reported under “other changes in carbon stocks”. The loss factor is calculated from the stock increase reported for the period between the 1st and the 2nd Swiss National Forest Inventory, as displayed below (Table 112). This stock increase is compared with the reported accumulated harvest from the annual forest statistics for the 1985 -1995 period. It accounts for natural losses of trees and harvested parts not commercially utilized and therefore not recorded in the national forest statistics.

Totally removed volume, (stem wood, source Brassel P / U.-B. Brändli1999)	72.043 mio m^3 (100%)
Minus stem wood without bark (minus 11%)	64.118 mio m^3 (89%)
Plus timber of branches (3% of stem wood =+ 2.161 mio m3) = a	66.279 mio m^3 (92%)
10 year total of commercially harvested industrial round wood and fuel wood as per national forest statistics = b	47.47 mio m^3
Difference between the national forest inventory and the annual forest statistics = a-b	18.809 mio m^3
Loss factor: Removed volume NFI – harvested volume forest statistics: = (a-b)/b 18.809/47.47	0.396

Table 112 Calculation of loss factor 1985–1995.

7.2.3. Uncertainties and Time-Series Consistency

Uncertainties have not been evaluated quantitatively within the uncertainty analysis of chapter 1.7. However, uncertainties are assessed qualitatively as “medium”. Due to the 10 year interval between Swiss National Forest Inventories, the annual increase or decrease of forest area is taken from the annual forest statistics. Time series consistency of national forest inventory and national forest statistics is good. There is however an uncertainty on the absolute size of the forest area (Table 113). The forest area since 1995 has been updated on the basis of annual forest statistics (SAEFL 2005b), taking the 1995 value from the forest inventory as a value of departure. The annual change in managed forest area according to annual forest statistics is added annually to the previous total. In future the data from the Swiss land use statistics are planned to be used for reporting land use and land-use change.

[21] For 2004 equivalent to 1189 kt dry matter.

	1985	1995	Difference 1985-1995
1st and 2nd National Forest Inventory (NFI)	1'186'300 ha	1'234’000 ha	47'700 ha
Forest Statistics (SFSO)	1'184'571 ha	1'206'293 ha	21'722 ha
Difference NFI/SFSO	1'729 ha	27'707 ha	25'978 ha

Table 113 Statistical differences between the two National Forest Inventories (1985, 1995) and the annual Forest Statistics.

A calibration/recalculation will be done as soon as the 2006 values of the 3rd National Forest Inventory become available (expected for 2008).

7.2.4. Source-Specific QA/QC and Verification

Plausibility cross checks are performed at 10 year intervals between National Forest Inventory (stocked area) and the stocked area as per the yearly forest statistics (see Section 7.2.3). A special investigation was carried out in 2003 (Fischlin 2003).

7.2.5. Source-Specific Recalculations

No recalculation for 5A Changes in Forest and Other Woody Biomass Stocks was carried out.

7.2.6. Source-Specific Planned Improvements

The present methodology will be improved up to end of 2006 in response to reporting requirements as adopted at COP9 (updated methodology applied to 1990 data refer to Annex A4.4).

7.3. Source Category 5B – Forest and Grassland Conversion

Deforestation: 100 to 200 ha annually, accounted for under 5A2 Changes in Forest and Other Woody Biomass Stocks, Temperate Forests (see Table 108, row “Stem wood on forest area lost”).

Conversion of grassland: not estimated, but actually occurring as conversion of grassland to settlement; see Planned Improvements, Section 7.2.6.

Planned Improvements: The present methodology will be updated by 2006 on the basis of Swiss land use statistics in response to reporting requirements as adopted at COP9 (updated methodology applied to 1990 data refer to Annex 4.5).

7.4. Source Category 5C – Abandonment of Managed Lands

5C2 Temperate Forest: Emissions are included in 5A2 Changes in Forest and Other Woody Biomass Stocks, Temperate Forests.

Planned Improvements: The present methodology will be updated by 2006 on the basis of Swiss land use statistics in response to reporting requirements as adopted at COP9 (updated methodology applied to 1990 data refer to Annex 4.6).

7.5. *Source Category 5D – CO_2 Emissions and Removals from Soil*

7.5.1. Source Category Description

In accordance with IPCC guidelines, the LUCF sector is **not subject to key source analysis**.

This source category includes CO_2 emissions from Cultivation of Organic Soils and CO_2 emissions from Liming of Agricultural Soils only.

In 1999, a tentative estimation was made for the forest soil carbon budget of the year 1985 (Perruchoud et al 1999). Forest soil was estimated to be a sink sequestering an amount of 1'300 Gg CO_2 per annum. Due to resource limitations, this investigation has not been substantiated or repeated since.

7.5.2. Methodological Issues

Methodology

Emissions from cultivated organic soils are estimated by multiplying the total area of cultivated organic soils with the peat decay rate (t CO_2–C ha^{-1} a^{-1}) (FAL 2003a).

Emissions from liming of agricultural soils are estimated by multiplying the totally estimated limestone input (traded quantities) with the IPCC carbon conversion factor. The carbon emissions from liming are converted into CO_2 emissions.

Emission factors

Peat decay rate is based on literature data (Presler / Gysi 1989, Kasimir-Klemedtsson et al. 1997, Zeitz 1997). Estimates range from 7.34 to 11.68 t CO_2–C ha^{-1} a^{-1}, with a mean value of 9.52 t CO_2–C ha^{-1} a^{-1} (FAL 2003a, SAEFL 1998).

This IPCC carbon conversion factor for limestone is 0.12 MgC/MgCa(CO_3)

Activity data

The area of cultivated organic soils has been estimated using various assumptions. The mean area calculated is 17’000 ha with an uncertainty range of ± 5'000 ha (FAL 2003a). This leads to carbon emissions of 161’840 MgC/yr.

The total annual amount of limestone input to agricultural soils of 45’000 Mg has been stable over the reporting period 1990–2003 and has been estimated by Würsch 2004. The carbon emissions associated to liming are 5’400 MgC/yr.

The emissions from both sources are equivalent to 613 Gg CO_2.

7.5.3. Uncertainties and Time-Series Consistency

Due to uncertainties in emission factors as well as in activity data, upper and lower emission estimates differ by a factor of 3. This estimate is not integrated in the uncertainty analysis of chapter 1.7. It is assumed that yearly emissions do not change at present.

7.5.4. Source-Specific QA/QC and Verification

No source-specific QA/QC have been carried out.

7.5.5. Source-Specific Recalculations

No recalculation for 5D CO_2 Emissions and Removals from Soils was carried out

7.5.6. Source-Specific Planned Improvements

The present methodology will be improved up to 2006 in response to reporting requirements as adopted at COP9 (up-dated methodology applied to 1990 data refer to Annex 4.7).

8. Waste

8.1. Overview GHG 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”.

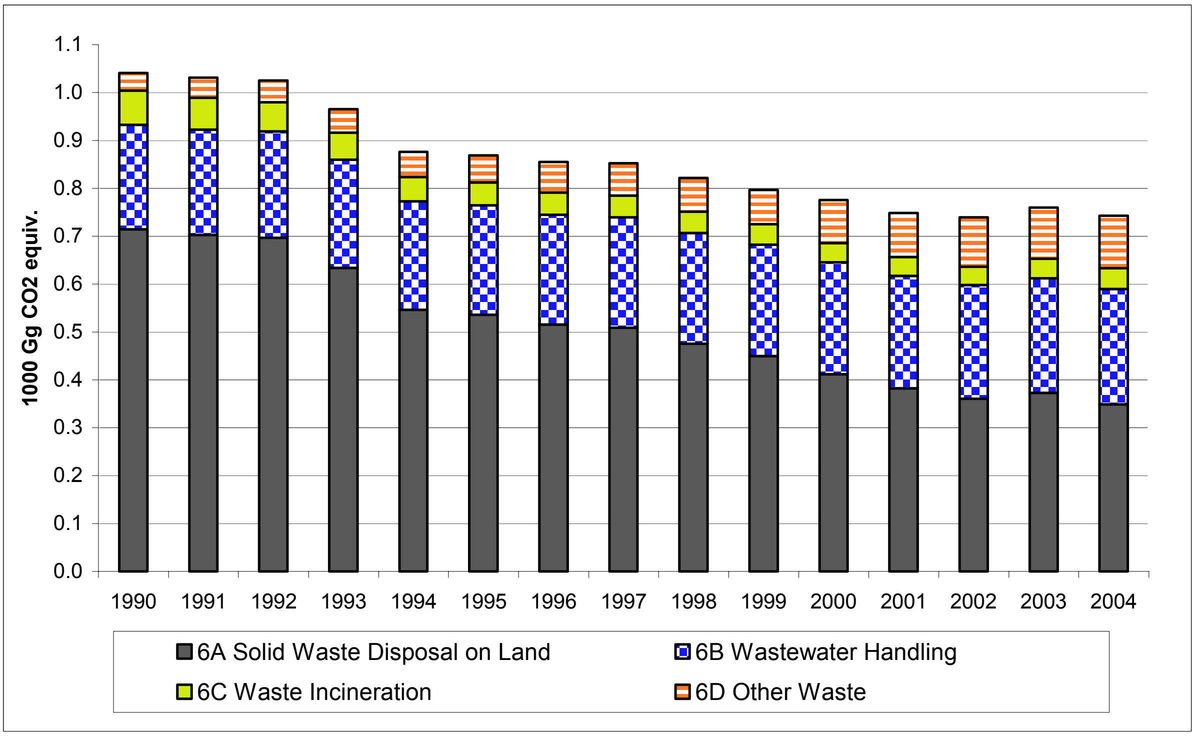

Figure 31 Switzerland’s greenhouse gas emissions in the waste sector 1990–2004.

Gas	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
	CO_2 equivalent (Gg)														
CO_2	75	75	84	76	51	45	42	39	37	31	26	21	17	16	16
CH_4	756	744	727	672	608	603	590	588	557	537	516	490	481	497	477
N_2O	210	212	214	217	217	220	223	226	228	229	234	237	242	246	251
Sum	1'041	1'031	1'025	965	876	869	855	853	822	797	776	749	740	760	743

Table 114 Trend of total GHG emissions from waste management in Switzerland 1990-2004.

In source category 6 "Waste" a total of 743 Gg CO_2 equivalents were emitted in the year 2004. 47% of the emissions stem from the sub-category 6A “Solid Waste Disposal on Land”, 32.4% from 6B “Wastewater Treatment”, 14.8% from 6D “Others” and 5.8% from 6C “Waste Incineration”.

The total greenhouse gas emissions in source category 6 "Waste" show a decrease from 1990 until 2004. 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 2004. N_2O and CO_2 are of minor importance in the waste sector. The relative trends of the gases can be seen in Figure 32.

Please note that with the present submission, all emissions related to municipal solid waste incineration are reported under 1A1 Energy industries. Therefore the largest share of waste-related emissions in Switzerland is not reported under category 6 Waste, as the box below shows.

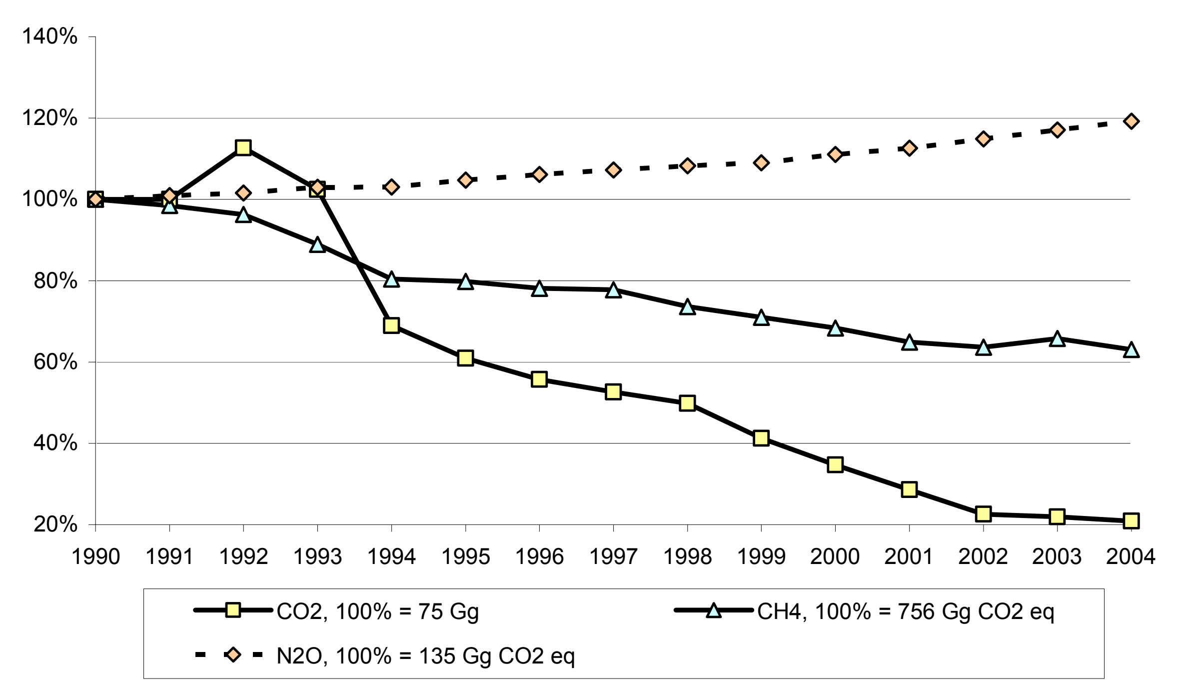

Figure 32 Trend of total GHG emissions from waste management in Switzerland 1990-2004.

Box: Waste related GHG emissions in Switzerland

There are very different activities for the proper waste disposal in Switzerland. The respective GHG emissions are reported in different chapters within the National Inventory. Subsequent Figure provides an overview on all waste related GHG emissions in Switzerland, not only the one reported in the present Chapter 8.

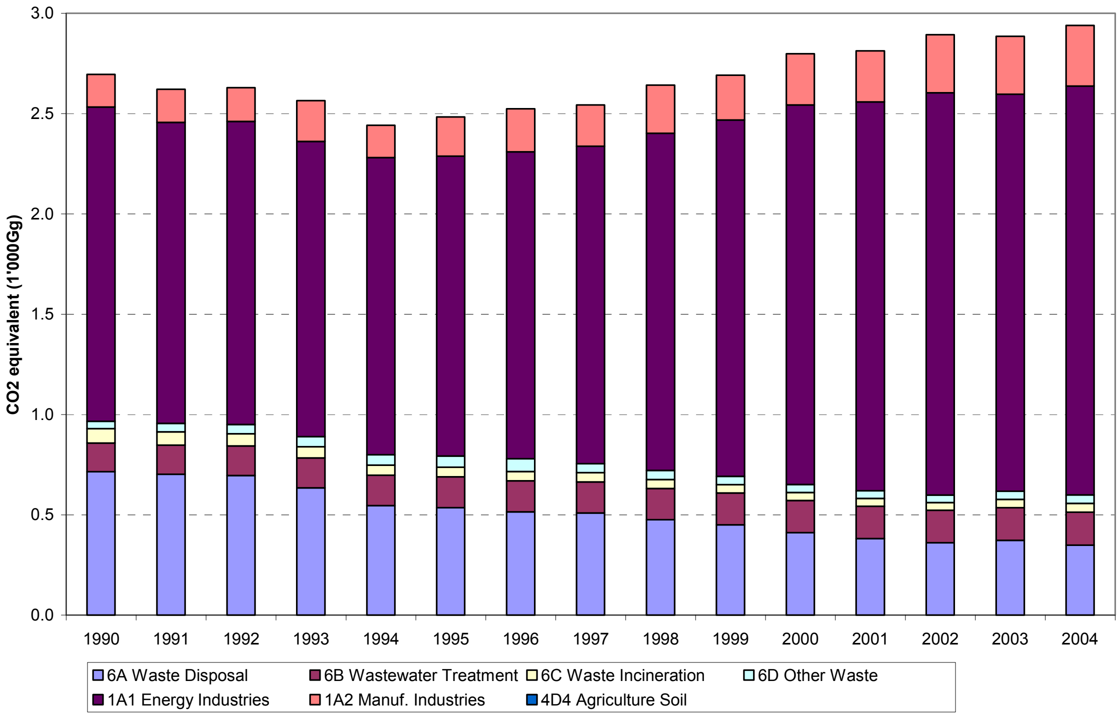

Figure 33 Waste related GHG emissions from 1990-2004.

8.1.1. Overview on Waste Management in Switzerland

The goals and principles regarding waste management in Switzerland are stated in the Guidelines on Swiss Waste Management (SAEFL 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 115 gives an overview on the waste quantities generated in 2004, and indicates the main treatment options as well as the waste treatment facilities. A more detailed description of the treatment facilities is provided in the respective chapters. [22]

Waste category Disposal Option and Waste Type	Quantity Gg	 %
Municipal solid waste	**4'992**	100
Recyling	**2'412**	48
paper	1'163	
used glas	304	
organic waste	770	
aluminium, aluminium cans	4	
PET (bottles)	31	
tinplate	13	
textiles	44	
batteries	3	
electrical equipment	80	
Treatment	**2'554**	51
MSW incineration	2'554	
Final Disposal	**26**	1
landfilled	26	
Construction waste	**11'000**	100
Recyling	**9'000**	82
direct use at construction site	4700	
separation and recyling	4300	
Treatment	**400**	4
incineration (used wood etc.)	400	
Final Disposal	**1'600**	15
landfilled	1650	
Hazardous waste	**1'126**	100
Recyling	**123**	11
	123	
Treatment	**700**	62
incineration and detoxified	700	
Final Disposal	**303**	27
landfilled	303	
Sewage sludge	**206**	100
Recyling	**80**	39
used in agriculture	80	
Treatment	**126**	61
incineration	126	
Final Disposal		
landfilled	incl. in treatment	

Table 115 Overview on waste generation and waste disposal in 2004.

[22] Detailed Data on various aspects of the waste sector in Switzerland can be found on the internet-site of SFOE (http://www.umwelt-schweiz.ch/buwal/eng/fachgebiete/fg_abfall/zahlen/statistiken/index.html).

Table 115 shows that of the 4'992 Gg of municipal solid waste (MSW) generated in 2004, 2'412 Gg or 48% have been recycled. The main recycled waste types are paper/cardboard (1'163 Gg), organic waste (770 Gg treated in centralized composting plants, without backyard composting), and used glass (304 Gg) (SAEFL 2005c). The part of the MSW that has not been recycled has mainly been incinerated (2'554 Gg or 51%) or disposed off in landfills (26 Gg or 1%).

About 11'000 Gg construction waste is generated in Switzerland[23]. From this quantity about 9'000 Gg (82%) has been recycled. About half of the recycling takes place at the construction site, e.g. by reusing material left after breaking up the road cover. About the other half is separated at the construction site and recycled individually, e.g. used glass, used metals, used concrete etc. A minor amount of 400 Gg of the construction waste is incinerated and about 1'600 Gg is disposed of on landfills (SAEFL 2001).

About 1'126 Gg hazardous waste is generated in Switzerland[24]. 1'004 Gg hazardous waste has been domestically treated and 121.6 Gg exported for disposal. About one third of the domestically disposed hazardous waste has been recycled and physically-chemically treated. 41% of the hazardous waste has been incinerated in different plant types or used as fuel in industry.

About 206 Gg (dry matter) sewage sludge has been generated in 2004. 39% of sewage sludge has been recycled, i.e. this sewage sludge has been used as fertilizer in agriculture. 61% or 126 Gg sewage sludge has been incinerated (in MSW incineration plants or mono incineration plants) or disposed of in landfills.

The greenhouse gas emissions from domestic recycling activities are estimated in the appropriate chapters, i.e. energy, agriculture or waste.

8.2. Source Category 6A – Solid Waste Disposal on Land (Key Source)

8.2.1. Source Category Description

Key sources 6A
The CH_4 emissions from Solid Waste Disposal on Land (6A) are a key source regarding 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 2004 11 managed "reactive" landfills have been equipped to recover landfill gas (SFOE 2004). 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.

[23] The latest available data for construction waste on this general level refer to the year 2000.

[24] The latest available data for hazardous waste on this general level refer to the year 2002.

6A	Source	Specification	Data Source
6A1	Managed Waste Disposal on Land	Emissions from handling of solid waste on managed landfill sites.	EMIS
6A2	Unmanaged Waste Disposal Sites	Emissions from all other waste disposal sites that don't fall into 6A1. (included in 6A1)	EMIS
6A3	Others	Not occurring in Switzerland	

Table 116 Specification of source category 6A "Solid Waste Disposal on Land".

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 according to IPCC (IPCC 1997a-c). The subsequent equation is applied to calculate the CH_4 generation in the year t:

CH_4 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 ($MCF(x) \cdot DOC(x) \cdot DOC_F \cdot F \cdot 16/12$) [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 subsequent 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 generation:

	k [1/yr]	L_0 [Gg CH_4 / Gg waste]	DOC [-]
municipal solid waste	0.139	0.050	0.12
construction waste	0.046	0.120	0.30
sewage sludge	0.069	0.068	0.17

ii) In a second step, CH_4 recovered and used as fuel for co-generation units as well as for flaring is subtracted from the landfill CH_4 emissions.

CH_4 emissions step ii) = CH_4 emissions step i) – (CH_4 emissions step i) * Fl(t)) – Qco-gen(t)

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 step iii) = CH_4 emissions step ii) + Qopen(t)

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 and in the draft technical commentary[25] to the new 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:

25 As cited in the *Draft* Technical Commentary "09 04 00 Kehrichtdeponien" of the new EMIS data base of 21 February 2005.

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 burned						
Co-generation	2'750	0		6	10		0
Flaring	2'750	0		1	17		0
	kg / t waste burned						
Open burning	400	1500[26]	6	2	60	16	1

Table 117 Emission Factors for 6A1 "Managed Waste Disposal Sites on Land" in 2004.

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 extracted from in the draft technical commentary[27] to the new EMIS.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
6A1 Managed Waste Disposal on Land																
Municipal solid waste (MSW)	Gg	637	637	637	637	581	532	483	473	463	465	287	184	81	54	27
Construction waste	Gg	147	171	169	122	77	59	41	47	53	53	53	29	5	5	5
Sewage sludge	Gg (dry)	59	59	58	35	41	30	19	16	13	9	4.8	4.6	4.5	3.96	4
Open burned waste	Gg	17	20	30	27	11.4	10	8.7	8.6	8.6	5.7	3.9	2.4	0.95	0.67	0.2
Total waste quantity	**Gg**	**860**	**887**	**894**	**821**	**710.4**	**631**	**551.7**	**544.6**	**537.6**	**532.7**	**348.7**	**220**	**91.45**	**63.63**	**36.2**

Table 118 Activity data in 6A1: Waste disposed of on Managed Landfill Sites from 1990 to 2004.

Table 118 documents the reduction by about 24 times of municipal solid waste, construction waste and sewage sludge disposed of over the period 1990–2004. 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 set of activity data for Managed Waste Disposal on Land (6A1) are CH_4 recovered as fuel for co-generation units and the fraction of CH_4 recovered. The landfill gas recovered in co-generation units as well as the landfill gas flared is metered.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
6A1 Managed Waste Disposal on Land																
CH4 as fuel for co-generatio units	Gg	4.9	5.7	7.6	10.4	12.6	12.1	12.1	11.5	11.3	11.4	11.3	9.9	8.1	5.7	4.1
CH4 flared	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Table 119 Activity data in 6A1: Share of CH_4 used as fuel in co-generation units and flared from 1990 to 2004.

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 2004 this is the reason for CH_4 emissions from the source category 6A being a key source regarding trend.

[26] Value under review

[27] As cited in the *Draft* Technical Commentary "09 04 00 Kehrichtdeponien" of the new EMIS data base of 21 February 2005.

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%[28].

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 deposed of in the eighties, when waste statistics were less elaborated. From this, an emission factor uncertainty of 56.6% is calculated (resulting in combined uncertainty of 60%).

Qualitative estimate of uncertainties of non-key source emissions in 6A

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

Consistency: The time series is consistent.

8.2.4. Source-Specific QA/QC and Verification

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

8.2.5. Source-Specific Recalculations

A recalculation for 6A Solid Waste Disposal on Land was carried out. See Chapter 9.

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

Source category 6B "Wastewater Handling" is **not a key source**.

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).

[28] Source: EMIS. 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).

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: SFSO 2004c, 2005 EF: EMIS
6B3	Others	Not occurring in Switzerland	

Table 120 Specification of source category 6B “Wastewater Handling”.

The emissions related to wastewater treatment fall under various categories as laid out in Figure 34 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.

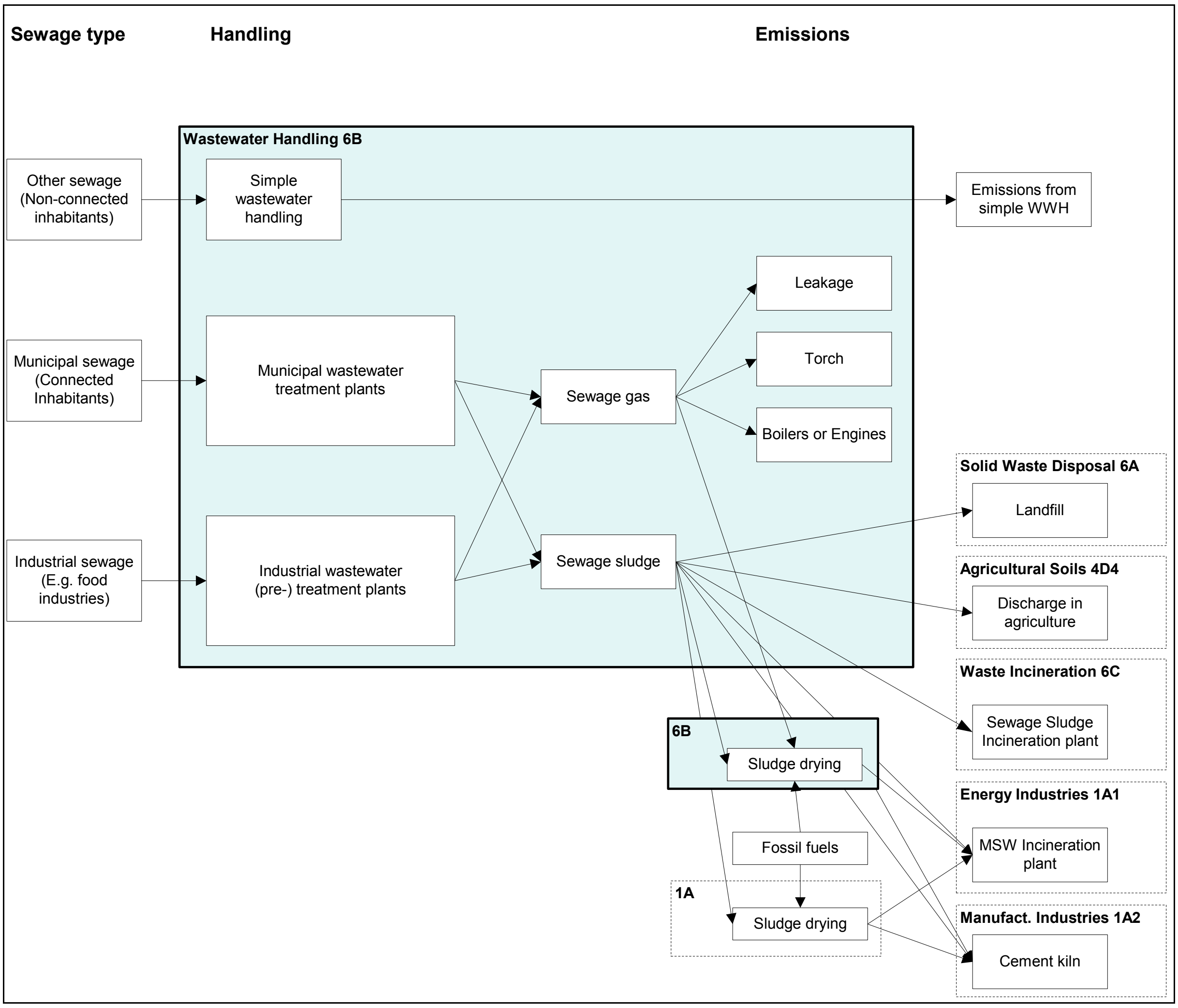

Figure 34 System boundaries of emissions related to wastewater treatment.

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.

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:

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

Table 121 Emission Factors for 6B2 Domestic and Commercial Waste Water in 2004.

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.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
6B2 Domestic and Commercial Waste Water																
Population	inhabitants in 1000	6'751	6'813	6'875	6'983	7'000	7'062	7'083	7'103	7'124	7'164	7'204	7'261	7'314	7'364	7'418
Fraction connected to waste water treatment plants	%	91.1%	91.5%	92.0%	92.4%	92.8%	93.2%	93.7%	94.1%	94.5%	95.0%	95.4%	95.4%	95.4%	95.4%	95.4%
Connected Inhabitants	inhabitants in 1000	6'150	6'234	6'325	6'452	6'496	6'582	6'637	6'684	6'732	6'806	6'873	6'927	6'978	7'025	7'077

Table 122 Activity data in 6B2 Domestic and Commercial Waste Water: Population and fraction connected to waste water treatment plants.

8.3.2. 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.

8.3.3. Source-Specific QA/QC and Verification

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

8.3.4. Source-Specific Recalculations

A recalculation for 6B Waste-water Handling was carried out. See Chapter 9.

8.3.5. Source-Specific Planned Improvements

No plans for source-specific improvements have been made so far.

8.4. Source Category 6C – Waste Incineration

8.4.1. Source Category Description

Source category 6C “Waste Incineration” is **not a key source**.

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:

Waste incineration	Specification	Data Source
Hospital waste incineration	Emissions from incinerating hospital waste in hospital incinerators	AD, EF: EMIS
Illegal waste incineration	Emissions from illegal incineration of gardening and household wastes Emissions from waste incineration at construction sites (open burning)	AD, EF: EMIS
Insulation material from cables	Emissions from incinerating cable insulation materials	AD, EF: EMIS
Sewage sludge	Emissions from sewage sludge incineration plants	AD, EF: EMIS
Crematoria	Emissions from the burning of dead bodies	AD, EF: EMIS
Sewage sludge	Emissions from sewage sludge incineration plants	AD, EF: EMIS

Table 123 Overview on waste incineration sources reported under 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.

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	1A2 d Biomass
Municipal solid waste incineration plants	Emissions from waste incineration in municipal solid waste incineration plants	1A1 a Other
Waste in cement plants	Emissions from waste incineration as alternative fuels in cement kilns	1A2 f Other
Special waste	Emissions from incinerating industrial and hazardous wastes	1A1 a Other

Table 124 Overview of other waste incineration activities in Switzerland, and indication of source categories where the waste incineration activity is reported in the national inventory.

8.4.2. Methodological Issues

Methodology

For the calculation of the greenhouse gas emissions a country specific Tier 2 method is used, based on CORINAIR. 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 database.

The following table presents the emission factors used in 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	0.51	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	0.18	0.0047	0.43
	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	0.310	0.024	0

Table 125 Emission Factors for 6C "Waste Incineration" in 2004.

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.

Source/Parameter	**Unit**	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Hospital Waste Incineration		30	27.5	25	22.5	20	17.5	15	12.5	10	7.5	5	2.5	0	0	0
Illegal waste	Gg	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Insulation material cables	Gg	7.5	6	4.5	3	1.5	0	0	0	0	0	0	0	0	0	0
Sewage sludge	Gg dry	57	53.85	50.7	47.55	44.4	50.2	56	59.6	63.2	63.75	64.3	70.15	76	86	96
Total	**Gg**	**124.5**	**117.4**	**110.2**	**103.1**	**95.9**	**97.7**	**101**	**102.1**	**103.2**	**101.3**	**99.3**	**102.7**	**106**	**116**	**126**
Crematoria	Numb.	37'513	37'407	37'939	38'884	39'620	40'986	40'998	42'460	42'536	43'480	43'604	45'681	46'419	48'080	48'100

Table 126 Activity data for the different emission sources within source category 6C "Waste Incineration".

Note: Since 2002, all special hospital waste incinerator plants have been closed and all hospital waste is incinerated in municipal solid waste incineration plants (accounted for in 1A1).

8.4.3. Uncertainties and Time-Series Consistency

Qualitative estimate of uncertainties of (non-key source) emissions in 6C

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

The time series is consistent.

8.4.4. Source-Specific QA/QC and Verification

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

8.4.5. Source-Specific Recalculations

With the submission 2006 all emissions from the incineration of municipal solid waste and of special waste is reported under 1A1. Therefore, a recalculation of 6C Waste Incineration was carried out. See Chapter 9.

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 sources 6D
The CH_4 emissions from Others (6D) are a key source regarding trend.

The source category 6D "Other" comprises the GHG emissions from car shredding plants, 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.

6D		Specification	Data Source
	Car shredding plants	Emissions from car shredding plants	AD, EF: EMIS
	Composting and digesting	Emissions from composting and digesting organic waste	AD, EF: EMIS

Table 127 Specification of source category 6D “Other”.

8.5.2. Methodological Issues

Methodology

For the emissions from car shredding a country specific method is used, based on CORINAIR. 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 (i) the use of biogas in engines and (ii) the composting of the residues of the fermentation process. The GHG emissions are calculated by (i) multiplying the amount of CH_4 (biogas) times the emission factor and (ii) 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 database.

The following table presents the emission factors used in 6D:

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	
Fermentation engine [g/t CH_4]			6'000	10'000		

Table 128 Emission Factors for 6D Others in 2004.

Activity data

Activity data for Other (6D) are extracted from EMIS.

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.

Source/Parameter	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Shredder	Gg	280	284	288	292	296	300	300	300	300	300	300	300	300	300	300
Compost	Gg	260	300	320	350	370	400	450	480	500	510	640	650	730	745	760
Fermentation	Gg	27.3	31.8	33.9	37.1	39.22	42.8	48.15	51.84	54	55.59	69.76	71.5	81.03	95.53	104
Fermentation (CH4 used in engine)	Gg	1.4	1.6	1.7	1.9	2	2.2	2.4	2.6	2.7	2.8	3.5	3.6	4.1	4.68	5.26

Table 129 Activity data in 6D Other.

8.5.3. Uncertainties and Time-Series Consistency

A preliminary uncertainty assessment based on expert judgment results in medium confidence in emissions estimates.

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.

The time series is consistent.

8.5.4. Source-Specific QA/QC and Verification

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

8.5.5. Source-Specific Recalculations

Emissions from composting and digesting of organic waste have been reported for the first time. Therefore a recalculation of 6D Other was carried out. See Chapter 9.

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

An exceptional number of recalculations have been carried out for the current submission. In the last few years, Switzerland has undertaken strong efforts to update and complete its GHG inventory. Not only the data but also the software tools have been brought up to date. As explained in Chapter 1.4.3, the national database EMIS was fully redesigned, was extended to incorporate more data sources, updated and migrated to a new software platform. Based on new studies, all activity data and all emission factors have been checked and updated at the same time.

All source categories affected –1 Energy (without 1A3b/e), 2 Industrial Processes, 3 Solvent and other Product Use, 6 Waste – have therefore been recalculated for the full time series 1990-2003

1 Energy

- General:
  - All previous submissions of Switzerland contained the emissions “1 Energy, 1A Fuel Combustion Activities” of the Principality of Liechtenstein. For the present submission, Liechtenstein’s emissions have been subtracted for the first time. Liechtenstein’s activity data (energy consumption) was used as follows: Gas oil, LPG and natural gas consumption were taken from the two available CRFs 1990/2004 and were subtracted from the corresponding figures of the Swiss overall energy statistics (which, due to the customs union, contains the sum of Swiss and Liechtenstein’s consumption data). The Swiss emissions were then modelled using the reduced activity data. For the other years 1991–2003, no CRF tables for Liechtenstein are available yet. FOEN interpolated (linearly) Liechtenstein’s consumption data between 1990 and 2004. (This procedure may be rough but it should be noted that Liechtenstein’s consumption, 3700 TJ in 2004, is only 0.56% of the Swiss consumption. That means that deviations between interpolated and true consumption are not of great influence for the Swiss inventory.)
  - All source categories affected by the update of EMIS – 1A1 Energy Industries, 1A2 Manufacturing Ind. and Construction, 1A4 Other Sectors, 1A5 Others (off-road) – have therefore been recalculated for the full time series 1990-2003. Also, the 1A3 categories have been partly recalculated (see below).
  - In the present submission, the net calorific value of hard coal has been revised (for details see Annex A2.2.1). The net calorific value is used to convert the hard coal consumption data from the Swiss overall energy statistics from tons to energy units (TJ). Therefore, the time series 1990-2003 of solid fuel related emissions (in 1A2 and 1A4) have been recalculated.
- 1A1 Energy Industries:
  - All emissions from the combustion of waste-to-energy activities (municipal solid waste, construction and hazardous waste) have been removed from 6C and transferred to 1A1 in order to conform with IPCC guidelines. In the 2005 submission, this was implemented only partially. The transfer corresponds to a change in allocation of emissions but the total emissions remain unchanged. See also 6C Waste Incineration below.
  - The emission factors for waste incineration ("Other fuels") have been revised. Also, other (non-CO_2) emission factors have been revised based on new studies (SAEFL 2005d).

- 1A2 Manufacturing Industries and Construction:
  - In the 2005 submission, estimated stock changes of heavy fuel oil and coal have been introduced to improve consistency of bottom-up and top-down energy consumption data. In the present 2006 submission, bottom-up modelled consumption data of heavy fuel oil and coal are used for the various processes in 1A2 (see Annex A2.4.1).
  - 1A2a-f: The disaggregation of activity data on the level of processes has been improved (Basics 2006, CEPE 2005).
  - 1A2d Pulp, Paper and Print: The energy produced by the incineration of black liquor and bark has been transferred from 6C Waste Incineration to 1A2d, in line with IPCC 1997. See also in 6C Waste Incineration below.
  - The non-CO_2 emission factors have been revised based on a new evaluation of the periodic control of stationary installations in the cantons of Berne and Zurich. The results of the evaluation led to a revision of the emission factors. They are published on the internet (SAEFL 2005e).
- 1A3 Transport and further Off-road transportation in 1A4c and 1A5:
  - 1A3a: The emissions of civil aviation have been completely revised using a detailed Tier 3a method. It replaces the former method based on Tier 2 combined with a Tier 1 top-down element for the splitting of domestic and international flights. Since this splitting is crucial (emissions from international flights are reported under memo items/international bunker emissions), the new method stands for an important improvement regarding the precision and the reliability of the Swiss GHG inventory.

Civil Aviation	**Submission**	**1990**	**2003**	**1990**	**2003**
		fuel consumtion (TJ)		current subm (prev.=100%)	
Total domestic	Submission Apr 06 (previous)	1'270	1'366	100%	100%
1A3a	Submission May 06 (current)	3'450	1'951	272%	143%
Total international	Submission Apr 06 (previous)	44'071	50'355	100%	100%
Bunker	Submission May 06 (current)	41'891	49'771	95%	99%
Sum	Submission Apr 06 (previous)	45'341	51'722	100%	100%
Fuel sold	Submission May 06 (current)	45'341	51'722	100%	100%

Table 130 Civil aviation, comparison of activity data (fuel consumption). Due to the recalculation, the total domestic consumption is higher and the bunker consumption is correspondingly lower. The sum of domestic and bunker, which is identical to the fuel sold, is the same in both submissions.

  - 1A3c-d, 1A4c, 1A5: The emissions of off-road vehicles and machinery (railways, navigation, agriculture, forestry, construction, hobby, industry vehicles, military) have been completely revised. In an in-depth study the activity data has been updated by surveys and in collaboration with professional associations. Emission factors were updated where new country-specific or published measurements were available (SAEFL 2005a).
- 1A4 Other Sectors
  - 1A4a and 1A4b: The non-CO_2 emission factors have been revised: For stationary sources new data is available from the compulsory periodic control of stationary installations (see 1A2 above). The results of the evaluation led to a revision of the emission factors. They are published on the internet (SAEFL 2005e). For mobile sources, the update is based on the new off-road study (SAEFL 2005a).
  - 1A4a: The calculated gas losses of the Swiss gas pipeline network are presently subtracted from the consumption of natural gas, which was not the case in the previous submissions. The consumption of natural gas is therefore decreased by

ca. 0.3% in 2004 and 1% in 1990 respectively. For reasons of simplicity, the losses were subtracted from the category with the largest leakages (1A4b Residential). The whole time series has been recalculated.

- 1A4c grass drying: The activity data have been updated in EMIS. The update is based on new data gathered by the branch association “Verband schweizerischer Trocknungsbetriebe” (VSTB). The data is documented in EMIS.

- 1B Fugitive Emissions from Fuels
  - 1B2b Fugitive emissions from natural gas: In the submission 2005, the emission data have been supplied by the Swiss Gas and Water Industry Association. In the present submission, FOEN has adopted a more sophisticated model. Current activity data and emission factors were used to calculate the methane losses of the gas distribution network, and additional leakage sources are considered (e.g. gas metering equipment). The model is published in Xinmin (2004).
  - 1B2a.iv/v, 1B2b.ii: NMVOC losses of refining/storage (1B 2a.iv), distribution of oil products (1B2a.v) and of transmission(1B2b.ii) are transformed into CO2 emissions and are added. The whole time series are recalculated.
  - 1B2c Fugitive emissions from venting and flaring: The emission factors have been revised in EMIS.

2 Industrial Processes

- In the course of the implementation of the new EMIS database, numerous activity data and emission factors have been updated; more than 95% of the processes were affected. The source categories concerned were recalculated for the full time period 1990–2003.
- Synthetic gases: The organisation for the compilation of the data of the import statistics has been centralised (Carbotech 2006). This has led to improved consistency of the activity data. Together with the implementation of the 2004 data, the full time series has been recalculated.

3 Solvent and other Product Use

- In the submission 2005, no indirect CO_2 emissions from NMVOC had been calculated in the sectors 3A-3D. For the current submission this has been carried out by applying the methodology used by the Netherlands (NIR NL 2005). The full time period has been recalculated correspondingly.
- IPCC categories 3A-3D include now CO_2 emissions from post combustion of NMVOC, which was not the case for the previous submissions. Therefore, a recalculation was carried out for the whole time series.

4 Agriculture

- Please note that agricultural emissions for 2004 were only updated in the course of April/May 2006 (with the country-specific IULIA model) and were therefore not yet reported in the submission of April 2006. Instead, the 2003 emissions were filled in for 2004 as a first guess in the April submission. The present submission now reports the correct model values 2004.
- The emissions of category 4F Field Burning of Agricultural Residues are estimated in the EMIS air pollution database (and not within the IULIA model). These emissions

have been updated and recalculated for the full time period 1990–2003 on the basis of new activity data from EMIS and new emission factors (EMEP/CORINAIR 2002).

5 LULUCF No recalculations were performed.

6 Waste

Emissions of 6 Waste were recalculated for the full time period 1990–2003.

- 6A1 Managed Waste Disposal on Land: The activity data has been updated in line with waste statistics (SAEFL 2002). The emission factor for the transformation of methane into CO_2 has been modified slightly.
- 6B2 Domestic and Commercial Wastewater: Emission factors and activity data have been updated in EMIS (source data from wastewater treatment plant operators and technology providers for gas engines and flares).
- 6B Waste Water Handling: N_2O emissions from human sewage have newly been modelled according to IPCC method. The time series was recalculated.
- 6C Waste Incineration: All emissions from the combustion of waste-to-energy activities (municipal solid waste and special waste, incineration of black liquor and bark) have been removed from 6C and transferred to 1A1 Energy Industries or 1A2d Pulp, Paper and Print. See also 1A1 and 1A2d above.
- 6D Other: Emissions from composting and digestion of organic waste are reported for the first time in the present submission. Data sources used include SFOE 1999, SAEFL 2004d, AQMD 2002.

9.2. *Implications for Emission Levels 2003 and 1990*

Recalculation	CO_2			CH_4			N_2O			Sum (CO_2, CH_4 and N_2O)		
Emissions for 2003	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	41'721	42'779	1'058	355	272	-83	291	364	73	42'368	43'414	1'047
2 Ind. Processes (without syn. gases)	1'815	1'904	89	9	7	-2	97	16	-81	1'921	1'927	6
3 Solvent and Other Product Use	NO	195	194.5	0	0	0	124	52	-72	124	247	123
4 Agriculture	IE	IE	---	2'898	2'902	4	2'475	2'479	4	5'372	5'380	8
5 Land-Use Change and Forestry	-1'766	-1'766	0	NO	NO	---	NO	NO	---	-1'766	-1'766	0
6 Waste	1'188	16	-1'171	407	497	91	92	246	154	1'686	760	-927
Sum (without synthetic gases)	42'957	43'127	170	3'669	3'678	9	3'079	3'157	79	49'705	49'962	258

Recalculation	HFC			PFC			SF6			Sum (synthetic gases)		
Emissions for 2003	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)	529	539	10	66	73	7	169	187	18	765	800	35

Recalculation		Sum (all gases)		
Emissions for 2003		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LUCF		**50'469**	**50'762**	**293**
		100.00%	100.58%	0.58%
Total CO_2 eq Em. without LUCF		**52'236**	**52'529**	**293**
		100.00%	100.56%	0.56%

Table 131 Overview of implications of recalculations on 2003 data. Emissions are shown before the recalculation according to the previous submission in 2005 (prev.) and after the recalculation according to the present submission (latest). The differences (Differ.) are defined as latest minus previous submission.

The recalculations result in an increase of the total 2003 emissions in CO_2 equivalents (without CO_2 emissions from LUCF) of 293 Gg CO_2 eq. This corresponds to an increase of the latest submission compared to the previous submission of 0.56% of the national total.

Table 132 shows the recalculation results for the base year 1990. In this case, the recalculations result in an increase of the total emissions in CO_2 equivalents (without CO_2 emissions from LUCF) of 379 Gg CO_2 eq. This corresponds to an increase of the latest submission compared to the previous submission of 0.72% of the national total.

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	40'267	41'251	984	473	535	61	227	259	32	40'968	42'045	1'077
2 Ind. Processes (without syn. gases)	2'841	2'830	-11	9	9	0	99	101	2	2'949	2'940	-9
3 Solvent and Other Product Use	NO	357	357	0	0	0	108	109	2	108	466	359
4 Agriculture	IE	IE	---	3'225	3'229	4	2'857	2'861	4	6'082	6'090	8
5 Land-Use Change and Forestry	-1'273	-1'273	0	NO	NO	---	NO	NO	---	-1'273	-1'273	0
6 Waste	1'264	75	-1'189	743	756	13	54	210	156	2'061	1'041	-1'020
Sum (without synthetic gases)	43'099	43'240	141	4'451	4'529	78	3'344	3'541	196	50'894	51'309	415

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	0	0	100	100	0	179	143	-35	279	244	-35

Recalculation		Sum (all gases)		
Emissions for 1990		Prev.	Latest	Differ.
Source and Sink Categories		CO_2 equivalent (Gg)		
Total CO_2 eq Em. with LUCF		**51'173**	**51'553**	**379**
		100.00%	100.74%	0.74%
Total CO_2 eq Em. without LUCF		**52'446**	**52'826**	**379**
		100.00%	100.72%	0.72%

Table 132 Overview of implications of recalculations on 1990 data. Emissions are shown before the recalculation according to the previous submission in 2005 (prev.) and after the recalculation according to the present submission (latest). The differences (Differ.) are defined as latest minus previous submission.

9.3. Implications for Emissions Trends, including Time Series Consistency

Due to recalculations, the emission trend 1990–2003 reported in the 2005 submission is slightly changed. Compared to 1990, 2003 emissions showed a decrease of -0.40% before recalculation (previous submission). After recalculation, the decrease turns out to be somewhat larger, -0.56% (latest submission). All time series in the present submission are consistent.

Recalculation	**1990**		**2003**		**change 1990/2003**	
submission	previous	latest	previous	latest	previous	latest
unit	CO_2 eq (Gg)				%	
gross CO_2 em. (without LUCF)	52'446	52'826	52'236	52'529	-0.40%	-0.56%

Table 133 Change of the emission trend 1990–2003 due to recalculations

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Annexes

Annex 1: Key Category Analysis and Uncertainty Evaluation (Monte Carlo)

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) and the newly defined source "1A3_o" which is the rest (i.e. includes all sources of 1A3 without 1A3a, 1A3b and 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). A similar partial disaggregation as with Transport has been carried out for CO_2 emissions from Cement Industry (2A1-CO2) which has been separated from the rest (2A1_o). Also CO_2 and PFC emissions from Aluminium Production (2C3-CO2, 2C3-PFC) has been separated from the rest (2C_o). In Consumption of Halocarbons and SF_6 (2F), HFC from Refrigeration and AC Equipment (2F1-HFC) and SF_6 from Electrical Equipment (2F7-SF6) is separated from the rest (2F_o). In Agricultural Soils (4D), N_2O from Direct respectively Indirect soil Emissions (4D1-N2O, 4D3-N2O) is separated from the rest (4D_o).

Results of Key Category Analysis – Level

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***	***52'825.82***	***53'018.68***	***100.00%***		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'332.18	11'363.39	21.43%	21.43%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.62	9'422.83	17.77%	39.21%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'375.39	3'999.73	7.54%	46.75%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'411.97	3'606.74	6.80%	53.55%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	3'392.42	2'911.27	5.49%	59.04%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'766.81	2'515.70	4.74%	63.79%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'364.86	2'249.66	4.24%	68.03%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	1'064.14	2'029.07	3.83%	71.86%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.24	1'925.46	3.63%	75.49%	KC level
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'714.25	3.23%	78.72%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	940.95	1'415.20	2.67%	81.39%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.82	1'223.29	2.31%	83.70%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	849.56	1.60%	85.30%	KC level
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	713.45	727.72	1.37%	86.67%	KC level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	679.25	1.28%	87.96%	KC level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	512.90	668.86	1.26%	89.22%	KC level
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	544.59	1.03%	90.24%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	1'391.18	541.43	1.02%	91.27%	KC level
4B	4. Agriculture	B. Manure Management			CH4	452.34	404.02	0.76%	92.03%	KC level
4B	4. Agriculture	B. Manure Management			N2O	448.20	396.83	0.75%	92.78%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.83	374.20	0.71%	93.48%	KC level
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	348.63	0.66%	94.14%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	156.87	286.36	0.54%	94.68%	KC level
6B	6. Waste	B. Wastewater Handling			N2O	189.40	208.11	0.39%	95.07%	KC level
3	3. Solvent and Other Product Use				CO2	356.97	182.53	0.34%	95.42%	-
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	179.70	0.34%	95.76%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	379.76	177.93	0.34%	96.09%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	155.95	0.29%	96.39%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	143.72	0.27%	96.66%	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	123.97	124.45	0.23%	96.89%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	87.76	117.35	0.22%	97.11%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	112.78	0.21%	97.33%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CO2	129.50	109.49	0.21%	97.53%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	109.07	0.21%	97.74%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.99	105.40	0.20%	97.94%	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	83.29	94.78	0.18%	98.11%	-
6D	6. Waste	D. Other			CH4	30.34	91.38	0.17%	98.29%	-
2F7	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	63.85	86.28	0.16%	98.45%	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	73.91	0.14%	98.59%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	71.84	0.14%	98.72%	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	55.89	0.11%	98.83%	-
3	3. Solvent and Other Product Use				N2O	109.41	50.36	0.09%	98.93%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	50.19	0.09%	99.02%	-
2A_o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.16	44.70	0.08%	99.10%	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F7-SF6			SF6	79.58	39.70	0.07%	99.18%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	57.21	35.18	0.07%	99.25%	-
6B	6. Waste	B. Wastewater Handling			CH4	28.41	32.70	0.06%	99.31%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.29	25.36	0.05%	99.36%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	23.84	0.04%	99.40%	-
6C	6. Waste	C. Waste Incineration			N2O	14.69	23.81	0.04%	99.44%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.29	22.95	0.04%	99.49%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	21.24	21.60	0.04%	99.53%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	7.66	19.70	0.04%	99.57%	-
6D	6. Waste	D. Other			N2O	6.23	18.75	0.04%	99.60%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	11.94	18.28	0.03%	99.64%	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	100.75	16.12	0.03%	99.67%	-
6C	6. Waste	C. Waste Incineration			CO2	52.86	15.30	0.03%	99.70%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	N2O	4.74	15.07	0.03%	99.72%	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	13.60	0.03%	99.75%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	N2O	29.39	12.84	0.02%	99.77%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	11.40	0.02%	99.80%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.07	10.12	0.02%	99.81%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	0.02%	99.83%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	N2O	13.53	9.48	0.02%	99.85%	-
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	5.92	6.36	0.01%	99.88%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	4.53	5.91	0.01%	99.89%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.13	5.15	0.01%	99.90%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CH4	2.39	4.65	0.01%	99.90%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	4.18	4.25	0.01%	99.91%	-
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.96	0.01%	99.92%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	0.01%	99.93%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	2.35	3.60	0.01%	99.93%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	N2O	1.95	3.43	0.01%	99.94%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.16	3.24	0.01%	99.95%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Biomass	CH4	1.73	3.05	0.01%	99.95%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.07	2.57	0.00%	99.96%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.42	0.00%	99.96%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	0.00%	99.97%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.90	1.91	0.00%	99.97%	-

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IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Cumulative Total Column E-L	Result level assessment
						[Gg CO2eq]	[Gg CO2eq]			
TOTAL					***All***	***52'825.82***	***53'018.68***	***100.00%***		
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.40	0.00%	99.97%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	1.47	1.27	0.00%	99.98%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.77	1.27	0.00%	99.98%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.44	1.23	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	1.43	1.17	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.97	1.12	0.00%	99.98%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.07	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.50	1.03	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.86	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.80	0.00%	99.99%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.35	0.79	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.44	0.66	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.56	0.00%	100.00%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.46	0.41	0.00%	100.00%	-
2A_o	2. Industrial Proc.	A. Mineral Products			CH4	0.58	0.39	0.00%	100.00%	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	21.76	0.30	0.00%	100.00%	-
2G	2. Industrial Proc.	G. Other			CH4	0.37	0.24	0.00%	100.00%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.22	0.00%	100.00%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.56	0.21	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.21	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%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.11	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.02	0.09	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.02	0.08	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.06	0.00%	100.00%	-
2G	2. Industrial Proc.	G. Other			CO2	0.05	0.05	0.00%	100.00%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		N2O	0.03	0.02	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%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.00	0.00	0.00%	100.00%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous 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	0.00	NO	0.00%	100.00%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			N2O	0.00	NO	0.00%	100.00%	-
2D	2. Industrial Proc.	D. Other Production			CO2	IE	IE	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 & 2F7-SF6			CO2	0.00	0.00	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%	-

Table 134 Key category analysis 2004 regarding level.

Results of Key Category Analysis – Trend

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***	***52'825.82***	***53'018.68***	***100.00%***		
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	11'332.18	11'363.39	21.43%	21.43%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	10'215.62	9'422.83	17.77%	39.21%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	4'375.39	3'999.73	7.54%	46.75%	KC level
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	2'411.97	3'606.74	6.80%	53.55%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CO2	3'392.42	2'911.27	5.49%	59.04%	KC level
4A	4. Agriculture	A. Enteric Fermentation			CH4	2'766.81	2'515.70	4.74%	63.79%	KC level
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	1'364.86	2'249.66	4.24%	68.03%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CO2	1'064.14	2'029.07	3.83%	71.86%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	1'519.24	1'925.46	3.63%	75.49%	KC level
2A1	2. Industrial Proc.	A. Mineral Products; Cement Production-CO2			CO2	2'524.77	1'714.25	3.23%	78.72%	KC level
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	940.95	1'415.20	2.67%	81.39%	KC level
4D1	4. Agriculture	D. Agricultural Soils; Direct Soil Emissions			N2O	1'389.82	1'223.29	2.31%	83.70%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	691.23	849.56	1.60%	85.30%	KC level
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	713.45	727.72	1.37%	86.67%	KC level
4D3	4. Agriculture	D. Agricultural Soils; Indirect Emissions			N2O	818.89	679.25	1.28%	87.96%	KC level
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	512.90	668.86	1.26%	89.22%	KC level
2F1	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.			HFC	0.02	544.59	1.03%	90.24%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CO2	1'391.18	541.43	1.02%	91.27%	KC level
4B	4. Agriculture	B. Manure Management			CH4	452.34	404.02	0.76%	92.03%	KC level
4B	4. Agriculture	B. Manure Management			N2O	448.20	396.83	0.75%	92.78%	KC level
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	234.83	374.20	0.71%	93.48%	KC level
6A	6. Waste	A. Solid Waste Disposal on Land			CH4	693.04	348.63	0.66%	94.14%	KC level
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	CO2	156.87	286.36	0.54%	94.68%	KC level
6B	6. Waste	B. Wastewater Handling			N2O	189.40	208.11	0.39%	95.07%	KC level
3	3. Solvent and Other Product Use				CO2	356.97	182.53	0.34%	95.42%	-
4D_o	4. Agriculture	D. Agricultural Soils without 4D1-N2O & 4D3-N2O			N2O	200.19	179.70	0.34%	95.76%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CH4	379.76	177.93	0.34%	96.09%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			CO2	112.45	155.95	0.29%	96.39%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CO2	252.55	143.72	0.27%	96.66%	-
1A3d	1. Energy	A. Fuel Combustion	3. Transport; Navigation		CO2	123.97	124.45	0.23%	96.89%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	N2O	87.76	117.35	0.22%	97.11%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	48.42	112.78	0.21%	97.33%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		CO2	129.50	109.49	0.21%	97.53%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CO2	200.04	109.07	0.21%	97.74%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CO2	46.99	105.40	0.20%	97.94%	-
1A3c	1. Energy	A. Fuel Combustion	3. Transport; Railways		CO2	83.29	94.78	0.18%	98.11%	-
6D	6. Waste	D. Other			CH4	30.34	91.38	0.17%	98.29%	-
2F7	2. Industrial Proc.	F. Consumption of Halocarbons and SF6; Electrical Eq.			SF6	63.85	86.28	0.16%	98.45%	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC			HFC	0.00	73.91	0.14%	98.59%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-CO2			CO2	139.26	71.84	0.14%	98.72%	-
2F	2. Industrial Proc.	F. Consumption of Halocarbons and SF6			PFC	0.04	55.89	0.11%	98.83%	-
3	3. Solvent and Other Product Use				N2O	109.41	50.36	0.09%	98.93%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			SF6	0.00	50.19	0.09%	99.02%	-
2A_o	2. Industrial Proc.	A. Mineral Products without Cement Production-CO2			CO2	40.16	44.70	0.08%	99.10%	-
2F_o	2. Industrial Proc.	F. Consumption of Halocarbons and SF6 without 2F7-SF6			SF6	79.58	39.70	0.07%	99.18%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CO2	57.21	35.18	0.07%	99.25%	-
6B	6. Waste	B. Wastewater Handling			CH4	28.41	32.70	0.06%	99.31%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CO2	40.29	25.36	0.05%	99.36%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	N2O	25.84	23.84	0.04%	99.40%	-
6C	6. Waste	C. Waste Incineration			N2O	14.69	23.81	0.04%	99.44%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	91.29	22.95	0.04%	99.49%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	CH4	21.24	21.60	0.04%	99.53%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	N2O	7.66	19.70	0.04%	99.57%	-
6D	6. Waste	D. Other			N2O	6.23	18.75	0.04%	99.60%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	CH4	11.94	18.28	0.03%	99.64%	-
2B	2. Industrial Proc.	B. Chemical Industry			N2O	100.75	16.12	0.03%	99.67%	-
6C	6. Waste	C. Waste Incineration			CO2	52.86	15.30	0.03%	99.70%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Other Fuels	N2O	4.74	15.07	0.03%	99.72%	-
2B	2. Industrial Proc.	B. Chemical Industry			CO2	13.60	13.60	0.03%	99.75%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	N2O	29.39	12.84	0.02%	99.77%	-
2C3	2. Industrial Proc.	C. Metal Production; Aluminium Production-PFC			PFC	100.17	11.40	0.02%	99.80%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	N2O	11.07	10.12	0.02%	99.81%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			CH4	10.00	10.00	0.02%	99.83%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	N2O	13.53	9.48	0.02%	99.85%	-
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	5.92	6.36	0.01%	99.88%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	N2O	4.53	5.91	0.01%	99.89%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CH4	3.13	5.15	0.01%	99.90%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	CH4	2.39	4.65	0.01%	99.90%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Biomass	N2O	4.18	4.25	0.01%	99.91%	-
6C	6. Waste	C. Waste Incineration			CH4	3.96	3.96	0.01%	99.92%	-
4F	4. Agriculture	F. Field Burning of Agricultural Residues			N2O	3.91	3.91	0.01%	99.93%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Biomass	N2O	2.35	3.60	0.01%	99.93%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	N2O	1.95	3.43	0.01%	99.94%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CH4	2.16	3.24	0.01%	99.95%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Biomass	CH4	1.73	3.05	0.01%	99.95%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	N2O	2.07	2.57	0.00%	99.96%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CH4	5.83	2.42	0.00%	99.96%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Solid Fuels	CH4	3.83	2.36	0.00%	99.97%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		N2O	1.90	1.91	0.00%	99.97%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.40	0.00%	99.97%	-

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IPCC Source Categories (and fuels if applicable)					Direct GHG	Base Year 1990 Estimate	Year t Estimate	Level Assessment	Cumulative Total Column E-L	Result level assessment
						[Gg CO2eq]	[Gg CO2eq]			
TOTAL					***All***	***52'825.82***	***53'018.68***	***100.00%***		
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		N2O	2.46	1.40	0.00%	99.97%	-
1A5	1. Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CH4	1.47	1.27	0.00%	99.98%	-
1A4b	1. Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	N2O	0.77	1.27	0.00%	99.98%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CH4	1.44	1.23	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Gaseous Fuels	N2O	1.43	1.17	0.00%	99.98%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Liquid Fuels	CH4	1.97	1.12	0.00%	99.98%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		N2O	1.97	1.07	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CH4	2.50	1.03	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CH4	0.54	0.86	0.00%	99.99%	-
1A4a	1. Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	N2O	0.53	0.80	0.00%	99.99%	-
1A3b	1. Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CH4	1.35	0.79	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CH4	0.44	0.66	0.00%	99.99%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	N2O	0.25	0.56	0.00%	100.00%	-
1A3_o	1. Energy	A. Fuel Combustion	3. Transport without 3a, 3b & 3e		CH4	0.46	0.41	0.00%	100.00%	-
2A_o	2. Industrial Proc.	A. Mineral Products			CH4	0.58	0.39	0.00%	100.00%	-
6A	6. Waste	A. Solid Waste Disposal on Land			CO2	21.76	0.30	0.00%	100.00%	-
2G	2. Industrial Proc.	G. Other			CH4	0.37	0.24	0.00%	100.00%	-
1A3a	1. Energy	A. Fuel Combustion	3. Transport; Civil Aviation		CH4	0.24	0.22	0.00%	100.00%	-
1A2	1. Energy	A. Fuel Combustion	2. Manufacturing Industries and Construct	Solid Fuels	CH4	0.56	0.21	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	N2O	0.13	0.21	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%	-
1A3e	1. Energy	A. Fuel Combustion	3. Transport; Other Transportation (military aviation)		CH4	0.16	0.11	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	N2O	0.02	0.09	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Biomass	CH4	0.02	0.08	0.00%	100.00%	-
1A1	1. Energy	A. Fuel Combustion	1. Energy Industries	Solid Fuels	CH4	0.10	0.06	0.00%	100.00%	-
2G	2. Industrial Proc.	G. Other			CO2	0.05	0.05	0.00%	100.00%	-
1B2	1. Energy	B. Fugitive Emissions f	2. Oil and Natural Gas		N2O	0.03	0.02	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%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous Fuels	CH4	0.00	0.00	0.00%	100.00%	-
1A4c	1. Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Gaseous 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	0.00	NO	0.00%	100.00%	-
2C_o	2. Industrial Proc.	C. Metal Production without Aluminium Production			N2O	0.00	NO	0.00%	100.00%	-
2D	2. Industrial Proc.	D. Other Production			CO2	IE	IE	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 & 2F7-SF6			CO2	0.00	0.00	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%	-

Table 135 Key category analysis 2004 regarding trend.

List of Key Categories

No.	IPCC Source Categories (and fuels if applicable)			Direct GHG	1990 Gg CO2 eq	2004 Gg CO2 eq	Contribut. Level	Contrib. Trend	Result level assessment	Result trend assessment
1	1A1	1A. Fuel Combustion	Gaseous Fuels	CO2	234.8	374.2	0.71%	1.2%	KC level	KC trend
2	1A1	1A. Fuel Combustion	Liquid Fuels	CO2	691.2	849.6	1.60%	1.4%	KC level	KC trend
3	1A1	1A. Fuel Combustion	Other Fuels	CO2	1'519.2	1'925.5	3.63%	3.6%	KC level	KC trend
4	1A1	1A. Fuel Combustion	Other Fuels	N2O	48.4	112.8	0.21%	0.6%	-	KC trend
5	1A1	1A. Fuel Combustion	Solid Fuels	CO2	47.0	105.4	0.20%	0.5%	-	KC trend
6	1A2	1A. Fuel Combustion	Gaseous Fuels	CO2	1'064.1	2'029.1	3.83%	8.6%	KC level	KC trend
7	1A2	1A. Fuel Combustion	Liquid Fuels	CO2	3'392.4	2'911.3	5.49%	4.4%	KC level	KC trend
8	1A2	1A. Fuel Combustion	Other Fuels	CO2	156.9	286.4	0.54%	1.2%	KC level	KC trend
9	1A2	1A. Fuel Combustion	Solid Fuels	CO2	1'391.2	541.4	1.02%	7.6%	KC level	KC trend
10	1A3a	1A. Fuel Combustion		CO2	252.6	143.7	0.27%	1.0%	-	KC trend
11	1A3b	1A. Fuel Combustion	Diesel	CO2	2'412.0	3'606.7	6.80%	10.6%	KC level	KC trend
12	1A3b	1A. Fuel Combustion	Gasoline	CO2	11'332.2	11'363.4	21.43%	0.1%	KC level	-
13	1A3b	1A. Fuel Combustion	Gasoline	CH4	91.3	22.9	0.04%	0.6%	-	KC trend
14	1A3e	1A. Fuel Combustion		CO2	200.0	109.1	0.21%	0.8%	-	KC trend
15	1A4a	1A. Fuel Combustion	Gaseous Fuels	CO2	941.0	1'415.2	2.67%	4.2%	KC level	KC trend
16	1A4a	1A. Fuel Combustion	Liquid Fuels	CO2	4'375.4	3'999.7	7.54%	3.5%	KC level	KC trend
17	1A4b	1A. Fuel Combustion	Gaseous Fuels	CO2	1'364.9	2'249.7	4.24%	7.9%	KC level	KC trend
18	1A4b	1A. Fuel Combustion	Liquid Fuels	CO2	10'215.6	9'422.8	17.77%	7.4%	KC level	KC trend
19	1A4c	1A. Fuel Combustion	Liquid Fuels	CO2	713.4	727.7	1.37%	0.1%	KC level	-
20	1A5	1A. Fuel Combustion	Liquid Fuels	CO2	512.9	668.9	1.26%	1.4%	KC level	KC trend
21	1B2	1B. Fugitive Emissions from Fuels		CH4	379.8	177.9	0.34%	1.8%	-	KC trend
22	2A1	2A. Mineral Products; Cement Production-CO2		CO2	2'524.8	1'714.2	3.23%	7.3%	KC level	KC trend
23	2B	2B. Chemical Industry		N2O	100.8	16.1	0.03%	0.8%	-	KC trend
24	2C3	2C. Metal Production; Aluminium Production-PFC		PFC	100.2	11.4	0.02%	0.8%	-	KC trend
25	2C3	2C. Metal Production; Aluminium Production-CO2		CO2	139.3	71.8	0.14%	0.6%	-	KC trend
26	2F	2F. Consumption of Halocarbons and SF6		PFC	0.0	55.9	0.11%	0.5%	-	KC trend
27	2F_o	2F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	0.0	73.9	0.14%	0.7%	-	KC trend
28	2F1	2F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	0.0	544.6	1.03%	4.9%	KC level	KC trend
29	3	3. Solvent and Other Product Use		CO2	357.0	182.5	0.34%	1.6%	-	KC trend
30	3	3. Solvent and Other Product Use		N2O	109.4	50.4	0.09%	0.5%	-	KC trend
31	4A	4A. Enteric Fermentation		CH4	2'766.8	2'515.7	4.74%	2.3%	KC level	KC trend
32	4B	4B. Manure Management		N2O	448.2	396.8	0.75%	0.5%	KC level	KC trend
33	4B	4B. Manure Management		CH4	452.3	404.0	0.76%	0.4%	KC level	-
34	4D1	4D. Agricultural Soils; Direct Soil Emissions		N2O	1'389.8	1'223.3	2.31%	1.5%	KC level	KC trend
35	4D3	4D. Agricultural Soils; Indirect Emissions		N2O	818.9	679.3	1.28%	1.3%	KC level	KC trend
36	6A	6A. Solid Waste Disposal on Land		CH4	693.0	348.6	0.66%	3.1%	KC level	KC trend
37	6B	6B. Wastewater Handling		N2O	189.4	208.1	0.39%	0.2%	KC level	-
38	6D	6D. Other		CH4	30.3	91.4	0.17%	0.5%	-	KC trend

Table 136 Key categories in Switzerland 2004 (sorted according to source category).

A1.2 Uncertainty Evaluation Tier 2 (Monte Carlo Simulation)

The uncertainty analysis presented in this paragraph is not based on the data of the current GHG inventory (May 2006) but on the data submitted in April 2006 (FOEN 2006a) as explained in Chapter 1.7 (on the level of the emissions, the modifications carried out since the April submission are modest).

A1.2.1 Assumptions for probability distribution and correlations

IPPC Source Category		Fuel	Gas	Probability Distribution		
				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	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	---
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	---	lognormal
1A3e	3. Transport; Other Transportation (mil. aviation)	Liquid Fuels	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	---
1B2	2. Oil and Natural Gas		CH4	---	---	normal
2A1	A. Mineral Products; Cement Production-CO2		CO2	normal	normal	---
2B	B. Chemical Industry		N2O	normal	normal	---
2C3	C. Metal Production; Aluminium Production-PFC		PFC	---	---	normal
2C3	C. Metal Production; Aluminium Production-CO2		CO2	---	---	normal
2F	F. Consumption of Halocarbons and SF6		PFC	---	---	normal
2F1	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	---	---	normal
2F_o	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	---	---	normal
3	Solvent and Other Product Use		CO2	---	---	normal
			N2O	---	---	normal
4A	A. Enteric Fermentation		CH4	---	---	normal
4B	B. Manure Management		CH4	---	---	normal
4B	B. Manure Management		N2O	---	---	lognormal
4D1	D. Agricultural Soils; Direct Soil Emissions		N2O	---	---	lognormal
4D3	D. Agricultural Soils; Indirect Emissions		N2O	---	---	lognormal
6A	A. Solid Waste Disposal on Land		CH4	---	---	normal
6D	D. Other		CH4	---	---	normal

Table 137 Probability distribution assigned to activity data, emission factors and emissions (both years).

Emission Factors																										
IPPC Source Category					Gas		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1A1	Energy	A. Fuel Combustion	1. Energy Industries	Gaseous Fuels	CO2	1	1																			
1A1	Energy	A. Fuel Combustion	1. Energy Industries	Liquid Fuels	CO2	2		1																		
1A1	Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	CO2	3			1																	
1A1	Energy	A. Fuel Combustion	1. Energy Industries	Other Fuels	N2O	4			0.8	1																
1A2	Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	5	1				1															
1A2	Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	6		0.7				1														
1A2	Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Other Fuels	CO2	7							1													
1A2	Energy	A. Fuel Combustion	2. Manufacturing Industries and Construction	Solid Fuels	CO2	8								1												
1A3b	Energy	A. Fuel Combustion	3. Transport; Road Transportation	Diesel	CO2	9									1											
1A3b	Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CO2	10									0.7	1										
1A3b	Energy	A. Fuel Combustion	3. Transport; Road Transportation	Gasoline	CH4	11										0.8	1									
1A3e	Energy	A. Fuel Combustion	3. Transport; Other Transportation (mil. aviation)	Liquid Fuels	CO2	12												1								
1A4a	Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	13	1				1								1							
1A4a	Energy	A. Fuel Combustion	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	14		0.7				0.9								1						
1A4b	Energy	A. Fuel Combustion	4. Other Sectors; Residential	Gaseous Fuels	CO2	15	1				1								1		1					
1A4b	Energy	A. Fuel Combustion	4. Other Sectors; Residential	Liquid Fuels	CO2	16		0.7				0.9										1				
1A4c	Energy	A. Fuel Combustion	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	17		0.7				0.9										0.9	1			
1A5	Energy	A. Fuel Combustion	5. Other	Liquid Fuels	CO2	18		0.3							0.9	0.5						0.5	0.9	1		
2A1	Ind. Proc.	A. Mineral Products; Cement Production-CO2			CO2	19																			1	
2B	Ind. Proc.	B. Chemical Industry			N2O	20																				1

Table 138 Correlation coefficients of emission factors.

Emissions																				
IPPC Source Category				Gas		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1B2	Energy	B. Fugitive Emissions from Fuels	2. Oil and Natural Gas	CH4	1	1														
2C3	Ind. Proc.	C. Metal Production; Aluminium Production-PFC		PFC	2		1													
2C3	Ind. Proc.	C. Metal Production; Aluminium Production-CO2		CO2	3		1	1												
2F	Ind. Proc.	F. Consumption of Halocarbons and SF6		PFC	4		-0.5		1											
2F1	Ind. Proc.	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	5					1										
2F_o	Ind. Proc.	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	6					-0.5	1									
3	Solvent and Other Product Use			CO2	7							1								
3	Solvent and Other Product Use			N2O	8								1							
4A	Agriculture	A. Enteric Fermentation		CH4	9									1						
4B	Agriculture	B. Manure Management		CH4	10									1	1					
4B	Agriculture	B. Manure Management		N2O	11									1	1	1				
4D1	Agriculture	D. Agricultural Soils; Direct Soil Emissions		N2O	12												1			
4D3	Agriculture	D. Agricultural Soils; Indirect Emissions		N2O	13												0.7	1		
6A	Waste	A. Solid Waste Disposal on Land		CH4	14														1	
6D	6. Waste	D. Other		CH4	15															1

Table 139 Correlation coefficients of emissions.

A1.2.2 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

$$\mathrm{V} = \frac{\mathrm{s}}{\mathrm{AD}}, \tag{1}$$

[AD] = [s] = 1 TJ/a; for normal distributions,

$$U = t_{95\%}\,\frac{s}{AD}; \quad t_{95\%} \approx 2 \tag{1a}$$

Activity Data

The total AD of each fuel type is derived based on the following key source categories

gaseous: $AD_{1A}^{g} = AD_{1A1} + AD_{1A2} + AD_{1A4a} + AD_{1A4b}$

liquid (stationary): $\mathrm{AD}_{1A}^{ls} = AD_{1A1} + AD_{1A2} + AD_{1A4a} + AD_{1A4b} + AD_{1A4c}$ (2)

liquid (mobile): $\mathrm{AD}_{1A}^{lm} = AD_{1A3b} + AD_{1A3e} + AD_{1A5}$

other fuels: $AD_{1A}^{o} = AD_{1A1} + AD_{1A2}$

Note that only key categories are included in the Monte Carlo simulation. Therefore, non-key categories like 1Ac Railways, 1A3d Navigation are excluded from these considerations.

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):

$$U_{1A}^{g} = 2V_{1A}^{g} = 5\%, \quad U_{1A}^{ls} = U_{1A}^{lm} = 2V_{1A}^{ls} = 2V_{1A}^{lm} = 1.4\%, \quad U_{1A}^{o} = 2V_{1A}^{o} = 10\% \tag{3}$$

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.

$$U_{1A1}^{g} = 5\%, \quad U_{1A1}^{ls} = U_{1A1}^{lm} = 1.4\%, \quad U_{1A1}^{o} = 10\% \tag{4}$$

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, personal communications), the standard deviation may be set proportional to the activity data AD of the sub-sector:

$$s_i^{(f)} = \alpha^{(f)} \cdot AD_i\,, \tag{5}$$

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

$$\alpha^{(f)} = \frac{s_i^{(f)}}{AD_i^{(f)}} = \frac{s_{1A2}^{(f)}}{AD_{1A2}^{(f)}} = \frac{s_{1A4a}^{(f)}}{AD_{1A4a}^{(f)}} = \ldots = V_i^{(f)} = \frac{1}{2}U_i^{(f)} \tag{6}$$

The constants $\alpha^{(f)}$ can be determined using the formula for simple error propagation (Gauss)

$$s_{1A}^{(f)2} = s_{1A1}^{(f)2} + \sum_i s_i^{(f)2} = s_{1A1}^{(f)2} + \left(\alpha^{(f)}\right)^2 \cdot \sum_i AD_i^{(f)2} \tag{7}$$

With $V_{1A1}^{(f)} = V_{1A}^{(f)}$ and Eq. (6), Eq. (7) can be rewritten as

$$\left(\alpha^{(f)}\right)^2 = \left(V_{1A}^{(f)}\right)^2 \cdot \frac{AD_{1A}^{(f)2} - AD_{1A1}^{(f)2}}{\sum_i AD_i^{(f)2}} \tag{8}$$

Applied to the three fuel types

$$\begin{aligned}
\left(\alpha^{g}\right)^2 &= \left(V_{1A}^{g}\right)^2 \cdot \frac{\left(AD_{1A}^{g}\right)^2 - AD_{1A1}^2}{AD_{1A2}^2 + AD_{1A4a}^2 + AD_{1A4b}^2} \\
\left(\alpha^{ls}\right)^2 &= \left(V_{1A}^{ls}\right)^2 \cdot \frac{\left(AD_{1A}^{ls}\right)^2 - AD_{1A1}^2}{AD_{1A2}^2 + AD_{1A4a}^2 + AD_{1A4b}^2 + AD_{1A4c}^2} \\
\left(\alpha^{lm}\right)^2 &= \left(V_{1A}^{lm}\right)^2 \cdot \frac{\left(AD_{1A}^{lm}\right)^2}{AD_{1A3b}^2 + AD_{1A3e}^2 + AD_{1A5}^2} \\
\left(\alpha^{o}\right)^2 &= \left(V_{1A}^{o}\right)^2 \cdot \frac{\left(AD_{1A}^{o}\right)^2 - AD_{1A2}^2}{AD_{1A2}^2}
\end{aligned} \tag{9}$$

The uncertainties for sub-sectors other than 1A1 may then be derived from equations (6) and (9). In our case, this yields (see Table 140 for input values)

$$\begin{aligned}
U^{g} &= 2\alpha^{g} = 0.181 = 9.1\% \\
U^{ls} &= 2\alpha^{ls} = 0.024 = 2.3\% \\
U^{lm} &= 2\alpha^{lm} = 0.018 = 1.8\% \\
U^{o} &= 2\alpha^{o} = 0.397 = 39.7\%
\end{aligned} \tag{10}$$

Source category		**Activity data 2004 (TJ)**				**Uncertainty of activity data U**			
		gaseous	liquid (s)	liquid (m)	other	gaseous	liquid (s)	liquid (m)	other
1A	Fuel Combustion	112'013	247'774	214'526	48'387	5.0%	1.4%	1.4%	10.0%
1A1	En. Industries	6'854	14'914	---	42'601	5.0%	1.4%	---	10.0%
				expansion factors		*1.81*	*1.70*	*1.32*	*3.97*
1A2	Manufacturing Ind. + Construc	37'290	39'540	---	5'786	9.1%	2.3%	---	39.7%
1A3b	Road Transportation, diesel	---	---	49'223	---	---	---	1.8%	---
1A3b	Road Transportation, gasoline	---	---	154'618	---	---	---	1.8%	---
1A3e	Military Aviation	---	---	1'490	---	---	---	1.8%	---
1A4a	Other sectors Comm./Institutic	26'209	55'037	---	---	9.1%	2.3%	---	---
1A4b	Other sectors Residential	41'660	128'400	---	---	9.1%	2.3%	---	---
1A4c	Other sectors Agricuture	---	9'883	---	---	---	2.3%	---	---
1A5	Others (Off-road)	---	---	9'195	---	---	---	1.8%	---

Table 140 Activity data and uncertainties key categories in 1A Fuel Combustion due to the data of submission April 2006.

In Table 140, so called expansion factor $\varepsilon^{(f)}$ 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

$$\varepsilon^{(f)} = \frac{U_{1A2}^{(f)}}{U_{1A}^{(f)}} = \frac{U_{1A4a}^{(f)}}{U_{1A}^{(f)}} = \frac{U_{1A4b}^{(f)}}{U_{1A}^{(f)}} \tag{11}$$

A1.2.3 Further Results of the Monte Carlo Uncertainty Analysis

In addition to the results of Table 12, Table 141 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” (source categories 1A, 1B, 2A, 2B). In the other cases (2C, 2F etc.), the uncertainty of the emission is an input data for the Monte Carlo simulation.

IPPC Source Category			Gas	Activity Data year t (2004)		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	6'854	TJ	4.9	55	t/TJ	4.5	377	6.7
1A1	1. Energy Industries	Liquid Fuels	CO2	14'914	TJ	1.3	64	t/TJ	0.5	955	1.5
1A1	1. Energy Industries	Other Fuels	CO2	42'601	TJ	9.8	45	t/TJ	29.4	1'925	31.0
1A1	1. Energy Industries	Other Fuels	N2O	42'601	TJ	9.8	3	t/TJ	78.4	113	79.2
1A2	2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	37'290	TJ	8.9	55	t/TJ	4.5	2'051	10.0
1A2	2. Manufacturing Industries and Construction	Liquid Fuels	CO2	39'540	TJ	2.3	74	t/TJ	0.5	2'926	2.4
1A2	2. Manufacturing Industries and Construction	Other Fuels	CO2	5'786	TJ	38.9	49	t/TJ	29.4	286	49.0
1A2	2. Manufacturing Industries and Construction	Solid Fuels	CO2	5'651	TJ	18.0	94	t/TJ	4.9	532	18.7
1A3b	3. Transport; Road Transportation	Diesel	CO2	49'223	TJ	1.8	74	t/TJ	0.5	3'623	1.9
1A3b	3. Transport; Road Transportation	Gasoline	CO2	154'618	TJ	1.8	74	t/TJ	0.5	11'426	1.9
1A3b	3. Transport; Road Transportation	Gasoline	CH4	154'618	TJ	1.8	0.1	t/TJ	0.0	23	58.8
1A3e	3. Transport; Other Transportation (mil. aviation)	Liquid Fuels	CO2	1'490	TJ	1.8	73	t/TJ	0.5	109	1.9
1A4a	4. Other Sectors; Commercial/Institutional	Gaseous Fuels	CO2	26'209	TJ	8.9	55	t/TJ	4.5	1'441	10.0
1A4a	4. Other Sectors; Commercial/Institutional	Liquid Fuels	CO2	55'037	TJ	2.3	74	t/TJ	0.5	4'046	2.3
1A4b	4. Other Sectors; Residential	Gaseous Fuels	CO2	41'660	TJ	8.9	55	t/TJ	4.5	2'291	10.0
1A4b	4. Other Sectors; Residential	Liquid Fuels	CO2	128'400	TJ	2.3	74	t/TJ	0.5	9'438	2.4
1A4c	4. Other Sectors; Agriculture/Forestry	Liquid Fuels	CO2	9'883	TJ	2.3	74	t/TJ	0.5	728	2.4
1A5	5. Other	Liquid Fuels	CO2	9'195	TJ	1.8	73	t/TJ	0.5	671	1.9
1B	B. Fugitive Emissions from Fuels										
1B2	2. Oil and Natural Gas		CH4	--	--	--	--	--	--	183	49.0
2	Industrial Processes										
2A1	A. Mineral Products; Cement Production-CO2		CO2	3'265	kt	2.0	0.5	t/t	5.9	1'714	6.2
2B	B. Chemical Industry		N2O	65	kt	9.8	0.2	t/t	39.2	16	40.5
2C3	C. Metal Production; Aluminium Production-PFC		PFC	--	--	--	--	--	--	11	48.0
2C3	C. Metal Production; Aluminium Production-CO2		CO2	--	--	--	--	--	--	70	29.8
2F	F. Consumption of Halocarbons and SF6		PFC	--	--	--	--	--	--	56	17.2
2F1	F. Consumption of Halocarbons and SF6; Refrig. & AC Eq.		HFC	--	--	--	--	--	--	545	13.5
2F_o	F. Consumption of Halocarbons and SF6 without 2F1-HFC		HFC	--	--	--	--	--	--	74	21.4
3	Solvent and Other Product Use		CO2	--	--	--	--	--	--	122	49.0
			N2O	--	--	--	--	--	--	50	78.4
4	Agriculture										
4A	A. Enteric Fermentation		CH4	--	--	--	--	--	--	2'492	23.2
4B	B. Manure Management		CH4	--	--	--	--	--	--	400	40.7
4B	B. Manure Management		N2O	--	--	--	--	--	--	397	72.7
4D1	D. Agricultural Soils; Direct Soil Emissions		N2O	--	--	--	--	--	--	1'208	78.8
4D3	D. Agricultural Soils; Indirect Emissions		N2O	--	--	--	--	--	--	683	93.2
6	Waste										
6A	A. Solid Waste Disposal on Land		CH4	--	--	--	--	--	--	349	58.8
6D	D. Other		CH4	--	--	--	--	--	--	91	49.0
	Other			--	--	--	--	--	--	1'612	39.2
Total				--	--	--	--	--	--	53'034	3.97

Table 141 Activity data, emission factors, emissions (all data taken from the submission of April 2006) and their corresponding uncertainties of key categories in Monte Carlo simulation (to be compared with Table 9).

Annex 2: Energy

A2.1 Swiss Energy Flux

The diagram shows a summary of the Swiss energy flux 2004 as published by the Swiss Federal Office of Energy (SFOE 2005). The diagram languages are German and French.

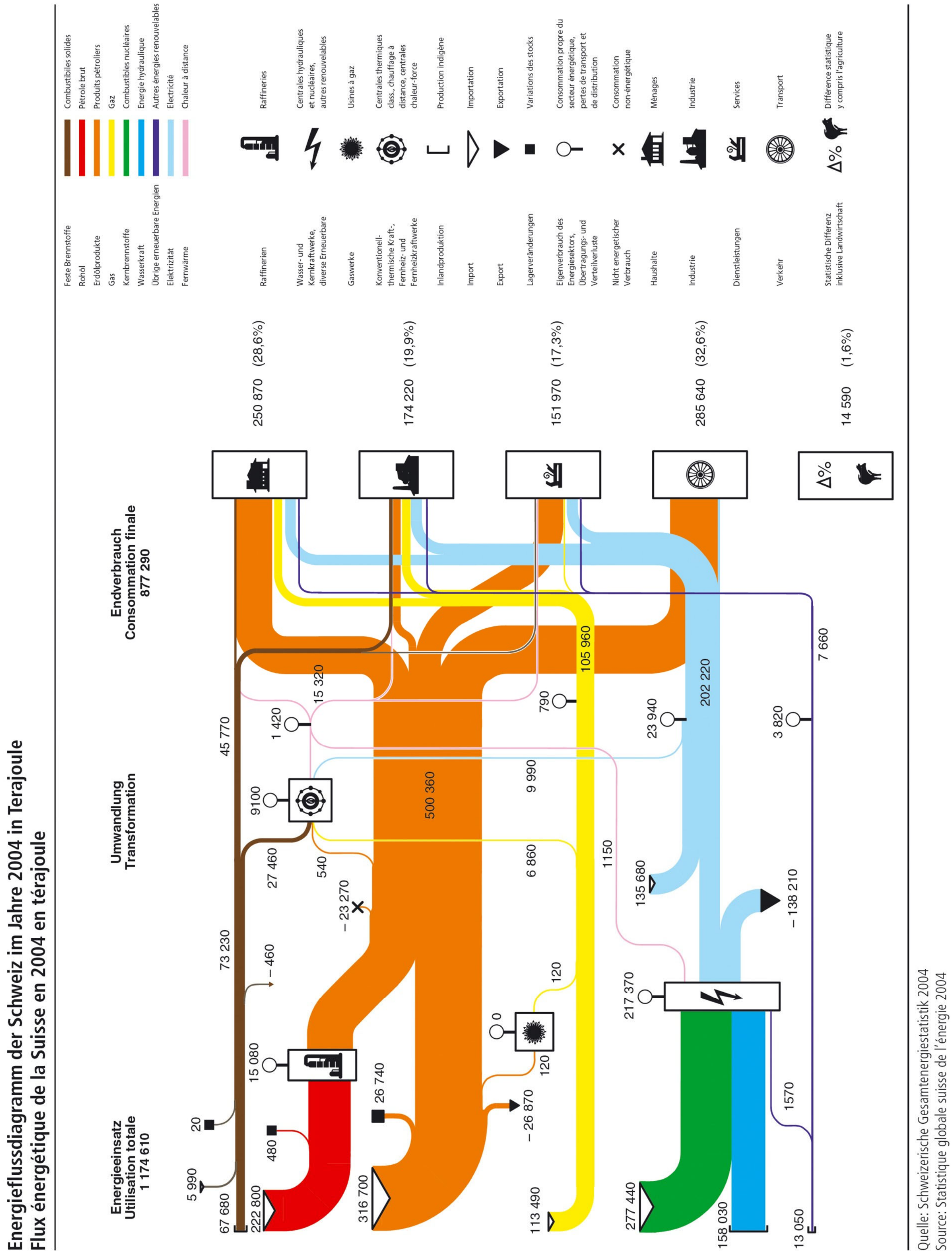

Figure 35 Energy flux in Switzerland 2004 (SFOE 2005)

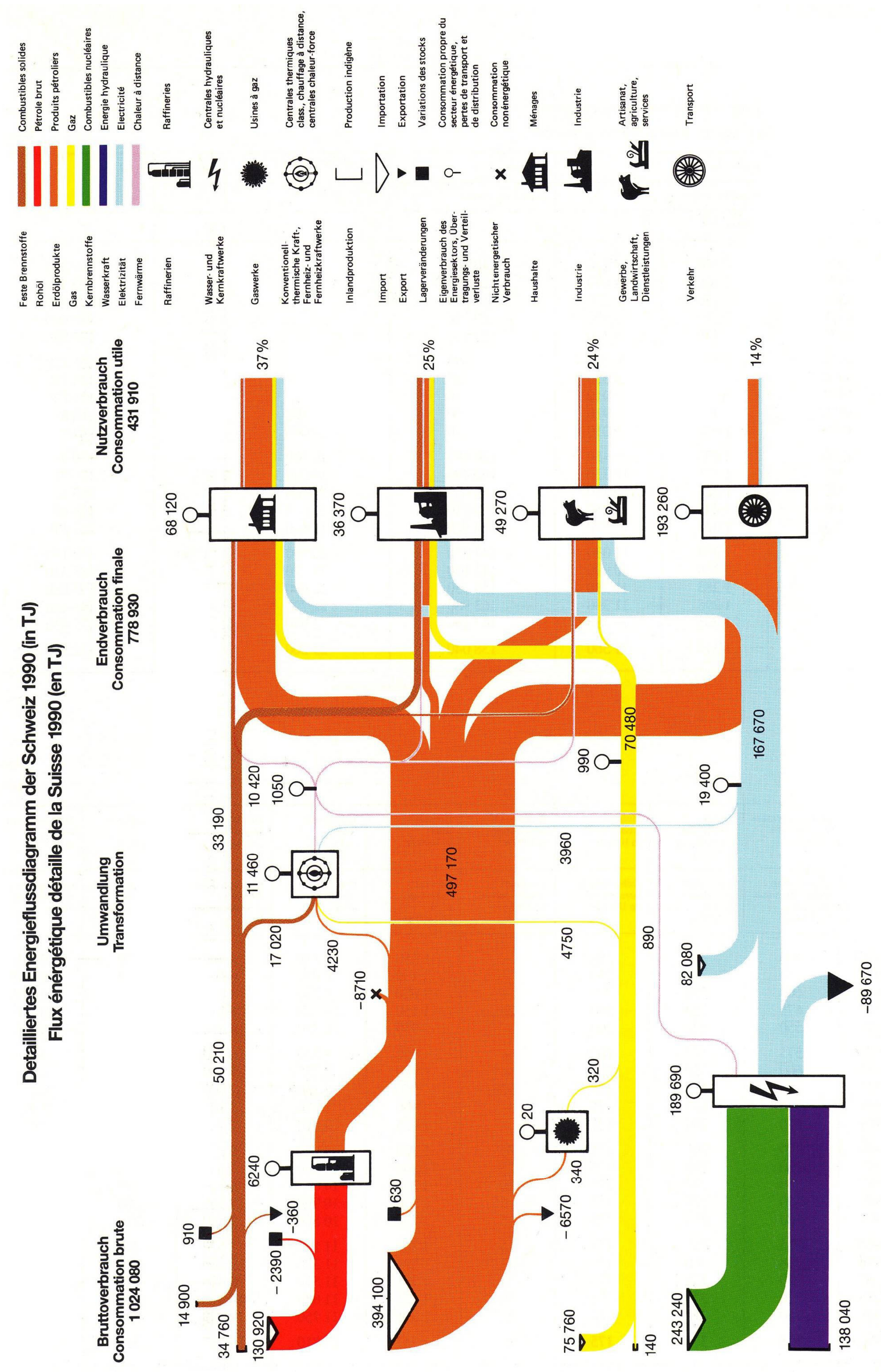

Figure 36 Energy flux in Switzerland 1990 (SFOE 1990)

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
b) CO_2 emission factors of the fuels
c) Swiss overall energy statistics 2004 (SFOE 2005).

A2.2.1 Net calorific values (energy content) and density of fossil fuels

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

Table 142 Note that the NCV for coal has been changed from 28.1 GJ/t to 26.3 GJ/t (see below).

Note that the NCV for hard coal has been changed since the submission 2005 from 28.1 GJ/t to 26.3 GJ/t. Consultations with the Swiss Federal Office of Energy and with importers of coal showed that the previous NCV of 28.1 GJ/t stems from the 70ies or 80ties and is outdated. It is not representative for the coal as it has been used since 1990, which was used primarily in cement industry. Therefore from data on coal, Coke and P-coke usage from the Swiss cement industry (Cemsuisse 2004) and from the Swiss overall energy statistics (SFOE 2005) has been used to determine the corrected NCV of coal of 26.3 GJ/t.

Because the consumption of coal in Switzerland has decreased significantly in Switzerland since 1990, the reduction of the coal NCV (and therefore of the related GHG emissions) is conservative.

The NCV of fossil fuels is assumed to be constant for the period 1990 to 2004.

A2.2.2 CO_2 emission factors of fossil fuels

	CO_2 Emission Factor		
Fuel	t CO_2 / TJ	t CO_2 / t	t CO_2 / volume
Hard Coal	94.0	2.64	---
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

Table 143 CO_2 emission factors. 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 2004.

A2.3 Sulphur Dioxide (SO_2)

year	maximum legal limit of sulphur content					
	Diesel oil ppm	Gasoline ppm	Gas oil ppm	Natural gas ppm	Res. fuel oil %	Coal %
1990	1400	200	2000	190	1.0	1.0
1991	1300	200	2000	190	1.0	1.0
1992	1200	200	2000	190	1.0	1.0
1993	1000	200	2000	190	1.0	1.0
1994	500	200	2000	190	1.0	1.0
1995	500	200	2000	190	1.0	1.0
1996	500	200	2000	190	1.0	1.0
1997	500	200	2000	190	1.0	1.0
1998	500	200	2000	190	1.0	1.0
1999	500	200	2000	190	1.0	1.0
2000	350	150	2000	190	1.0	1.0
2001	350	150	2000	190	1.0	1.0
2002	350	150	2000	190	1.0	1.0
2003	350	150	2000	190	1.0	1.0
2004	350	150	2000	190	1.0	1.0

year	Effective sulphur content					
	Diesel oil ppm	Gasoline ppm	Gas oil ppm	Natural gas ppm	Res. fuel oil %	Coal %
1990	1400	200	1600	11.6	0.97	0.9
1991	1300	200	1300	11.6	0.89	0.9
1992	1200	200	1200	11.6	0.86	0.9
1993	1000	200	1000	11.6	0.87	0.9
1994	434	200	1350	11.6	0.77	0.9
1995	341	200	1170	11.6	0.78	0.9
1996	372	200	1160	11.6	0.78	0.9
1997	353	200	1250	11.6	0.70	0.9
1998	402	200	926	11.6	0.83	0.9
1999	443	200	650	11.6	0.62	0.9
2000	272	142	680	11.6	0.66	0.9
2001	250	121	830	11.6	0.82	0.9
2002	235	101	798	11.6	0.82	0.9
2003	200	81	700	11.6	0.79	0.9
2004	10	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

Table 144 Sulphur content and SO_2 emission factors. For explanations see next page.

Explanation to the table

- For liquid and solid fuels the SO_2 emission factors are determined by the sulphur content. The table on the top shows the maximum values due to the Federal Ordinance on Air Pollution Control (OAPC 2004, annex 5)
- The table in the middle contains 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 table at the bottom gives 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

$$\boxed{\frac{M_{SO_2}}{M_S}\frac{S}{NCV} = 2\frac{S}{NCV}}$$

- Note on the effective sulphur content of coal: Because the net calorific value of coal had been revised in the present submission (see Section A2.2.1 above) and simultaneously, the absolute sulphur content (350 kg/TJ) is still correct, the relative sulphur content had to be corrected from 0.8% (as given in the previous submission) to the new value of 0.9% (1990-2004).

A2.4 Emissions from Fuel Consumption

A2.4.1 Disaggregation of Fuel Consumption

Swiss global energy statistics 2004

The consumption of Solid, Liquid, Gaseous and Other Fuels in the Swiss global energy statistics 2004 (SFOE 2005) 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 global 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 global 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 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 2004 of Basics (Basics 2006) 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 2004), industry data from annual reports, fuel supply data from CARBURA for 1985 to 2004, 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 2005) provided the basis to estimate the fuel consumption of the services and institutional sector in Switzerland from 1990 to 2004. 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 global energy statistics. The model output is used as a proxy to distribute the total consumption from the Swiss global energy statistics between CRF source categories in the following steps:

1. The Swiss global 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) $$F_{1A2} = F_{1A2+4a} \cdot \frac{F_{1A2}^{Model}}{F_{1A2}^{Model} + F_{1A4a}^{Model}}$$

(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, and biomass from Manufacturing Industries based on the outputs of the Basics-model:

(3) $$F_{1A2a} = F_{1A2a}^{Model}; \quad F_{1A2b} = F_{1A2b}^{Model}; \quad F_{1A2c} = F_{1A2c}^{Model}; \quad F_{1A2d} = F_{1A2d}^{Model};$$
$$F_{1A2e} = F_{1A2e}^{Model}$$

(4) $$F_{1A2f} = F_{1A2} - \sum_{i=a}^{e} F_{1A2i}^{Model}$$

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, natural gas, and biomass reported in 1A2 is consistent with the Swiss global energy statistics.

4. For heavy fuel oil and coal, the data in the Swiss overall energy statistics (SFOE 2005) underestimate stock changes considerably: New governmental policy that was introduced from 1999 reduced significantly or stopped altogether state subsidies for fuel stocks and reduced the amount of mandatory stocks that (private) companies have to maintain ("Pflichtlager"; see DEA 2003). Experts within the Swiss cement industry confirmed that this resulted in a significant reduction of coal and heavy fuel oil stocks (and additional consumption) during the last few years that has not yet been accounted for in current data on stock changes from SFOE.

This is corroborated by the fact that summing up bottom-up data on consumption of coal and heavy fuel oil in industry results in higher total consumption than what the Swiss overall energy statistics report for these fuels.

Therefore, the results for coal and heavy fuel oil consumption from the Basics model (that are based on bottom-up data) are deemed more reliable than the consumption data from SFOE for the purpose of the Swiss inventory.

Therefore, for coal and heavy fuel oil, the consumption (in TJ) is taken directly from the model and is not "corrected" to the SFOE's overall consumption data:

(5) $$F_{1A2a} = F_{1A2a}^{Model}; \quad F_{1A2b} = F_{1A2b}^{Model}; \quad F_{1A2c} = F_{1A2c}^{Model}; \quad F_{1A2d} = F_{1A2d}^{Model};$$
$$F_{1A2e} = F_{1A2e}^{Model}; \quad F_{1A2f} = F_{1A2f}^{Model}$$

With this, the overall consumption of coal and heavy fuel oil reported in 1A2 tends to be higher than the data in the Swiss global energy statistics (SFOE 2005), because it takes into account the reduction of stocks over the last few years due to a change in governmental policy regarding stocks of coal and heavy fuel oil.

A2.5: Civil Aviation

This paragraph contains some further information to the emission modelling. More complete information will be available on request for reviewers by FOCA.

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 145 LTO-Cycle times (Minutes). “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.

Aircraft Engine Combinations							
Engine Name	Aircraft Name	Aircraft Registration	No. of Engines	Code	Type	Aircraft 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-Honey-well
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

Table 146 Aircraft-Engine Combinations and associated codes for SWISS FOCA emissions database. (Extract from list of 14043 individual aircraft)

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	0.766666667	0.021014333	4.14	364.1666667
AC68	0	P001FOCA	0.766666667	0.007452	4.14	364.1666667
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	0.766666667	0.021014333	4.14	364.1666667
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

Table 147 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).

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 TUG 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 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).

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

Table 148 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).

The emission factors published in the handbook (CD ROM, SAEFL 2004b) 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 1995a, chap. 4).

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

Table 149 Traffic situations (“TS name”) in Switzerland (SAEFL 1995a, SAEFL 2004b). 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 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.

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

Table 150 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.

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.

Veh categ.	Gas	Engine/Exh.Conc.	year (start)	Fuel	EF g/vec-km
PC	CO2	PW/B/Euro-1/FAV1	1987	G	224
PC	CO2	PW/B/Euro-2	1996	G	215
PC	CO2	PW/B/Euro-3	1999	G	208
PC	CO2	PW/B/Euro-4	2000	G	206
PC	CO2	PW/B/GKat<91	1986	G	225
PC	CO2	PW/B/Konv	1980	G	242
PC	CO2	PW/D/Euro-2	1995	D	219
PC	CO2	PW/D/Euro-3	1999	D	202
PC	CO2	PW/D/Euro-4	2003	D	184
PC	CO2	PW/D/konv	1980	D	227
PC	CO2	PW/D/XXIII/FAV1	1987	D	220
PC	CH4	PW/B/Euro-1/FAV1	1987	G	0.011
PC	CH4	PW/B/Euro-2	1996	G	0.015
PC	CH4	PW/B/Euro-3	1999	G	0.003
PC	CH4	PW/B/Euro-4	2000	G	0.002
PC	CH4	PW/B/GKat<91	1986	G	0.027
PC	CH4	PW/B/Konv	1980	G	0.114
PC	CH4	PW/D/Euro-2	1995	D	0.002
PC	CH4	PW/D/Euro-3	1999	D	0.001
PC	CH4	PW/D/Euro-4	2003	D	0.001
PC	CH4	PW/D/konv	1980	D	0.004
PC	CH4	PW/D/XXIII/FAV1	1987	D	0.002
PC	N2O	PW/B/Euro-1/FAV1	1987	G	0.014
PC	N2O	PW/B/Euro-2	1996	G	0.006
PC	N2O	PW/B/Euro-3	1999	G	0.003
PC	N2O	PW/B/Euro-4	2000	G	0.001
PC	N2O	PW/B/GKat<91	1986	G	0.014
PC	N2O	PW/B/Konv	1980	G	0.000
PC	N2O	PW/D/Euro-2	1995	D	0.005
PC	N2O	PW/D/Euro-3	1999	D	0.006
PC	N2O	PW/D/Euro-4	2003	D	0.006
PC	N2O	PW/D/konv	1980	D	0.000
PC	N2O	PW/D/XXIII/FAV1	1987	D	0.000
LDV	CO2	LI/B/Euro-1/FAV1	1987	G	269
LDV	CO2	LI/B/Euro-2	1996	G	238
LDV	CO2	LI/B/Euro-3	2000	G	219
LDV	CO2	LI/B/Euro-4	2002	G	217
LDV	CO2	LI/B/GKat<91	1986	G	262
LDV	CO2	LI/B/Konv	1980	G	313
LDV	CO2	LI/D/Euro-1/FAV1	1987	D	325
LDV	CO2	LI/D/Euro-2	1996	D	321
LDV	CO2	LI/D/Euro-3	2000	D	283
LDV	CO2	LI/D/konv	1980	D	362
LDV	CH4	LI/B/Euro-1/FAV1	1987	G	0.030
LDV	CH4	LI/B/Euro-2	1996	G	0.025
LDV	CH4	LI/B/Euro-3	1999	G	0.025
LDV	CH4	LI/B/Euro-4	2001	G	0.011
LDV	CH4	LI/B/GKat<91	1986	G	0.008
LDV	CH4	LI/B/Konv	1980	G	0.104
LDV	CH4	LI/D/Euro-1/FAV1	1987	D	0.002
LDV	CH4	LI/D/Euro-2	1996	D	0.002
LDV	CH4	LI/D/Euro-3	2000	D	0.001
LDV	CH4	LI/D/konv	1980	D	0.012
LDV	N2O	LI/B/Euro-1/FAV1	1987	G	0.014
LDV	N2O	LI/B/Euro-2	1996	G	0.006
LDV	N2O	LI/B/Euro-3	2000	G	0.003
LDV	N2O	LI/B/Euro-4	2002	G	0.001
LDV	N2O	LI/B/GKat<91	1986	G	0.014
LDV	N2O	LI/B/Konv	1980	G	0.000
LDV	N2O	LI/D/Euro-1/FAV1	1987	D	0.003
LDV	N2O	LI/D/Euro-2	1996	D	0.005
LDV	N2O	LI/D/Euro-3	2000	D	0.005
LDV	N2O	LI/D/konv	1980	D	0.000

Table 151 Mean emission factors of passenger cars (PW) and light duty vehicles (LI). PW/B: PC gasoline, PW/D PC diesel, LI/B LDV/gasoline, LI/D LDV diesel; G gasoline, D diesel. The values shown hold for the start year and may differ in subsequent years.

Veh categ.	Gas	Engine/Exh.Conc.	year (start)	Fuel	EF g/vec-km
HDV	CO2	SMW/60er_Jahre	1960	D	870
HDV	CO2	SMW/70er_Jahre	1970	D	838
HDV	CO2	SMW/80er_Jahre	1980	D	790
HDV	CO2	SMW/Euro-1	1993	D	709
HDV	CO2	SMW/Euro-2	1996	D	682
HDV	CO2	SMW/Euro-3	1999	D	700
HDV	CH4	SMW/60er_Jahre	1960	D	0.032
HDV	CH4	SMW/70er_Jahre	1970	D	0.026
HDV	CH4	SMW/80er_Jahre	1980	D	0.021
HDV	CH4	SMW/Euro-1	1993	D	0.016
HDV	CH4	SMW/Euro-2	1996	D	0.009
HDV	CH4	SMW/Euro-3	1999	D	0.009
HDV	N2O	SMW/60er_Jahre	1960	D	0.012
HDV	N2O	SMW/70er_Jahre	1970	D	0.012
HDV	N2O	SMW/80er_Jahre	1980	D	0.012
HDV	N2O	SMW/Euro-1	1993	D	0.012
HDV	N2O	SMW/Euro-2	1996	D	0.011
HDV	N2O	SMW/Euro-3	1999	D	0.007
U-Bus	CO2	SMW/60er_Jahre	1960	D	1'273
U-Bus	CO2	SMW/70er_Jahre	1970	D	1'250
U-Bus	CO2	SMW/80er_Jahre	1980	D	1'166
U-Bus	CO2	SMW/Euro-1	1993	D	1'082
U-Bus	CO2	SMW/Euro-2	1995	D	1'055
U-Bus	CO2	SMW/Euro-3	2000	D	1'135
U-Bus	CH4	SMW/60er_Jahre	1960	D	0.085
U-Bus	CH4	SMW/70er_Jahre	1970	D	0.065
U-Bus	CH4	SMW/80er_Jahre	1980	D	0.056
U-Bus	CH4	SMW/Euro-1	1993	D	0.024
U-Bus	CH4	SMW/Euro-2	1995	D	0.014
U-Bus	CH4	SMW/Euro-3	2000	D	0.013
U-Bus	N2O	SMW/60er_Jahre	1960	D	0.015
U-Bus	N2O	SMW/70er_Jahre	1970	D	0.015
U-Bus	N2O	SMW/80er_Jahre	1980	D	0.015
U-Bus	N2O	SMW/Euro-1	1993	D	0.015
U-Bus	N2O	SMW/Euro-2	1995	D	0.015
U-Bus	N2O	SMW/Euro-3	2000	D	0.008

Table 152 Mean emission factors of heavy duty vehicles (HDV) and urban busses (U-Bus). SMW: schwere Motorwagen = HDV, D: diesel.

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 (TNO 2002a-b, 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.

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

Table 153 N_2O emission factors of passenger cars (PC), light duty vehicles (LDV), heavy duty vehicles (HDV) and two-wheelers (2-W). From TNO 2002a-b, 2003

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.

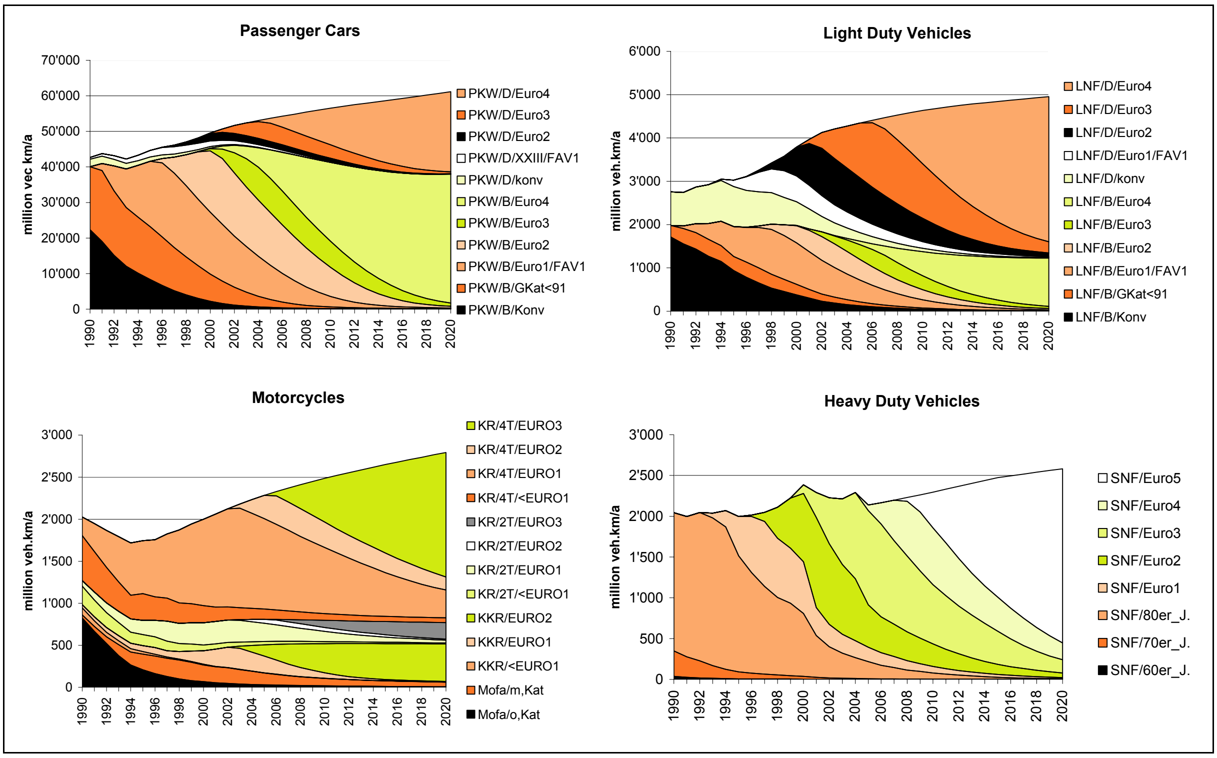

Figure 37 Mileage composition by emission concept (in million vehicle kilometres per year), SAEFL 2004a.

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 1995a/2004b.

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 were updated and the emission calculation was carried out in a new database that is structured in analogy the on-road database (SAEFL 2005a).

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

Fuel	Fuel cons.	Emission factors in g/kWh				
		CH_4	N_2O	NO_x	VOC	CO
	g/kWh	g/kWh				
Diesel	283-310	0.0054	0.027	11.7-12.6	1.08-3.87	2.25-8.64
Gasoline, 4-Stroke	460	0.45	0.045	3.6	18	315
Gasoline, 2-Stroke	650	3.60	0.045	2.7	135	540-558
CNG	460	0.90		1.8	0.18	0.45

Table 154 Emission factors for off-road vehicles. The range covers the variety of engine powers.

A comparison of the emission factors with the emission factors used in Switzerland for the CRF 2003 and the IPCC default factors (IPCC 1996) is given in the following table (SAEFL 2005a).

Fuel		N_2O (in g/kWh)			CH_4 (in g/kWh)		
		IPCC	CRF Switzerland		IPCC	CRF Switzerland	
		1996	2003	2004	1996	2003	2004
Diesel	Europe/USA	0.002	0.020	0.027	0.018	0.010	0.0054
Gasoline	4-stroke	0.002	0.025/0.060	0.045	0.072	0.50	0.45
	2-stroke	0.002-0.006	0.01	0.045	0.07-0.21	3.0	3.6

Table 155 Comparison of different emission factor sources: IPCC 1996 (vol III, tbl 1-7, 1-8, conversion factor used: 1 g/kWh = 278 kg/TJ) and SAEFL 2005a.

A2.7.3 Activity data off-road vehicles

Off-road	1990	1995	2000
family	no. of vehicles		
Construction	56'070	52'443	47'995
Industry	12'999	17'424	21'800
Agriculture	334'375	328'987	337'933
Forestry	13'839	13'350	13'045
Garden/hobby	749'010	809'043	871'060
Navigation	93'378	89'025	82'652
Railway	1'300	1'305	1'255
Military	1'340	1'340	1'340
Sum	**1'262'311**	**1'312'917**	**1'377'080**

Table 156 Number of vehicles per off-road family.

Off-road	1990	1995	2000
family	operating hours per vehicle per year		
Construction	299	353	383
Industry	623	645	658
Agriculture	160	161	155
Forestry	274	271	270
Garden/hobby	58	59	60
Navigation	40	39	40
Railway	612	627	616
Military	51	53	54
Average	**103**	**105**	**105**

Off-road	1990	1995	2000
family	mill. operating hours per year		
Construction	16.7	18.5	18.4
Industry	8.1	11.2	14.4
Agriculture	53.4	52.9	52.4
Forestry	3.8	3.6	3.5
Garden/hobby	43.4	47.9	52.5
Navigation	3.7	3.4	3.3
Railway	0.8	0.8	0.8
Military	0.1	0.1	0.1
Sum	**130.0**	**138.5**	**145.3**

Table 157 Operating hours per vehicle per year and (million) operating hours per off-road family.

Fuel	**Off-road family**	**1990**	**1995**	**2000**
		fuel consumption in 1000 t/a		
Diesel	Construction	117.5	136.7	145.0
	Industry	19.5	26.2	32.5
	Agriculture	149.3	160.2	169.3
	Forestry	9.8	10.2	11.0
	Navigation	21.7	20.0	20.2
	Railway	26.4	30.0	29.2
	Military	1.2	1.3	1.3
	Sum diesel	**345.5**	**384.5**	**408.5**
Gasoline	Construction	6.1	6.3	5.4
	Industry	1.5	2.1	2.7
	Agriculture	37.3	33.6	29.8
	Forestry	3.0	2.9	2.8
	Garden/hobby	14.2	15.8	17.3
	Navigation	12.5	11.7	12.5
	Military	0.01	0.01	0.01
	Sum gasoline	**74.6**	**72.3**	**70.4**
Gas oil	**Navigation**	**5.2**	**5.7**	**5.7**
CNG	**Industry**	**3.6**	**5.4**	**7.3**

Table 158 Fuel consumption of several off-road activities (in 1’000 t/a).

Annex 3: Industrial Processes

A3.1 Documentation of Model for Mobile Air-Conditioning / Cars

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

Table 159 Model structure and assumptions for calculating emissions from mobile air conditioning in cars (2003 data. For 2004 no change in model has taken place).

Annex 4: New LULUCF Reporting 1990

Authors

Sigmaplan: Ulrich Roth	Land Use, Activity Data
Meteotest: Beat Rihm, Beat Schaffner	 Reporting Computations
Agroscope, FAL: Jens Leifeld	Stocks and Emission Factors, Agriculture
FOEN: Esther Thürig	Stocks and Emission Factors, Forests

Advised by the FOEN Inventory Task Force

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A4.1 Glossary LULUCF

ASCH1	Swiss land use statistics, first survey 1979/85
ASCH2	Swiss land use statistics, second survey 1992/97
AREA	Swiss land use statistics, third survey 2004/09
BEF	biomass expansion factor
CRF	Common reporting format
DBH	Diameter (of trees) at Breast Height
FOEN	Swiss Federal Office for the Environment (until 2005 SAEFL)
FAL	Swiss Federal Research Station for Agroecology and Agriculture
Gg	Gigagram (10^9 g = 1'000 tons)
ha	hectare
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, Land-Use Change and Forestry
NFI I	First National Forest Inventory (1983-1985)
NFI II	Second National Forest Inventory (1993-1995)
NFI III	Third National Forest Inventory (2004-2006)
NIR	National Inventory Report
SAEFL	Swiss Agency for the Environment, Forests and Landscape (in 2006 renamed as FOEN)
SFSO	Swiss Federal Statistical Office

A4.2 Overview

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).

The land areas in 1990 are represented by geographically explicit land use data with a resolution of one hectare (following a Tier 3 approach; IPCC 2003). Direct and repeated assessment of land use with full spatial coverage (SFSO 2005) also enables to calculate a spatially explicit land-use change matrix.

The emission factors and carbon stock values for forests and partially for agricultural land are derived from country-specific surveys and measurements. For other land use categories, IPCC default values or expert estimates are used.

The main land categories required by IPCC are: A. Forest Land, B. Cropland, C. Grassland, D. Wetlands, E. Settlements and F. Other Land. These categories were further divided in 13 subcategories of land use (see Table 161). A further spatial stratification reflects the criteria 'altitude' (3 belts), 'geomorphologic and climatic conditions' (adopting the 5 regions of the National Forest Inventory) and 'soil type' (mineral, organic).

Table 160 shows the CO_2 emissions and removals for the year 1990 as calculated with the methodology described below. The data are aggregated to the main land use categories, each with the value for land use (the land type remained the same) and land-use change (the land type changed in 1990).

Main Land Use Categories	**CO_2** [Gg in 1990]
A. Forest Land	**-2'793**
1. Forest Land remaining Forest Land	-2'791
2. Land converted to Forest Land	-3
B. Cropland	**627**
1. Cropland remaining Cropland	547
2. Land converted to Cropland	60
C. Grassland	**-70**
1. Grassland remaining Grassland	22
2. Land converted to Grassland	-93
D. Wetlands	**28**
1. Wetlands remaining Wetlands	-2
2. Land converted to Wetlands	30
E. Settlements	**360**
1. Settlements remaining Settlements	-7
2. Land converted to Settlements	366
F. Other Land	**65**
1. Other Land remaining Other Land	0
2. Land converted to Other Land	65
Net removals from LULUCF in 1990	**-1'784**

Table 160 Switzerland's CO2 emissions/removals of the source category 5 „Land Use, Land-Use Change and Forestry" in 1990. Positive values refer to emissions, negative values refer to removals from the atmosphere.

In 1990, the total net removal of CO_2 amounted to 1'784 Gg. The largest sink were forests, as the growth of biomass exceeded the harvesting rate in this year. The largest emissions were caused by cropland management on organic soils as well as by land converted to settlements.

The next chapter (A4.3) gives an overview of the methodical approach including the calculation of the activity data (land use data). The following chapters (A4.4-A4.9) will focus on the details of the emission calculations for each main land use category.

A4.3 Methodical Approach and Activity Data

A4.3.1 General approach for Calculating Carbon Emissions/Removals

The selected procedure for calculating carbon emissions and removals in the LULUCF sector can be summarised as follows:

- Define land use categories and sub-divisions with respect to available land use data (see Table 161).
- 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 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 deltaC$_i$ over land use categories and strata according to the level of disaggregation displayed in the CRF-tables.

This calculation methods correspond to a Tier 2 approach as described in IPCC (2003; chapter 3).

Land Use category	**Sub-division**	**Mnemonic**	**LUcode**
A. Forest Land	Afforestations	FA	11
	Productive Forest	FP	12
	Unproductive Forest	FU	13
B. Cropland		CL	20
C. Grassland	Permanent Grassland	GP	31
	G. with perennial woody biomass	GW	32
	Unproductive Grassland	GU	33
D. Wetlands	Surface waters	WW	41
	Unproductive wetland	WU	42
E. Settlements	Buildings/Constructions	SB	51
	Surrounding of Buildings	SS	52
	Parks	SP	53
F. Other Land		OL	60

Table 161 The 13 land use categories employed in this assessment, including attributed LUcodes and mnemonics.

For calculating carbon stock changes, the following input parameters (mean values per hectare) must be quantified for all land use categories (b) and spatial strata (i):

$stockC_{l,i,b}$: carbon stock in living biomass
$stockC_{d,i,b}$: carbon stock in dead organic matter
$stockC_{s,i,b}$: carbon stock in soil
$increaseC_{l,i,b}$: annual increase (growth) of carbon in living biomass
$decreaseC_{l,i,b}$: annual decrease (harvesting) of carbon in living biomass
$changeC_{d,i,b}$: annual net carbon stock change in dead organic matter
$changeC_{s,i,b}$: annual net carbon stock change in soil

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 1.1-1.3 show the general approach of calculating C-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):

If land use after conversion **is *not* 'forest land'** then:

$$deltaC_{l,i,ba} = [\ increaseC_{l,i,a} - decreaseC_{l,i,a} + stockC_{l,i,a} - stockC_{l,i,b}\ ] \cdot A_{i,ba} \quad (1.1)$$
$$deltaC_{d,i,ba} = [\ changeC_{d,i,a} + stockC_{d,i,a} - stockC_{d,i,b}\ ] \cdot A_{i,ba} \quad (1.2)$$
$$deltaC_{s,i,ba} = [\ changeC_{s,i,a} + stockC_{s,i,a} - stockC_{s,i,b}\ ] \cdot A_{i,ba} \quad (1.3)$$

where:

a: land use after conversion (LUcode = a)
b: land use before conversion (LUcode = b)
ba: land use conversion from b to a
$A_{i,ba}$: area of land converted from b to a (activity data from the land-use change matrix).

Equations 2.1-2.3 reflect a special treatment of land-use changes in those cases where a land use category is converted to forest land: The differences of the carbon stocks in living biomass, dead organic matter and soils are neglected. The reason for this procedure is to avoid an overestimation of C-sinks in the case of natural succession from grassland to forest land, which is quite frequent in mountainous regions in Switzerland. Probably, "young" forest immediately after the conversion has lower carbon stocks than the mean carbon stock values determined for forest. Therefore, a full calculation of the stock differences could lead to an overestimation:

If land use after conversion **is 'forest land'** then:

$$deltaC_{l,i,ba} = [\ increaseC_{l,i,a} - decreaseC_{l,i,a}\ ] \cdot A_{i,ba} \quad (2.1)$$
$$deltaC_{d,i,ba} = 0 \quad (2.2)$$
$$deltaC_{s,i,ba} = 0 \quad (2.3)$$

If a = b there is no change in land use and the difference in carbon stocks becomes zero.

For calculating annual carbon stock changes in soils due to land use conversion IPCC (2003) suggests a default delay time (inventory period) of 20 years. In this study, the inventory period of land-use changes is approximately 12 years (see next chapter).

In the CRF tables 5.A to 5.F, LUcodes and spatial strata are shown at an aggregated level for optimal documentation and overview and the values of deltaC are accordingly summarised. Positive values of $deltaC_{l,i,ba}$ are inserted in the column "Increase" and negative values in column "Decrease", respectively.

A4.3.2 Land Use Statistics (Activity Data)

a) Basic data

The Swiss Land Use Statistics (Arealstatistik, ASCH) of the Swiss Federal Statistical Office (SFSO 2005) are used as basic data in this investigation. In the course of an ASCH survey every hectare of Switzerland's territory (4'128'372 ha) is assigned to one of 74 ASCH land use categories (see Table 162) by means of stereographic interpretation of aerial photos. In this manner, land-use changes are recorded approximately every 12 years (see below). For the reconstruction of the land use conditions in Switzerland in 1990 ('status 1990') two data sets are used:

- Land Use Statistics "1979/85" (ASCH1)
- Land Use Statistics "1992/97" (ASCH2).

The aerial photos for ASCH1 and ASCH2 were actually taken between 1977-1986 and between 1990-1998, respectively. As a direct consequence, the inter-survey period is not the same throughout the Swiss territory, but varies regionally. This situation is illustrated in Figure 38 in an exemplary manner. The grey rectangles represent the data collection periods of ASCH1 and ASCH2, whereas the coloured lines symbolise some hypothetical interim periods between the shooting of the aerial photos. This methodical characteristic needs to be considered when reconstructing the country-wide 'status 1990' (green vertical line in Figure 38) or when calculating annual rates of land-use change.

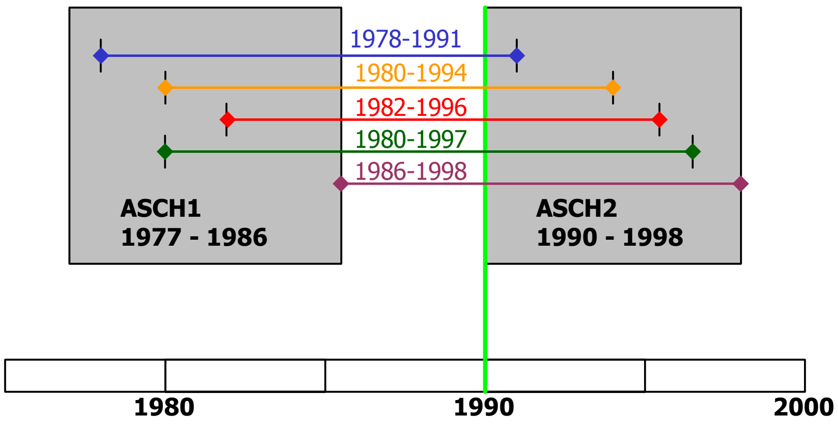


Figure 38 Schematic overview of ASCH1 and ASCH2 data-collection periods. Some hypothetical examples for resulting inter-survey periods in different parts of Switzerland are given.

The following Figure 39 shows the percentage of Swiss territory covered by ASCH1 aerial photo shootings by calendar year.

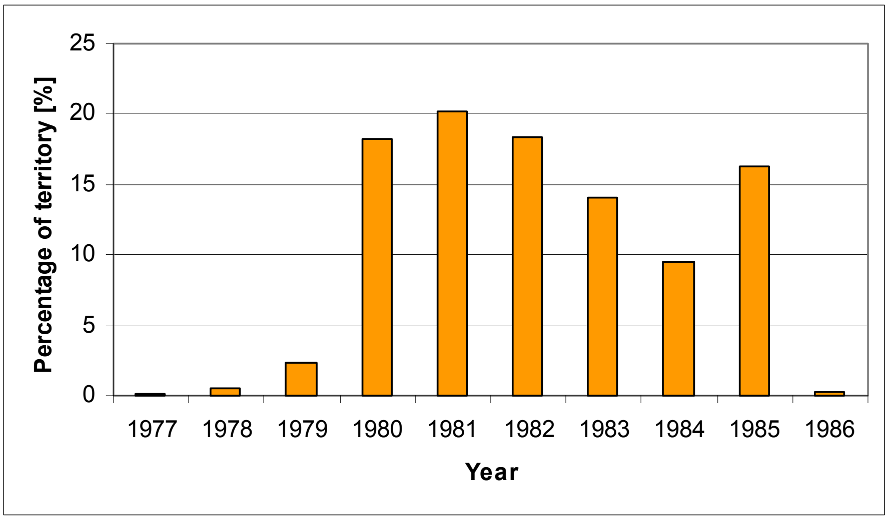


Figure 39 Percentage of Swiss territory covered by ASCH1 aerial photo shootings in different years.

Figure 40 shows the duration of the periods between both ASCH surveys (as they occur in different parts of Switzerland) in relation to the percentage of territory covered. The most frequent interim is found to be12 years, accounting for 75.6% of the whole territory.

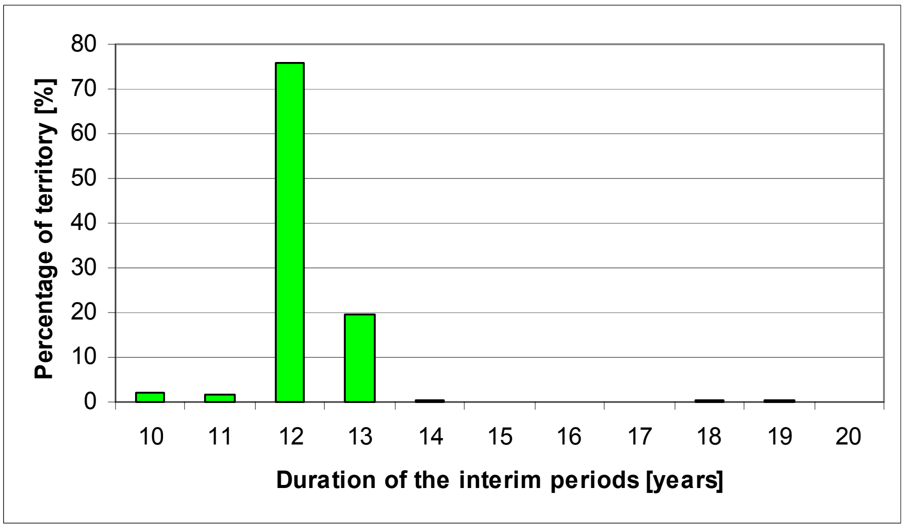


Figure 40 Duration of the interim periods in relation to the percentage of territory covered.

b) Definition of Land Use Categories

The 74 land use categories of ASCH1 and ASCH2 (SFSO 2005) have been assigned to the land use categories proposed by IPCC (see Table 162). Some of the IPCC categories have been split into sub-categories, which are identified by a unique number (LUcode). The ASCH land use categories that are assigned to one LUcode sub-division have similar CO_2 emission factors and carbon stocks.

The third survey of the Swiss Land Use Statistics (AREA 2004/09), which has recently been launched, operates with a modified set of land use categories. This will allow to further improve the correspondence of AREA and IPCC categories in the future.

Land-Use category	Sub-division	Mnemonic	LUcode	AScode	AScode description
Forest Land	Afforestations	FA	11	9	Afforestations
	Productive Forest	FP	12	10	Damaged forest areas
				11	Normal dense forest
				13	Open forest (on agricultural areas)
				14	Forest stripes, edges
	Unproductive Forest	FU	13	12	Open forest (on unproductive areas)
				15	Brush forest
Cropland		CL	20	52	Garden allotments
				71	Regular vineyards
				72	"Pergola" vineyards
				73	Extensive vines
				78	Horticulture
				81	Favourable arable land and meadows
Grassland	Permanent Grassland	GP	31	32	Green motorway environs
				38	Airfields, green airport environs
				54	Golf courses
				67	Green railway environs
				68	Green road environs
				82	Other arable land and meadows
				83	Farm pastures
				85	Mountain meadows
				87	Remote and steep alpine meadows/pastures
				88	Favourable alpine pastures
				89	Rocky alpine pastures
	G. with perennial woody biomass	GW	32	16	Scrub vegetation
				17	Groves, hedges
				18	Clusters of trees (on agricultural areas)
				19	Other woods
				75	Intensive orchards
				76	Rows of fruit trees
				77	Scattered fruit trees
				84	Brush meadows and farm pastures
				86	Brush alpine pastures
	Unproductive Grassland	GU	33	97	Unproductive grass and shrubs
Wetlands	Surface waters	WW	41	91	Lakes
				92	Rivers
	Unproductive wetland	WU	42	95	Wetlands
				96	Water shore vegetation
Settlements	Buildings/Constructions	SB	51	20	Ruins
				21	Industrial buildings
				23	Buildings in recreational areas
				24	Buildings in special urban areas
				25	One- and two-family houses
				26	Terraced houses
				27	Blocks of flats
				28	Agricultural buildings
				29	Unspecified buildings
				31	Motorways
				33	Roads and paths
				34	Parking areas
				35	Railway station grounds
				36	Railway lines
				37	Airports
				51	Sport grounds
				53	Camping, caravan sites
				61	Other supply or waste treatment plants
				62	Energy supply plants
				63	Waste water treatment plants
				64	Quarries, mines
				65	Dumps
				66	Construction sites
	Surrounding of Buildings	SS	52	41	Industrial grounds
				45	Surroundings of one- and two-family houses
				46	Surroundings of terraced houses
				47	Surroundings of blocks of flats
				48	Surroundings of agricultural buildings
				49	Surroundings of unspecified buildings
	Parks	SP	53	56	Cemeteries
				59	Public parks
Other Land		OL	60	69	River shores
				90	Glaciers, perpetual snow
				93	Flood protection structures
				98	Avalanche protection structures
				99	Rocks, sand, screes

Table 162 The 6 IPCC main land use categories and 13 sub-divisions (LUcode, mnemonic) with their reference to the 74 codes of the Swiss Land Use Statistics (AScode, AScode description).

c) Calculation of the annual rates of change of land-use

The land-use changes between ASCH1 and ASCH2 are listed in Table 163. These changes are "true" as far as the position and LUcode of every hectare have been observed in the surveys. The totals of the rows describe the state of ASCH1, the totals of the columns describe the state of ASCH2 approximately 12 years later.

	LUcode	To ASCH2													
		11 FA	12 FP	13 FU	20 CL	31 GP	32 GW	33 GU	41 WW	42 WU	51 SB	52 SS	53 SP	60 OL	sum AREA79/85
From ASCH1	12 FP	11	1025672	1443	143	1267	1773	329	241	47	1417	297	39	406	**1033085**
	13 FU	0	6738	103587	5	120	340	135	33	7	65	13	1	144	**111188**
	20 CL	101	17	0	553326	11854	1881	25	45	80	7532	4473	95	54	**579483**
	31 GP	1669	1660	539	9607	854655	18273	1581	185	179	8875	8826	215	764	**907028**
	32 GW	768	10751	6393	3994	13903	234405	383	224	44	2402	3003	67	438	**276775**
	33 GU	161	445	902	39	366	3506	177732	48	4	80	12	3	378	**183676**
	41 WW	8	108	26	16	54	198	50	169449	146	137	12	19	187	**170410**
	42 WU	22	61	19	32	24	8	1	31	8380	36	5	1	1	**8621**
	51 SB	560	293	35	1978	2414	437	105	61	69	125930	3266	122	72	**135342**
	52 SS	3	5	0	82	306	85	13	1	4	2613	92053	47	2	**95214**
	53 SP	0	2	0	6	11	1	0	3	0	76	16	4089	0	**4204**
	60 OL	46	218	395	29	1090	1180	2029	112	7	193	15	4	618028	**623346**
															4128372
	sum AREA92/97	**3349**	**1045970**	**113339**	**569257**	**886064**	**262087**	**182383**	**170433**	**8967**	**149356**	**111991**	**4702**	**620474**	**4128372**

Table 163 Land-use changes from ASCH1 to ASCH2, a period of approximately 12 years. Units: ha.

LUcode 11 (afforestations) appears only in ASCH2. It did not yet exist in the data catalogue of ASCH1. The land-use changes to "afforestations" are treated the same way as all other land-use changes.

The dates of aerial photo shootings are known for each of the 4'128'372 hectares. However, the exact year of the land-use change on a specific hectare is unknown. The actual change can have taken place in any year between the two ASCH surveys. In this study, it is assumed that the probability of a land-use change from ASCH1 to ASCH2 is uniformly distributed over the respective interim period between the two surveys. Therefore, the land-use change of each hectare has to be equally distributed over its specific interim period and the mean annual change rate of a specific hectare is 1 ha divided by the duration of the interim period of that hectare.

The mean annual rates of change in the whole country (change-matrix) is achieved by adding up the mean annual change rates of all hectares per LUcode. Table 164 shows an overview of the mean annual changes of all LUcodes. For example, there are 4'473 hectares changing from "cropland" to "surrounding of buildings" (see Table 163) and the averaged duration of their interim periods was 12.024 years. This results in a mean annual change of 372 ha (see Table 164). The totals of the columns are equal to the total increase of one specific category. The totals of the rows are equal to the total decrease of one specific category. The absolute values of increases and decreases are identical.

For calculating the carbon stock changes, the fully stratified land-use change matrix is used (not shown here). In principle, that matrix consists of 30 matrices like the one shown in Table 164, one for each spatial stratum (see Chapter A4.3.3).

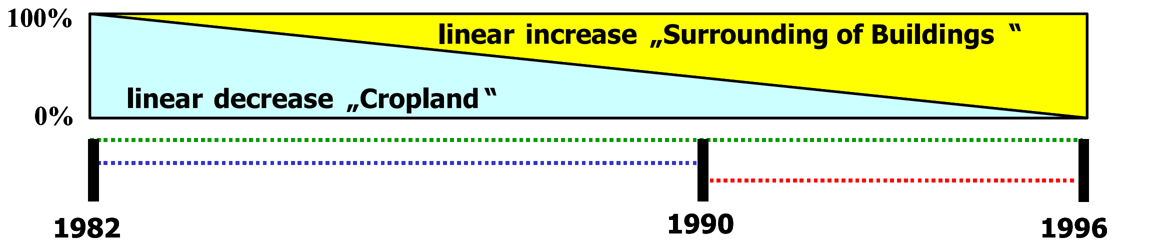
LUcode		To ASCH2 11 FA	12 FP	13 FU	20 CL	31 GP	32 GW	33 GU	41 WW	42 WU	51 SB	52 SS	53 SP	60 OL	decrease
From ASCH1	12 FP	1	0	118	12	104	146	27	20	4	117	25	3	33	609
	13 FU	0	554	0	0	10	28	11	3	1	5	1	0	12	625
	20 CL	9	1	0	0	978	156	2	4	7	626	372	8	4	2167
	31 GP	138	136	44	796	0	1493	128	15	15	731	730	18	62	4306
	32 GW	64	880	522	333	1146	0	31	18	4	198	249	6	36	3485
	33 GU	13	36	74	3	30	284	0	4	0	7	1	0	30	483
	41 WW	1	9	2	1	4	16	4	0	12	11	1	2	15	79
	42 WU	2	5	2	3	2	1	0	3	0	3	0	0	0	20
	51 SB	47	24	3	165	200	36	9	5	6	0	270	10	6	781
	52 SS	0	0	0	7	25	7	1	0	0	216	0	4	0	262
	53 SP	0	0	0	0	1	0	0	0	0	6	1	0	0	10
	60 OL	4	18	32	2	88	96	161	9	1	16	1	0	0	428
															13253
	increase	278	1664	797	1323	2587	2263	374	80	48	1938	1653	51	198	13253

Table 164 Mean annual rates of land-use change between ASCH1 and ASCH2 (change matrix). Units: ha/year, rounded values.

d) Interpolation of the 'status 1990'

The year 1990 lies between the data collection periods of ASCH1 and ASCH2 (see Figure 38). The 'status 1990' can therefore be calculated by linear interpolation. Dates of aerial photo shootings (= starting and ending year of the inter-survey period) and the land use categories of ASCH1 and ASCH2 for every hectare are used for these calculations.

Example (see Figure 41): A hectare has been assigned to the land use category "cropland" (LUcode = 20) in ASCH1. A land-use change to "surrounding of buildings" (LUcode = 52) has been discovered 14 years later in ASCH2. 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 "surrounding of buildings" during the whole interim period is assumed. Thus, in 1990 the hectare is split up in two fractions: 0.5714 ha is "surrounding of buildings" and 0.4286 ha is "cropland".



Definitions:

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

Calculation formulas:

Fraction „Surrounding of Buildings$_{1990}$" = (ybefore1990 / ydiff) = 0.5714

Fraction „Cropland$_{1990}$" = (yafter1990 / ydiff) = 0.4286

Figure 41 Linear development of land-use change between ASCH1 and ASCH2 considering as example a hectare changing from "cropland" to "surrounding of buildings".

The 'status 1990' for the whole country results from the summation of the fractions of all hectares per LUcode (see Table 165).

A special case is the category "afforestations" (LUcode = 11) as it is only a transitional category, gradually becoming forest: This area is set equal to zero at the beginning of every year and the affected area is transferred to the category "productive forest" (LUcode = 12).

A4.3.3 Spatial Stratification

In order to quantify carbon stocks and increases/decreases, a further spatial stratification of the territory turned out to be useful. For forests, 3 different altitudinal belts and the 5 production regions of the National Forest Inventory (NFI) are differentiated. The NFI regions are adopted from EAFV/BFL (1988): 1. Jura, 2. Central Plateau, 3. Pre-Alps, 4. Alps and 5. Southern Alps. Altitude data were available on a hectare-grid from the Swiss Federal Statistical Office (SFSO, GEOSTAT) and classified in belts <600 m asl (meters above sea level), 601-1200 m asl, and >1200 m asl (Figure 42).

For agriculture, it was important to differentiate two soil types (organic and mineral soils) and also altitudinal belts. For mapping the occurrence of organic soils, two appropriate categories of the digital soil map "BEK" (SFSO 2000) were selected, as shown in Figure 42. The codes F1 and Q3 represent organic soils (histosols) in the Central Plateau and in alpine valleys, respectively.

Table 165 shows the Swiss land use statistics for the year 1990 resulting from this spatial stratification.

		"State 1990", "Afforestations" set equal to zero													
	LU-Code	11 [ha]	12 [ha]	13 [ha]	20 [ha]	31 [ha]	32 [ha]	33 [ha]	41 [ha]	42 [ha]	51 [ha]	52 [ha]	53 [ha]	60 [ha]	sum [ha]
Altitude	< 600 m	0	221186	846	349624	125922	54897	677	138182	4226	94501	75729	3753	3097	1072640
	600 - 1200	0	489177	9854	216425	287231	59049	3793	12389	1996	39209	26404	691	7421	1153639
	>1200 m	0	332112	101690	6618	480358	153693	178459	19844	2608	11029	4450	100	611132	1902093
Sum 1:		0	1042474	112390	572668	893512	267639	182930	170415	8829	144739	106583	4543	621650	4128372
Soils:	organic	0	1'064	2	15'692	1'723	617	10	477	309	1'512	781	28	309	22524
	mineralic*	0	1'041'410	112388	556975	891789	267023	182920	169937	8520	143228	105802	4515	621341	4105848
Sum 2:		0	1042474	112390	572668	893512	267639	182930	170415	8829	144739	106583	4543	621650	4128372
* =Sum 1 - organic soils															
NFI - Regions	1	0	197414	1006	103362	101499	23376	305	23622	811	22761	17681	756	653	493247
	2	0	225846	456	352370	122762	41687	225	69543	3343	68934	54469	2636	1435	943706
	3	0	207314	7366	76884	229448	38846	13084	32150	2515	21821	15242	509	16272	661450
	4	0	290493	69166	34050	400489	126676	139703	31772	1742	23337	13301	418	543247	1674394
	5	0	121406	34396	6003	39314	37054	29612	13328	418	7886	5890	225	60042	355575
Sum 3:		0	1042474	112390	572668	893512	267639	182930	170415	8829	144739	106583	4543	621650	4128372

Table 165 Land use by the end of 1990 (31/12/1990), stratified separately for altitude (3 belts), soil type (mineral or organic) and NFI region (1-5). In this table, the afforestations (LUcode = 11) have already been transferred to the category "productive forest" (LUcode = 12) in order to start at zero again on 01/01/1991.

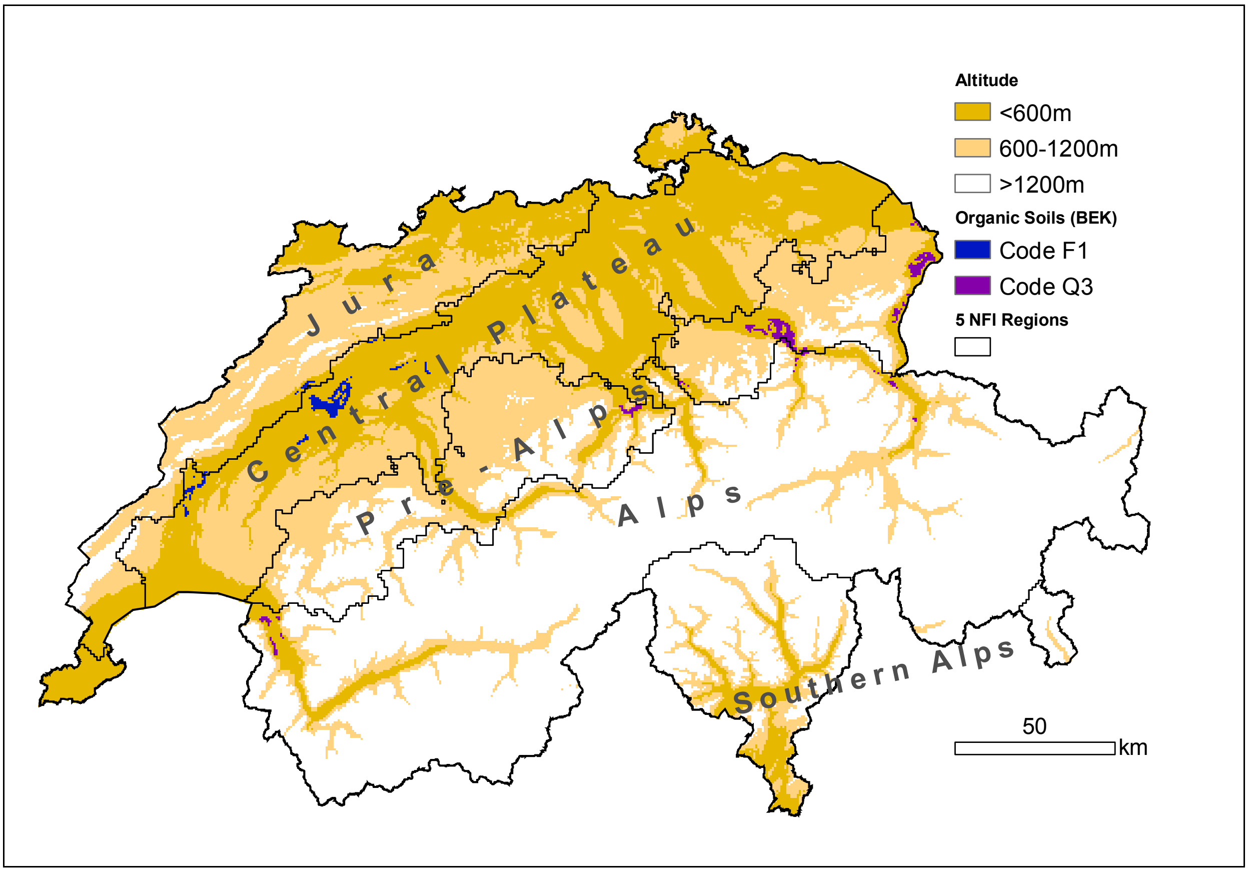


Figure 42 Map showing the spatial stratification according to altitude, soil type and NFI region.

A4.3.4 Carbon Emission Factors and Stocks at a Glance

Table 166 lists all values of stocks, increases, decreases and net changes of carbon per LUcode and stratum. The colours of the cells indicate the method used for estimating the values as explained in the legend of the Table.

Land-use (LUcode)	altitude zone z	NFI region	organic soil	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}			
12 FP	1	1	n.s.	128.76	2.34	76	3.57	-2.41	0	0
	1	2	n.s.	135.79	1.72	76	4.86	-4.35	0	0
	1	3	n.s.	157.24	4.45	76	4.42	-3.05	0	0
	1	4	n.s.	98.43	7.51	76	3.16	-2.49	0	0
	1	5	n.s.	74.13	5.13	76	2.26	-1.06	0	0
	2	1	n.s.	124.55	2.19	76	3.29	-2.40	0	0
	2	2	n.s.	148.86	1.67	76	4.93	-4.07	0	0
	2	3	n.s.	152.54	4.01	76	4.13	-3.11	0	0
	2	4	n.s.	102.07	6.75	76	2.54	-1.84	0	0
	2	5	n.s.	69.85	5.06	76	2.16	-0.83	0	0
	3	1	n.s.	85.11	2.18	76	2.02	-1.50	0	0
	3	2	n.s.	93.31	1.66	76	1.49	-0.95	0	0
	3	3	n.s.	116.36	3.98	76	2.47	-2.06	0	0
	3	4	n.s.	94.75	6.22	76	1.85	-1.66	0	0
	3	5	n.s.	78.04	4.06	76	1.65	-0.48	0	0
13 FU	1	1	n.s.	41.41	0	76	0	0	0	0
	1	2	n.s.	42.07	0	76	0	0	0	0
	1	3	n.s.	41.41	0	76	0	0	0	0
	1	4	n.s.	36.50	0	76	0	0	0	0
	1	5	n.s.	34.81	0	76	0	0	0	0
	2	1	n.s.	43.48	0	76	0	0	0	0
	2	2	n.s.	41.41	0	76	0	0	0	0
	2	3	n.s.	43.01	0	76	0	0	0	0
	2	4	n.s.	34.61	0	76	0	0	0	0
	2	5	n.s.	30.19	0	76	0	0	0	0
	3	1	n.s.	43.32	0	76	0	0	0	0
	3	2	n.s.	11.60	0	76	0	0	0	0
	3	3	n.s.	26.23	0	76	0	0	0	0
	3	4	n.s.	16.76	0	76	0	0	0	0
	3	5	n.s.	19.07	0	76	0	0	0	0
20 CL	n.s.	n.s.	0	5.53	0	53.40	0	0	0	0
	n.s.	n.s.	1	5.53	0	240	0	0	0	-9.52
31 GP	1	n.s.	0	7.45	0	62.02	0	0	0	0
	1	n.s.	1	7.45	0	240	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	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	0	0	0	-9.52
32 GW	1	n.s.	0	27.39	0	62.02	0	0	0	0
	1	n.s.	1	27.39	0	240	0	0	0	-9.52
	2	n.s.	0	26.20	0	67.50	0	0	0	0
	2	n.s.	1	26.20	0	240	0	0	0	-9.52
	3	n.s.	0	24.39	0	75.18	0	0	0	0
	3	n.s.	1	24.39	0	240	0	0	0	-9.52
33 GU	1	n.s.	0	2.95	0	50.70	0	0	0	0
	1	n.s.	1	2.95	0	240	0	0	0	0
	2	n.s.	0	2.95	0	50.70	0	0	0	0
	2	n.s.	1	2.95	0	240	0	0	0	0
	3	n.s.	0	2.95	0	50.70	0	0	0	0
	3	n.s.	1	2.95	0	240	0	0	0	0
41 WW	n.s.	n.s.	n.s.	0	0	0	0	0	0	0
42 WU	n.s.	n.s.	n.s.	2.95	0	53.40	0	0	0	0
51 SB	n.s.	n.s.	n.s.	0	0	29	0	0	0	0
52 SS	n.s.	n.s.	n.s.	7.45	0	53.40	0	0	0	0
53 SP	n.s.	n.s.	n.s.	7.45	0	53.40	0	0	0	0
60 OL	n.s.	n.s.	n.s.	0	0	0	0	0	0	0

(table continued on next page)

Legend

altitude zones:		(green)	measured or modelled values
1	< 600 m	(yellow)	first guess or default values
2	601 - 1200 m	(light blue)	NO, zero by definition
3	> 1200 m	(pink)	NE, set to zero
		n.s.	no stratification
NFI-regions:			
1	Jura		NO = not occurring
2	Central Plateau		NE = not estimated
3	Pre-Alps		
4	Alps		
5	Southern Alps		

Table 166 Carbon stocks and changes in biomass, dead organic matter and soils for the land use categories (LUcode), disaggregated for altitude, NFI-region, and soil type. Within the scope of this study, these data have not been estimated for afforstations (LUcode 11).

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 166. Thus, the difference of carbon stocks in organic soils is always zero.

While the carbon data for forests are based on monitoring data of the NFI, the data for agriculture are based on experiments, field studies and literature. For wetlands, settlements, and other land, only expert estimates or default values are available. The deduction of the individual values displayed in Table 166 is explained in detail in the following chapters.

A4.4 Source Category 5A – Forest Land

A4.4.1 Source Category Description

Only temperate forests are occurring in Switzerland. In the land use statistics (ASCH) and in the National Forest Inventory (NFI), forest land is defined by the following criteria:

- Normal dense forest: tree crown cover > 60%, width > 25m, height > 3m.
- Open forest: tree crown cover 20-60%, width > 50m, height > 3m.
- Other forest land: afforestations, brush forest, young or temporarily unstocked stands.

For reporting in the CRF, forest land was subdivided into afforestations (LUcode 11), productive forest (LUcode 12) and unproductive forest (LUcode 13) based on ASCH-categories (see Table 162).

A4.4.2 Methodological Issues

Data for growing stock, increment, cut (harvesting), and mortality were derived from the first and the second Swiss National Forest Inventory (see Table 167). The NFI I was conducted between 1983 and 1985 (EAFV/BFL 1988), the NFI II was conducted between 1993 and 1995 (Brassel and Brändli 1999). In 2007, first results from the third NFI will be available for the reporting.

	NFI I	NFI II	NFI III
Inventory cycle	1983-1985	1993-1995	2004-2006
Grid size	1x1 km	1.4 x1.4 km	1.4 x1.4 km
Terrestrial sample plots	~12'000	~6'000	~6'000
Measured single trees	~130'000	~70'000	~70'000

Table 167 Characteristics of the National Forest Inventories I, II and III.

a) Stratification, Subcategories

Forests in Switzerland reveal a high heterogeneity in terms of elevation, growth conditions, and tree species composition. To find explanatory variables that significantly reduce the variance of gross increment and biomass expansion factors (BEFs) an analysis of variance was done. The explanatory variables considered in this study are (see also Figure 42):

- the 5 NFI production regions (1. Jura, 2. Central Plateau, 3. Pre-Alps, 4. Alps, 5. Southern Alps)
- altitude (<600 m, 601-1200 m, >1200 m)
- tree species (coniferous and deciduous species).

The analysis of variance indicated that production region, elevation, and tree species all significantly explain differences in gross increment and biomass expansion factors (Table 168 and Table 169). Therefore, growing stock, increment, harvesting, as well as BEFs were estimated and applied separately for these subcategories.

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

Table 168 Analysis of variance of gross increment. 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

Table 169 Analysis of variance of BEFs. Explanatory variables: Tree species, production region, and altitude.

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, increment, harvesting and BEFs are to be applied, the total forest area has to be divided according to the species mixture. 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 subcategory (Table 170) 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 = subcategories

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

$R_{di} = 1 - R_{ci}$ i = subcategories

NFI region	Altitude [m]	Coniferous	Deciduous
1	<600	0.352	0.648
1	601-1200	0.581	0.419
1	>1200	0.751	0.249
2	<600	0.558	0.442
2	601-1200	0.646	0.354
2	>1200	0.902	0.098
3	<600	0.395	0.605
3	601-1200	0.713	0.287
3	>1200	0.925	0.075
4	<600	0.369	0.631
4	601-1200	0.652	0.348
4	>1200	0.962	0.038
5	<600	0.060	0.940
5	601-1200	0.152	0.848
5	>1200	0.810	0.190

Table 170 Ratio of coniferous and deciduous species (source: NFI II; Brassel and Brändli 1999).

b) Wood Densities

In the Swiss NFI, growing stock, increment, cut and mortality is expressed as round wood over bark. To convert this volume (m^3 ha^{-1}) into t ha^{-1} it was multiplied by a species specific density. Table 171 shows the applied densities.

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

Table 171 Wood densities for coniferous and deciduous trees (Vorreiter 1949).

c) Biomass Expansion Factors

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 II. 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 subcategory as the ratio between round wood over bark (t ha^{-1}) and the total above- and belowground biomass (t ha^{-1}). Table 172 shows the BEFs for coniferous and deciduous species stratified for production region and elevation.

NFI region	Altitude [m]	Conifers		Deciduous species	
		Number of trees	BEFs	Number of trees	BEFs
1	<600	801	1.47	1371	1.5
1	601-1200	2855	1.5	2392	1.5
1	>1200	549	1.6	225	1.55
2	<600	2965	1.46	2447	1.54
2	601-1200	2563	1.47	1504	1.55
2	>1200	106	1.65	-	1.55
3	<600	129	1.48	239	1.49
3	601-1200	4220	1.48	1980	1.49
3	>1200	2909	1.59	241	1.56
4	<600	142	1.48	177	1.59
4	601-1200	2550	1.51	1428	1.56
4	>1200	8556	1.57	327	1.62
5	<600	-	1.54	547	1.64
5	601-1200	260	1.54	1225	1.67
5	>1200	1576	1.61	369	1.7

Table 172 Biomass expansion factors to convert round-wood over bark (t C ha^{-1}) to total biomass (t C ha^{-1}) for conifers and deciduous species, respectively.

d) Carbon Content

The IPCC default carbon content of solid wood of 50% was applied (IPCC 2003; p. 3.25).

e) Growing stock, increment, cut and mortality in managed forests

Growing stock, increment, cut and mortality were derived from those 5’425 sample plots measured at both NFI I and NFI II (Kaufmann 2001). All values are related to round wood over bark (with stock, without branches) and are given in m^3 ha^{-1} per subcategory (Table 173 and Table 174).

NFI region	Altitude [m]	Growing stock 1985 [m^3 ha^{-1}]	Growing stock 1995 [m^3 ha^{-1}]	Gross inc. [m^3 ha^{-1} $10yr^{-1}$]	Cut and mortality [m^3 ha^{-1} $10yr^{-1}$]
1	<600	354.12	381.29	96.96	69.73
1	601-1200	372.1	393.62	97.35	75.82
1	>1200	255.32	265.31	61.42	52.01
2	<600	414.9	425.15	144.14	133.34
2	601-1200	458.41	477.94	146.7	127.01
2	>1200	282.75	291.16	34.55	26.14
3	<600	473.58	506.79	132.36	99.14
3	601-1200	482.43	515.95	132.71	98.85
3	>1200	356.09	372.59	76.12	59.58
4	<600	256.2	271.73	58.92	43.39
4	601-1200	322.68	338.36	78.92	63.47
4	>1200	295.36	304.62	56.58	47.51
5	<600	234.46	236.89	18.19	15.76
5	601-1200	245.82	263.12	46.73	29.43
5	>1200	229.02	258.05	42.89	13.88

Table 173 Growing stock, increment, cut and mortality for coniferous trees (related to coniferous forest area).

NFI region	Altitude [m]	Growing stock 1985 [m^3 ha^{-1}]	Growing stock 1995 [m^3 ha^{-1}]	Gross inc. [m^3 ha^{-1} $10yr^{-1}$]	Cut and mortality [m^3 ha^{-1} $10yr^{-1}$]
1	<600	322.29	357.28	96.07	61.19
1	601-1200	318.04	354.25	91.93	55.75
1	>1200	196.67	233.21	50.95	12.38
2	<600	342.05	377.85	134.41	99.01
2	601-1200	370.66	424.4	142.1	88.57
2	>1200	144.81	233.5	110.57	21.88
3	<600	379.93	427.12	115.75	68.56
3	601-1200	374.75	427.88	113.4	60.82
3	>1200	257.27	311.7	72.32	17.88
4	<600	241.37	261.42	91.15	72.19
4	601-1200	224.59	261.49	66.1	29.38
4	>1200	168.69	225.99	81.64	24.41
5	<600	152.1	176.26	52.55	28.43
5	601-1200	134.02	163.17	49.93	20.96
5	>1200	142.14	186.53	60.34	16.26

Table 174 Growing stock, increment, cut and mortality for deciduous trees (related to deciduous forest area).

From the NFI, gross increment as well as cut and mortality were derived for 10 years. To estimate the annual increment, the measured increment for 10 years was linearly interpolated:

[annual gross growth] = [gross growth of 10 years] / 10

Cut and mortality could only be quantified as sum of cut and mortality (CM). To calculate the annual cut and mortality (CM_y) the total amount of cut plus mortality between 1986-1995 was distributed among the ten years, weighted by the percentage of the annual harvesting amount from the forest statistic (www.agr-bfs.ch). As done in all former NIRs, 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.

The growing stock of the year 1990 (GS1990) was calculated from growing stock of 1985 (GS1985) as:

$$GS1990 = GS1985 + 5 * [\text{annual gross growth}] - \Sigma_y [CM_y] \qquad y = 1986\text{-}1990$$

These values given in round wood over bark (m^3 ha^{-1}) were converted to carbon in living biomass (t C ha^{-1}, see Table 175) as follows:

$$[\text{C in living biomass}]_i = \Sigma_t [\text{round wood over bark}]_{i,t} * \text{density}_t * BEF_{i,t} * \text{C-content} * [\text{percentage of tree species}]_{i,t}$$

Where:

i = subcategory
t = tree species

NFI region	Altitude [m]	C in Biomass 1990 [t C ha^{-1}]
1	<600	128.76
1	601-1200	124.55
1	>1200	85.11
2	<600	135.79
2	601-1200	148.86
2	>1200	93.31
3	<600	157.24
3	601-1200	152.53
3	>1200	116.36
4	<600	98.43
4	601-1200	102.07
4	>1200	94.75
5	<600	74.13
5	601-1200	69.85
5	>1200	78.04

Table 175 Growing stock in 1990 in t C ha^{-1}.

f) Growing stock in unproductive forests

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.

Inaccessible forest

Inaccessible forest in Switzerland is mainly located in the Alps and the southern Alps where the average growing stock is around 275 m^3 ha^{-1} and 205 m^3 ha^{-1}, respectively. As in the brush forest, no NFI data are available to derive growing stock. As inaccessible forest 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 inaccessible forest of 87 t ha^{-1} that translates to 43.5 t C ha^{-1} (using the IPCC default carbon content of 50%) was estimated.

In the ASCH land use data inaccessible forest is not distinguished as an own category. Therefore, inaccessible forest was approximated by “open forest on unproductive areas” (AScode 12; see Table 162).

Carbon content of unproductive forest: Weighted means

The unproductive forest in Switzerland mainly consists of brush forest and inaccessible forest. The carbon content of unproductive forest was therefore calculated as a weighted average of brush forest and inaccessible forest per subcategory:

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

where RS_i is the rate of the brush forest per subcategory i, CS is the carbon content of brush forest (11.6 t C ha^{-1}) and CI is the carbon content of inaccessible forest (43.5 t C ha^{-1}). Table 176 shows the carbon content per subcategory in t C ha^{-1}.

NFI region	Altitude [m]	Brush forest(*) [ha]	Inaccessible forest (*) [ha]	Total unproductive forest [ha]	Rate of brush forest	Weighted C content [t C ha^{-1}]
1	<600	25	356	381	0.0656	41.41
1	601-1200	1	1780	1781	0.000561	43.48
1	>1200	1	178	179	0.00558	43.32
2	<600	25	534	559	0.0447	42.07
2	601-1200	25	356	381	0.0656	41.41
2	>1200	1	0	1	1	11.60
3	<600	25	356	381	0.0656	41.41
3	601-1200	50	3204	3254	0.0154	43.01
3	>1200	2100	1780	3880	0.541	26.23
4	<600	100	356	456	0.219	36.50
4	601-1200	1925	4984	6909	0.279	34.61
4	>1200	36925	7120	44045	0.838	16.76
5	<600	200	534	734	0.272	34.81
5	601-1200	2550	3560	6110	0.417	30.19
5	>1200	16875	5162	22037	0.766	19.07

* Derived from the NFI II (Brassel and Brändli 1999)

Table 176 Rate of brush forest and inaccessible forest per subcategory and weighted carbon content in t C ha^{-1}.

g) 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 can be done. In Table 177, the amount of dead wood is differentiated for the production regions. So far, no data about the change of the dead-wood pool are available.

	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

Table 177 Dead wood per NFI production region (m^3 ha^{-1}) (Brassel and Brändli 1999).

Applying the same wood densities, BEFs and carbon content as for the living growing stock, dead wood per subcategory can be estimated (Table 178).

NFI region	Altitude [m]	Carbon in dead biomass [t C ha^{-1}]
1	<600	2.34
1	601-1200	2.19
1	>1200	2.18
2	<600	1.72
2	601-1200	1.67
2	>1200	1.66
3	<600	4.45
3	601-1200	4.01
3	>1200	3.98
4	<600	7.51
4	601-1200	6.75
4	>1200	6.22
5	<600	5.13
5	601-1200	5.06
5	>1200	4.06

Table 178 Dead wood per subcategory in t C ha^{-1}.

h) Soil carbon

Perruchoud et al. (2000) interpolated 168 forest soil samples from the "Waldzustandsinventar 1993 - Bodenkundliche Erhebungen" (Lüscher et al. 1994). According to this study an average carbon stock of forest soils of 76 t C ha^{-1} in 0-30 cm topsoil were assumed. Due to statistical reasons, the soil samples could not be stratified for subcategories. Therefore, the average value for soil carbon was applied for the entire Switzerland.

Due to following reasons we assume that in 1990 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 is very restrictive.
- Fertilization and drainage of forests are 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.

Therefore, and according to the Marrakesh Accords, Switzerland chooses not to account for organic carbon in forest soils.

i) Calculating carbon fluxes in case of land-use change

According to the land use statistic, each year certain areas switch from a non-forest land use category to forest. These are mainly areas that used to be populated with grassland or woody biomass (see Table 164) not fulfilling the definition of minimal forest density and area. According to the stock change approach, the growing stock of e.g. „grassland with woody biomass" (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 A4.3.1): 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 growth rate of normal forest. The change of soil carbon was set to zero.

In afforestations (LUcode 11) the increase of growing stock in the first few years is very small and was neglected.

Cut and mortality was inferred from NFI I and NFI II, 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 new areas were only multiplied with the average gross annual increment per strata i.

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 type was added. As different land use categories contain different carbon stocks, the categories had to be differentiated (see Table 166).

k) N_2O Emissions from N Fertilization and Drainage of Soils

Fertilization of forests is prohibited by the Swiss forest law. No emissions are reported in Table 5(I) of the CRF.

Drainage of forests is not common practice in Switzerland. There are no survey data available, but the drained area is probably very small. As a first guess it was set to zero, and no emissions are reported in Table 5(II) of the CRF.

l) Emissions from Wildfires

In 1990, fires were observed on a forest area of 1’100 ha (data from EMIS). 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 0.065 Mg CH_4 ha^{-1} (data from EMIS), resulting in a total emission of 0.0715 Gg CH_4 $year^{-1}$ (see CRF Table 5(V)).

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 200’000 kg biomass ha^{-1} (see Table 175, thereby taking into consideration the respective areas). 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), an emission of 10.9 t N_20 $year^{-1}$ results.

The emission of CO_2 is already included in Table 5.A of the CRF.

A4.4.3 Uncertainties and Time-Series Consistency

In case of gross increment, cut and mortality, the uncertainty is assessed as low. In case of BEFs, the uncertainty is assessed as medium.

A4.4.4 Source-Specific QA/QC and Verification

No source-specific QA/QC activities have been carried out.

A4.4.5 Source-Specific Recalculations

No source-specific recalculations have been carried out.

A4.4.6 Source-Specific Planned Improvements

As soon as the results from the third NFI (2004-2006) are available, growth rates and harvesting amounts currently extrapolated from NFI I (1983-1985) and NFI II (1993-1995) will be recalculated for the years from 1995 onwards.

In the third NFI, the total amount of dead wood will be measured by the line intersect method. Therefore, estimates about changes of the dead-wood pool will be done in 2007.

So far, growth rates are linearly interpolated between the first and the second NFI. In the next inventory report, the correlation between annual growth rates and annual climate values will be taken into account.

A4.5 Source Category 5B – Crop Land

A4.5.1 Source Category Description

Swiss croplands belong to the cold temperate wet climatic zone. Carbon stocks in aboveground living biomass and carbon stocks in soils are considered. Croplands (LUcode 20) include annual crops, leys in arable rotations, and vineyards (see Table 162).

A4.5.2 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 for vineyards, and as cumulated annual harvested biomass for leys (Table 179).

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
Vineyards	2.0

Table 179 Standard values for arable crop yields (t C ha^{-1}; FAL/RAC 2001, assuming a carbon fraction of 0.5). Vineyards: Mean standing stock based on woody biomass of 1.3 kg dry matter/tree and 3000 trees ha^{-1} (FAW 2005).

The mean standing biomass carbon stock per hectare is calculated as:

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

Where A_f = Area of crop type f, At = total cropping area and C_f = annual yield (annual crops, leys) or standing stock (vineyards) for the particular crop (t C ha^{-1}).

The resulting mean biomass stock for Swiss cropland is 5.53 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, 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 organic soils is 240 ± 48 t C ha^{-1}.

Changes in carbon stocks biomass and mineral soil are assumed to be zero for cropland remaining cropland. Carbon stock changes in soil for cropland remaining cropland occurs in the case of shifts from mineral to organic soils or vice versa. These soil carbon stock changes are calculated as:

$$\text{delta } C_s \text{ cropland (t)} = (A_{s\ organic,\ t2} - A_{s\ organic,\ t1}) * (C_{s\ organic} - C_{s\ mineral})$$

where $A_{s\ organic}$ is the area of cropland on organic soils (ha), $C_{s\ organic}$ the soil carbon stock on organic soils, $C_{s\ mineral}$ the soil carbon stock on mineral soils (t ha^{-1}), t1 and t2 beginning and end of inventory, respectively. Implicitly, this effect is included in the general equations in Chapter A4.3.1.

c) N_2O Emissions from Land Use Conversion to Cropland

So far, the ASCH land use data do not clearly distinguish grassland and cropland. Arable cropland can be covered by grass for several years and then be ploughed again. In the face of the current agricultural policy in Switzerland it is unlikely that really new cropland emerges.

N_2O emissions from drained organic soils are already reported under the agricultural sector. Therefore, the emissions are assumed to be zero in Table 5 (III) of the CRF.

d) Carbon Emissions from Agricultural Lime Application

In Table5(IV) of the CRF the same values are reported as in former NIRs. The total annual amount of limestone input to agricultural soils of 45’000 Mg has been stable over the period 1990–2003 and has been estimated by Würsch (2004).

The IPCC default carbon conversion factor for limestone is 0.12 Mg C per Mg $Ca(CO_3)$. The resulting carbon emissions associated to liming are 5’400 Mg C $year^{-1}$.

A4.5.3 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 percent 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.

A4.5.4 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.

A4.5.5 Source-Specific Recalculations

No source-specific recalculations have been carried out.

A4.5.6 Source-Specific Planned Improvements

A new version of the land use statistics (AREA 2004/09) will clearly distinct arable land and permanent grassland.

A4.6 Source Category 5C – Grassland

A4.6.1 Source Category Description

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 grasslands (LUcode 31), permanent grasslands with perennial woody biomass/orchards (LUcode 32), and unproductive permanent grasslands (LUcode 33) as shown in Table 162. 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 classes of altitude (corresponding to those used in source category 5A – Forest Land).

A4.6.2 Methodological Issues

a) Carbon in living Biomass

Standing stocks for permanent grasslands (t C ha^{-1}) are calculated from the annual yield based on FAL/RAC (2001), assuming a carbon fraction of 0.5. Root biomass-C is assumed to be the same for all grasslands and was taken from Ammann et al. (subm.) due to lack of additional data. Table 178 shows the living biomass of permanent grassland (LUcode 31) as the cumulated annual yield including roots.

Altitude (m)	C_l [t C ha^{-1}]
<600	7.45
601-1200	6.26
>1200	4.45

Table 180 Living biomass of permanent grassland (LUcode 31).

Standing stocks for permanent grasslands with perennial woody biomass (LUcode 32) were calculated as:

$$C_l = C_{l\ grass} + C_{l\ woody\ biomass}$$

C_l grass is the same as in Table 180 because both categories, LUcode 31 and LUcode 32 span the whole elevational range and yields in FAL/RAC (2001) refer to both categories. Carbon in living woody biomass of LU 32 is calculated based on the number, spatial extension, and woody biomass of orchard trees. Orchards include row trees with grass understory (Niederstamm) as well as mixed orchards with loosely planted larger fruit trees (Hochstamm). C_l of orchards is calculated as:

$$C_{l\ woody\ biomass} = \text{(carbon per fruit tree [t] * number fruit trees) / area orchards [ha]}$$

Calculation of C contents of fruit trees is described in the subsequent section. The total C_l in woody biomass is:

$$C_l\ \text{total} = C_l\ \text{Hochstamm} + C_l\ \text{Niederstamm}.$$

Because no other data are available, the mean C_l woody biomass ha^{-1} in orchards is used for the whole LUcode 32. The corresponding C_l values are given in Table 181.

Altitude (m)	**C_l [t C ha^{-1}]**
<600	27.39
601-1200	26.20
>1200	24.39

Table 181 Biomass-C in living biomass (including roots) of permanent grassland with perennial woody biomass/orchards.

Unproductive permanent grassland (LUcode 33) includes grasses and herbaceous vegetation mainly at high elevations above 2000m. The corresponding C_l value (FAL/RAC 2001) for high alpine pastures plus root-C is 2.95 t C ha^{-1}.

b) Biomass of Fruit Trees

In order to estimate the carbon stock of grassland with woody biomass (LUcode 32) the carbon content of two types of fruit trees was calculated.

The carbon content of a fruit tree of the type “Hochstamm”, with a diameter at breast height (DBH) of 25-35cm was calculated as follows:

$$C_{Hochstamm} = \text{Stem wood volume * KE-Factor} = 225\ \text{kg C}$$

where:

- Stem wood volume of an apple tree with DBH between 25 and 35 cm: 500 dm^3 (expert knowledge);
- KE-Factor = BEF * Density * Carbon content = 0.45 kg C dm^{-3} (Wirth et al. 2004)

For small apple trees with a low stem (“Niederstamm”), for biomass expansion factor no literature values were found. Therefore, following assumptions were met. DBH of such trees was assumed to be around 12 cm and the tree height was assumed to be around 3 m. The bole shape of Niederstamm apple trees can be approximated by a cylinder shape.

Stem wood volume = $r^2 * \pi *$ height = $(6\ cm)^2 * 3.1 * 300\ cm = 33.5\ dm^3$

The percentage of branches was estimated as 100%, the percentage of roots was estimated as 30%. A wood density of 0.55 kg dm^3 (Vorreiter 1949) and the default carbon content of

50% were assumed. With these assumption the carbon content of a tree of the type "Niederstamm" is calculated as follows:

$C_{Niederstamm}$ = stem wood volume * BEF * wood density * carbon content
= 33.5 dm^3 * 2.3 * 0.55 kg/dm^3 * 50% C content = 21 kg C

c) Carbon in soils

Soil carbon stocks in mineral soils under grassland 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 and topography. No differentiation between permanent grassland and permanent grassland with perennial woody biomass is possible due to lack of data. Mean C_s values calculated for grasslands LUcode 31 and LUcode 32 are given in Table 182.

Altitude (m)	**C_s [t C ha^{-1}, 0-30 cm]**
<600	62.02 ± 13
601-1200	67.50 ± 12
>1200	75.18 ± 9

Table 182 Mean carbon stock under grassland on mineral soils.

Unproductive permanent grassland (LUcode 33) includes grasses and herbaceous vegetation mainly at high elevations above 2000 m. For mineral soils in LUcode 33, a C_s value of 50.70 ± 7 t ha^{-1} is calculated for grasslands higher than 2000 m based on data presented in Leifeld et al. (2003) for unfavourable grasslands at that elevation.

Soil carbon stocks in organic soils under grassland 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 organic soils is 240 ± 48 t C ha^{-1}.

Changes in carbon stocks biomass and mineral soil are assumed to be zero for grassland remaining grassland. Carbon stock changes in soil for grassland remaining grassland occurs in the case of shifts from mineral to organic soils or vice versa. These soil carbon stock changes are calculated as:

$$\text{delta } C_s \text{ grassland (t)} = (A_{s\ organic,\ t2} - A_{s\ organic,\ t1}) * (C_{s\ organic} - C_{s\ mineral})$$

where $A_{s\ organic}$ is the area of grassland on organic soils (ha), $C_{s\ organic}$ the soil carbon stock on organic soils, $C_{s\ mineral}$ the soil carbon stock on mineral soils (t ha^{-1}), t1 and t2 beginning and end of inventory, respectively. Implicitly, this effect is included in the general equations in Chapter A4.3.1.

A4.6.3 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 percent 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.

A4.6.4 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.

A4.6.5 Source-Specific Recalculations

The area of organic soils is somewhat higher than in former calculations due to new methods for assessing activity data and spatial stratification.

A4.6.6 Source-Specific Planned Improvements

A new version of the land use statistics (AREA 2004/09) will clearly distinct arable land and permanent grassland.

A4.7 Source Category 5D – Wetlands

A4.7.1 Source Category Description

Wetlands consist of surface waters (LUcode 41) and unproductive wet areas such as shore vegetation and fens (LUcode 42) (see Table 162).

A4.7.2 Methodological Issues

As shown in Table 166, surface waters have no carbon stocks by definition.

For unproductive wetland a first guess was made: the carbon stock in living biomass was set to 2.95 t C ha^{-1}, in dead organic matter to 0 t C ha^{-1} (same values as for unproductive grassland) and the stock in soil is 53.40 t C ha^{-1} (same value as for cropland). The net changes in biomass and soil are assumed to be 0.

Drainage of wetlands is very unlikely, as bogs and fens are protected to a large part by Federal Ordinances. Therefore, no emissions are reported in Table 5 (II) of the CRF.

A4.7.3 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.

A4.7.4 Source-Specific QA/QC and Verification

No source-specific QA/QC activities have been carried out.

A4.7.5 Source-Specific Recalculations

No source-specific recalculations have been carried out.

A4.7.6 Source-Specific Planned Improvements

There are no planned improvements.

A4.8 Source Category 5E – Settlements

A4.8.1 Source Category Description

Settlements consist of buildings/constructions (LUcode 51), surroundings of buildings (LUcode 52) and parks (LUcode 53) as shown in Table 162.

A4.8.2 Methodological Issues

A first guess was made for carbon stocks in settlements (Table 166).

For buildings/constructions the carbon stock in soil was set to 29 t C ha^{-1} assuming that approximately 50% of the soil carbon is emitted when cropland, grassland or forest is converted to LUcode 51 (see discussion in Leifeld et al. 2003: 67). The oxidative carbon loss is due to disturbance of the soil structure. In most cases, 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.

For surroundings of buildings and parks the carbon stock in living biomass was set to 7.45 t C ha^{-1} (same value as for grassland in NFI region 1 below 600 m). The carbon stock in soil was assumed to be 53.40 t C ha^{-1} (same value as for cropland).

A4.8.3 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.

A4.8.4 Source-Specific QA/QC and Verification

No source-specific QA/QC activities have been carried out.

A4.8.5 Source-Specific Recalculations

No source-specific recalculations have been carried out.

A4.8.6 Source-Specific Planned Improvements

There are no planned improvements.

A4.9 Source Category 5F – Other Land

A4.9.1 Source Category Description

Other land (LUcode 60) covers non-vegetated areas such as glaciers, rocks and shores (see Table 162).

A4.9.2 Methodological Issues

As shown in Table 166, other land has no carbon stocks by definition.

A4.9.3 Uncertainties and Time-Series Consistency

In the case of other land, the uncertainty of activity data and carbon stock data is assessed as low.

A4.9.4 Source-Specific QA/QC and Verification

No source-specific QA/QC activities have been carried out.

A4.9.5 Source-Specific Recalculations

No source-specific recalculations have been carried out.

A4.9.6 Source-Specific Planned Improvements

There are no planned improvements.

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Annex 5: Agriculture

Livestock Population Data for N_2O Emission Calculation

Animals 2004		Number of animals	kg N per head/year	FracGASM (6)	N volatilized (kg N)
Cattle		**1'544'547**			
	dairy cows (1)	690'997	106.5	0.19	13'739'067
	rearing cattle 1st year	214'653	25	0.01	50'245
	rearing cattle 2nd year	205'397	40	0.01	117'774
	rearing cattle 3rd year	120'865	55	0.01	77'102
	fattening cattle >1/2 hear	108'862	33	0.01	37'871
	fattening cattle < 1/2 year	35'823	8	0.00	241
	fattening calves	167'950	13	0.01	13'988
Pigs		**1'537'505**			
	fattening pig places (2)	859'216	13	0.04	455'164
	breeding pig places (3)	145'760	35	0.02	94'949
Sheep		**440'522**			
	sheep places (4)	227'499	12	0.00	8'275
Goats		**70'627**			
	goat places (5)	37'864	16	0.00	844
Horses		**53'701**			
	foals < 1 year	3'414	17	0.00	9
	foals 1 - 2 years	5'964	42	0.00	159
	Other horses	44'323	44	0.00	9'652
Ponies, Mules and Asses		**14'846**	26	0.00	378
Poultry		**8'060'688**			
	laying hens	2'088'751	0.7	0.01	9'419
	young hens < 18 weeks	853'080	0.3	0.00	360
	broilers	4'970'793	0.4	0.01	15'050
	turkeys	148'064	1.4	0.00	164
Total		**11'722'436**		0.33	14'630'712

(1) N excretion calculated based on milk production: 105 kg N/head/year at a milk production of 5000 kg/head/year, increased by 10% for every 500 kg additional milk production. Milk production 2003: 5590 kg/head/year
(2) one fattening pig place per fattening pig > 25 kg
(3) one breeding pig place per sow, 1/2 place per boar
(4) one sheep place per ewe > 1 year
(5) one goat place per goat > 1.5 years

(6) includes ammonia volatilization calculated for each species based on management practice and NO emissions of 1.5% of the excreted N

Table 183 Livestock population data 2004 for N_2O calculation.

Additional Data for N_2O Emission Calculation of Agricultural Soils

2004	Nitrogen incorporated with crop residues (t N)	Dry matter production (kg DM)	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	3'413	458'065'000	67			
Barley	1'245	218'875'000	24			
Maize	1'287	153'510'000	25			
Oats	99	13'175'000	2			
Rye	76	9'350'000	1			
Other (please specify)						
Spelt	77	8'585'000	2			
Triticale	832	70'720'000	16			
Mix of fodder cereals	7	1'190'000	0			
Mix of bread cereals	1	85'000	0			
2. Pulse						
Dry bean	31	787'950	1	0.0443	41'020	0.8
Eiweisserbsen/peas	335	14'224'750	7	0.0330	552'255	10.8
Soybeans	254	6'137'000	5	0.0571	412'406	8.1
Other (please specify)						
Leguminous vegetables	336	3'277'895	7	0.0177	322'747	6.3
3. Tuber and Root						
Potatoes	503	115'676'000	10			
Other (please specify)						
Fodder beet	185	19'800'000	4			
Sugar beet	3'009	318'780'000	59			
5. Other (please specify)						
Grass	22'334	6'255'233'127	439	0.0051	31'623'498	621.2
Silage corn	247	1'094'280'000	5			
Green corn	27	186'027'600	1			
Fruit	267	66'786'030	5			
Vine	182	30'380'600	4			
Renewable energy crops	49	3'150'000	1			
Non-leguminous vegetables	1'081	69'200'000	21			
Sunflowers	243	11'475'000	5			
Tobacco	36	1'400'000	1			
Rape	746	47'988'000	15			
Total Non-leguminous	13'612	2'898'498'230	267	0.0051	31'623'498	621.2
Total Leguminous	956	24'427'595	19	0.1521	1'328'428	26.1
Total	14'568	2'922'925'825	286	0.1571	32'951'926	647.3

Table 184 Additional data for N_2O emission calculation of agricultural soils.

Swiss Greenhouse Gas Inventory

Inventory Development Plan

Updated Version 12 May 2006

This updated version of the Inventory Development Plan covers the inventory status of the 31 May 2006 submission. The columns “Status” and “time schedule” have been updated with regard to the version of the 15 April 2006 submission. Newly added improvement items are listed in Section 11 of the Inventory Development Plan.

Explanation of column “Responsibility”:

If more than one institution is mentioned, the first one has the lead.

Explanation of column “Status”:

P: Work in progress

F: Work finished

pR: Work partially realized

Abbreviations:

AD	Activity data	LUCF	Land Use Change and Forestry
CS	Country-specific	LULUCF	Land Use, Land Use Change and Forestry
CRF	Common Reporting Format	NIR	National Inventory Report
EF	Emission factor	NFI	National Forest Inventory
ERT	Expert review team	Para.	Paragraph
ICR	In-country review	QA/QC	Quality assurance/Quality control
IEF	Implied emission factor	Ref.	Reference
GPG	Good Practice Guidance	Sub.	Submission

Agencies / Consultants

BAFU	Federal Office for the Environment FOEN
BAZL	Federal Office for Civil Aviation
BFE	Swiss Federal Office of Energy
Carbotech	Private Consultants (Experts synthetic gases)
EBP	Ernst Basler + Partner AG, private consultants (NIR co-authors)
ETHZ	Swiss Federal Institute of Technology, Zürich, Institute of Animal Sciences / Animal Nutrition
FAL	Swiss Federal Research Station for Agroecology and Agriculture
Infras	Infras Forschung und Beratung, private consultants (NIR co-authors)

Persons (from FOEN)

FP	Filliger Paul
LA	Liechti Andreas
MBU	Müller Beat
NM	Nauser Markus
SA	Schellenberger Andreas
THE	Thürig Esther

1. General Aspects

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
1	Implementation of National Inventory System within Climate Reporting Project	8, 34	High	September 06	BAFU (NM)	Medium to high	pR
2	Redesign of EMIS database including a checking and updating of activity data and emission factors	33, 106					F
3	Exclusion of the fossil fuel emissions of Liechtenstein from Swiss GHG inventory for all inventory years	5, 35g					F
4	Consistent use of notation keys and extended use of documentation boxes	19, 35c	Medium	September 06 With use of CRF reporter	BAFU (LA, MBU)	Medium	pR
5	Background documentation in English	107	Low	End 06	BAFU (FP)	Medium to high	pR

2. Transparency and Completeness

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
6	Increase of transparency: - in particular for country-specific approaches, - for Agriculture - and LUCF sector; - Better explanation of external sources for estimating country-specific emission factors	7, 9a, 32, 35c, 40 20, 111,112 20, 139 21	High				F
7	Data in CRF and NIR not identical, to be corrected in NIR	22					F
8	Documentation and verification of the decisions to use country-specific approaches	7					F

3. Recalculations, Time Series Consistency, Key Source Analysis

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
9	Refinement of key source analysis, more detailed disaggregation to identify important sub-sources	77, 110 +Verbal Proposition of experts during ICR					F
10	Explanation of the reasons and expanded discussion of recalculations, QA/QC procedures before starting recalculations	9c, 24, 35c, 44	Medium	Better description in NIR: Sub. 06, QA/QC driven recalculations from 06 onwards	Decision about recalc. BAFU (FP, LA), description Infras/EBP	Medium	pR

4. Uncertainties and Quality Assurance / Quality Control

	Improvement	**Ref. to paragraph of review report[1]**	**Priority**	**Time-schedule Implementation**	**Responsi-bility**	**Workload**	**Status**
11	Quantitative uncertainty analyses	9b, 11, 25, 26, 32, 35d, 47, 105, 115, 141, 155, 166					F
12	Development of a formal Quality assurance/quality control plan	9c, 9d, 22, 27, 28, 35f, 48, 116, 142, 156, 167	High	Extended draft for Sub. April 06, final version September 06	BAFU (SA) + all data suppliers	Very high	P
13	Plan for the verification of AD provided by outside agencies	48	Low				F

5. Institutional Arrangements and Record Keeping / Archiving

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
14	Establishment of institutional and procedural arrangements for collaboration between the SAEFL and other contributors	30, 113, 71, 162	High	September 06	BAFU (NM)	Medium to high	P
15	Institutional arrangements and responsibility in LULUCF sector to be defined	137, 158	High	September 06	BAFU (NM, FP)	Medium	pR
16	Improving flow of information for CRF and NIR in LUCF sector						F
17	Improving archiving system for documentation	9d, 31, 35b	Medium	End 06	BAFU (SA)	Medium to high	P
18	Improving archiving system for data sets	9d, 31					F

6. Energy

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
19	Time series inconsistency of manufacturing Industries and Other Sectors (new division of data into industry and commercial sector)	46, 71					F
20	Industry-data of 1.A.2f Other to be disaggregated into the IPCC categories	60, 71					F
21	More details for emissions from waste fuels in cement industry (AD and EF)	63					F
22	More details on use of EF's across the time series and carbon content / heating value of fuels in NIR (year-to-year variations of carbon content)	42, 47, 75					F
23	Revision of oxidation factor (in particular coal), inclusion in uncertainty estimate	73					F
24	Emissions arising from electricity generation by waste combustion to be moved from Waste to Energy sector	74, 160					F
25	Clear distinction between	41					F

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
	annually collected and interpolated data						
26	Description of interpolation/extrapolation methods	41					F
27	Inclusion of new Off-Road data, better description of off-road data	44, 55, 59, 66, 71					F
28	More precise description of methodologies that differ from IPCC	35e					F
29	Better Documentation of weighted fuel averages in sector 1.A.1 as well as in general	42, 65					F
30	Further details on military and civil aviation (separate reporting)	58					F
31	New modelling of aviation emissions (division domestic vs. international)	71					F
32	Better documentation for civil aviation	44, 51, 52					F
33	Further details on estimation of 1990, 91 emissions of cement industry	63					F
34	Table of EFs used in the calculations for cement	63					F

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
	industry						
35	Inconsistent IEF (1994 CRF) for biomass from commercial/institutional	45					F
36	CO2 emissions from oil refinery fugitives to be included	39					F
37	International marine bunker to be included	39, 50					F
38	Inconsistencies of trend shown for iron and steel combustion and process emission	48, 61					F
39	Improved AD for grass drying (held constant since 1990)	55					F
40	Discrepancy with IEA aviation data	58					F
41	Different EF for industrial boilers and engines (precursors only)	62, 71	Low	September 06	BAFU (LA)	Low	P
42	CH4 and N2O emissions from fuel consumption of cement industry to be included	63, 71					F
43	Details on AD of lime and glass production in NIR	64					F
44	Estimation of CO2 emissions from distribution of oil products missing	67					F
45	New estimation of emissions	68					F

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
	from CH4 leaks in gas pipelines (incl. transfer pipeline crossing Switzerland)						
46	EF for flaring of oil is outlier and should be checked	69					F

7. Industrial Processes and Solvent Use

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
47	Inconsistencies in CRF and NIR data (synthetic gases, errors in CRF, wrong units in NIR)	84, 85, 92					F
48	Review of emission factor for CO_2 from clinker. Measurements of CaO content of clinker and possible non-carbonate feeds to kiln	88	High	September 06	BAFU (FP) / EBP	Medium	P
49	PFC EF not consistent between CRF and NIR, better description in NIR	98					F
50	SF_6 from magnesium foundries: NIR incorrect for start time (1997), use of notation key "C" in CRF	102					F
51	CO_2 from solvent emission missing (oxidation in atmosphere), to be checked	Not covered in ICR report					F
52	Consistency of time series of SF_6 for 1990-94 to be checked, better documentation of recalculation of 1990 SF_6 data	82					F
53	Difference between CRF and UN statistics for cement	90					F

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
	production to be explained						
54	Move emissions from ferroalloys production to non-ferrous metals	101					F
55	C3F8 ratio of potential to actual emissions should be checked	104					F
56	SF6 in sub-source 2.F.5. Solvents not covered by IPCC GPG	94					F
57	CO2 EF for Iron and Steel and Aluminium Production to be documented	95					F
58	Revision of country-specific PFC emission factor	98					F
59	Review of EF and AD of lime production	99, 100					F

8. Agriculture

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
60	Improve documentation in the NIR	133					F
61	Consideration of subcategories of dairy and non-dairy cattle	117	High	September 06	FAL / ETHZ	Medium to high	P
62	Units of EFs of crop residues and N-fixing crops to be checked	120					F
63	Information currently given in Table 4.F to be included in a table in NIR	126					F
64	Explanation of „animal places“, discussion of use in tables 4.A and 4.B	129					F
65	Not enough information in NIR about country-specific methods and EFs	111, 112	Medium	September 06	Infras / ETHZ	Medium	P
66	Time series inconsistency in N2O from cattle	Not covered in ICR report					F
67	ERT questions low uncertainty for enteric fermentation	115, 25					F
68	More detailed description of country-specific method for calculating gross energy intake	118	Medium	September 06	Infras / ETHZ	Medium	P

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
69	Emissions from sewage sludge and compost used for fertilizing to be reported in table 4.D. Other (AD in NIR)	119					F
70	Explanation of choice of $Frac_{Leach}$ of 0.2 instead of 0.3 (IPCC)	122					F
71	Documentation of N-input values as AD for indirect emissions of N2O from leaching and run-off	123					F
72	Documentation of NH3 input values for calculation of indirect N2O emissions from deposition, more details on losses of NH3 from pasture	124					F
73	Create table for N amount that ends up in N2O in NIR	125					F
74	Check table of fractions used for N2O from soils (not filled in properly)	126					F
75	More information about CS values for volatile solids in manure (CH4)	127					F
76	Are all manure management systems covered? NIR should mention on what basis the distribution between the	128					F

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
	management systems has been made						
77	Description of the method used for CH4 conversion rate of poultry missing	118	Low	September 06	Infras / ETHZ	Low	P
78	N2O from burning of agricultural residues missing	111					F
79	Notation key NO in 4.C and 4.E	131					F
80	Tables 4.C, 4.E to be completed	19					F

9. Land-Use Change and Forestry

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
81	Gross annual growth of timber still among the highest values reported by Annex 1 countries; to be checked	147					F
82	Conversion from cropland or grassland to forest (as well as other Land use changes) to be reported separately; Accounting for land use changes in general	138, 157	Medium	Sub. 06 for 1990 / September 06 for 1991 – 2004	BAFU (SA, FP)	High	pR
83	CO2 emissions from liming to be estimated	138, 149					F
84	More detailed information in NIR on how annual changes in forest area from annual forest statistics are combined with NFI data	138					F
85	NIR not transparent enough: - Sources of AD for forest area - methodological approach of NFI - method to estimating area covered by cultivated organic soils	139, 158	Medium	Sub. 06, September 06	Infras / BAFU (THE) / FAL	Medium	P

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
86	Better fit with IPCC categories; disaggregation 5.A., 5.B., 5.C.; fill in data in 5.B (Forest and Grassland Conversion) and 5.C (Abandonment of Managed Land)	144, 146, 19					F
87	Problems of different forest definitions by AD (from NFI, Area statistics, digital maps)	145					F
88	Information in table 5.D missing	151	Medium	Sub. 06, September 06	FAL / BAFU (THE)	Medium	pR
89	Estimation of above-ground and below-ground carbon budgets	152	Medium	Sub. 06, September 06	BAFU (THE)	High	P
90	Notation keys and AD for cultivated organic soils to be checked	143					F
91	Incorporate non-forest trees	148	Low	Sub. 06, September 06	BAFU (SA,FP)	Medium	pR

10. Waste

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
92	Completeness of Waste sector to be checked: - CH4 from composting - N2O and CH4 from on-site waste water treatment for commercial sources and industrial waste water	162, 170					F
93	Check use of notation keys and give values of methane correction factor and degradable organic carbon in 6.A and 6.C	163					F
94	Check fractions of waste in additional info to table 6.A	163					F
95	Inconsistency CRF – NIR (IEF in CRF not given, but EF given in NIR, e.g. 6.A)	163					F
96	Not enough information about existing model on CH4 from solid waste disposal. Country specific model not in line with IPCC (redesign of model)	164, 168					F
97	More information on activity data in NIR	164					F
98	Documentation of recalculations	165					F

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
99	Improvement of waste database	162					F
100	N2O from human sewage missing, more information on human sewage in general	163, 175					F
101	Better documentation in NIR on CH4 recovered for energy generation	169					F
102	More information on recycling activities to be provided in the NIR and reflected in CRF table 6.A (other waste)	170					F
103	Information on specific EFs on each type of waste incinerated and explanation of selection of 60 % for organic fraction	172					F
104	Improve transparency for each type of incinerated waste	172					F
105	Emissions from industrial waste-water treatment plants and industrial disposal facilities not covered, to be included	173					F
106	Improve method for estimating municipal waste water treatment	174					F
107	Various burn-out efficiencies for different kinds of waste not taken into account, to be	172					F

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
	checked						
108	Better data on clinical and special waste	171					F

11. New Items (2005)

	Improvement	Ref. to paragraph of review report[1]	Priority	Time-schedule Implementation	Responsi-bility	Workload	Status
109	CO_2 Emissions from thermal post-combustion of VOC's						F
110	Fill in potential emissions by sources in Table 2(I)		Medium	Sub. 07	Carbotech	low	P